Integration of Emergency Response Management System with Internet of Things

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Abstract. Disasters can be classified either from mother nature such as landslide, earthquake, tsunami and lightning or cause by human such as leakage in gas production or terrorist attacks. Disaster leads to huge destruction economically and affected human lives. Whilst various technologies available towards disaster analysis occurrence, the Internet of Things (IoT) offers reliable solutions in handling the relevant disasters situation, such as early warning system, real time data analytics, remote monitoring and search and rescue localization. This research developed an integration of emergency response management system with IoT. The system integrates heterogeneous wireless-enabled embedded controller with sensor, smart phones, desktop and wireless communication for end-to-end network connectivity which is monitored by a cloud platform. The system performance was evaluated in terms of the end-to-end link quality estimation and delay.

1. Introduction
Disaster is defined as sudden and calamitous incident resulting in a loss of lives, disrupts the functioning of community and causes damages environmentally and economically. Most of the times caused by nature, however disaster can also due to human origins. Floods and landslides contribute as major natural disaster threat in Malaysia. Hence, disaster management has consistently been an utmost focus as part of Malaysia’s development policy. Malaysia National Platform for Disaster Risk Reduction (DRR) formalized in 2013 which included several stakeholders from the government and private sectors. Furthermore, Malaysia 11th version of the Five-Year Plan (2016-2020) strengthened disaster risk management across five phases which are prevention, mitigation, preparedness, response and recovery.

The effective disaster management system can decrease the loses financially. This can be achieved by prompt actions of the emergency response units to locate disaster area using precise information. The real-time information for the movement of rescue management teams are crucial for data analysis as well as connectivity analysis. The usage of Geographic Information System (GIS) in disaster management focused for specific task or individual usage such as evacuation [1], mitigation, preparedness and monitoring or visualization [2]. Take into consideration, wireless network between the field rescuers and confined survivors; and interconnection between the emergency network to the internet are the crucial challenges arise during relief operations. Consequently, the rescue operations are difficult to conduct without another methods of data communication system for immediate deployment.
The usage of IoT as part of the emergency response tools contribute to the efficiency and effectiveness of emergency response system due to its real-time data transmission. Various communication technologies such as Wi-Fi and Bluetooth integrated with wireless devices [3] were used for real-time data transmission to cloud platform. In order to overcome the challenges in a wireless communication system from disaster area to control centre, the integration of formation and management of Virtual Objects [4], multisemantic model representation [5] and Web of Objects infrastructure were introduced.

2. Research Methodology

The IoT-enabled emergency response management system is taking advantages of the long range, low power wireless radio frequency technology. LoRa nodes served as transmitter and placed at the chosen disaster area. The signal transmitter by LoRa nodes will be received by LoRaWAN gateway and then transmitted to IoT cloud platform for real-time data collection. The usage of LoRa protocol solves biggest challenges involved with IoT applications such as energy management and communication shortage provided by wireless communication and Bluetooth technology.

![Figure 1](image.png)

**Figure 1.** The proposed network of IoT-enabled emergency response management system.

2.1. LoRa Nodes

RFM95 LoRa Shield integrated with Arduino microcontroller were used as LoRa nodes which allows users to transmit data and reach long ranges at low data-rates. It offers ultra-long range communication spectrum with high interference immunity and minimized power consumption. It transmitted signal to the LoRa Gateways. Three types selection switches were provided depending on types of emergency signals which are police as Switch 1 (S1), firefighter as Switch 2 (S2) and ambulance as Switch 3 (S3) as shown in Figure 2. This configuration is changeable depending on the local authority at the selected area. Three LED indicators shown in Figure 2(a) were set as follows:

- Red LED shows the power is supplied to LoRa Nodes
- Yellow LED shows the Lora nodes is switched ON
- Green LED shows the signal transmission from LoRa nodes to LoRa Gateway
2.2. **LoRa Gateways**

LoRa RFM95 Gateway used as receiver and integrated with Arduino LoLin V3 NodeMcu ESP8266 for real-time data transmission to IoT cloud platform. The LoRa Gateways will be stationed at the emergency response centers by local authorities such as police, firefighters, and hospitals for centralized data management centres.

![LoRa Gateway](image)

**Figure 3.** LoRa Gateway a) Lora Gateway unit b) Circuit

Figure 3(a) shows LoRa gateway which provides similar LED indicators as LoRa nodes. However, LoRa gateway is equipped with GSM SIM 800L to submit short messages to respective agencies triggered by the selection switches provided.

2.3 **IoT cloud Platform**

The open source cloud platform, Thinger.io is used in this research which supports REST API for controlling the end devices, bandwidth saving while transmission of data and automatic discovery of API. The connection from microcontroller to Thinger.io is served using WiFi, Ethernet, GSM, and GPRS. The real-time monitoring dashboard was built based on the system requirement and allows third-party service communication. The real-time data could be accessed through an Android platform.

Figure 4 shows the cloud dashboard for emergency monitoring. Every time the emergency occurs, it will be differentiated based on the displayed data thus will shorten the rescue response time due to precise information.
3. Results and Discussion
The LoRa nodes setting were made for individual interfaced devices to fetch the information from LoRa based on real time dashboard as shown in Figure 5. The same feature can be accessed through the smart phone Thinger.io application. The dashboard displays the status of the emergency and identified the affected area.
Figure 5. Emergency Response Profile

The important characteristic during emergency was the response time, as it is the key element in emergency situation. Thus, this feature was made available in the proposed system as shown in Figure 6. The rescue team will respond based on the type of emergency triggered by the victims. At the same time the message will also being sent to the on the move rescue team.
From the response for each rescue team shown in Figure 6, the time of the signal received by LoRa getaway was recorded at different time. The frequency of the emergency signal received can be evaluated based on the ON time.

The proposed system located the emergency area, (Figure 7) thus, shortened the search and rescue time. The location of the disaster area can be accessed by the administration of the local authority as well as the rescue teams on the go, solved the communication problem amongst the rescue team.
The additional feature offered in the proposed system is log repository (Figure 8). The feature enabled the local authority to look into the frequency of occurrences for each disaster and forecast the appropriate emergency plan required. This in long term reduce the operational cost involves in handling disaster situation.
Figure 8. Log repository recorded; a) Emergency recorded on receiver 2 and 3, b) LoRa nodes were powered OFF, c) LoRa nodes were powered ON but no emergency recorded

The LoRa devices maintenance had been made practical with the built in system indicator shown by the LED if the device is malfunction.

Figure 9. LoRa sensor turned OFF

4. Conclusions
The integration of Emergency Response Management System with IoT is important to reduce the risk involves in saving life during emergency. The usage of LoRa devices enhanced the performance of the proposed system. The system can be further improvised in terms of radio frequency range to cover wide area of disaster between affected area and the local authority to increase efficiency.

5. References
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Acknowledgments
This research is fully supported by STG grant, 9001-1805. The authors fully acknowledged University College TATI for the approved fund, which makes this important research viable and effective.