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# Real-time Intelligent Exit Path Indicator Using BLE Beacon Enabled Emergency Exit Sign Controller

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## Abstract

*Emergency lights and exit signs are an indispensable part of safety precautions for effective evacuation in case of emergency in public buildings. These emergency sign indicates safe escape routes and emergency doors, using an internationally recognizable sign. However visibility of those signs drops drastically in case of emergency situations like fire smoke, etc. and loss of visibility causes serious problems for safety evacuation. This paper propose a novel emergency light and exit sign built-in with Bluetooth Low Energy (BLE) Beacon to assist the emergency self-guiding evacuation using devices for crisis and emergency management to avoid panic condition inside the buildings. In this approach, the emergency light and exit sign with the BLE beacons deployed in the indoor environments and the smart devices detect their indoor positions, direction to move, and next exit sign position from beacon messages and interact with map server in the Internet / Intranet over the available LTE and/or Wi-Fi network connectivity. The map server generate an optimal emergency exit path according to the nearest emergency exit based on a novel graph generation method for less route computation for each smart device. All emergency exit path data interfaces among three system components, the emergency exit signs, map server, and smart devices, have been defined for modular implementation of our emergency evacuation system. The proposed exit sign experimental system has been deployed and evaluated in real-time building environment thoroughly and gives a good evidence that the modular design of the proposed exit sign system and a novel approach to compute emergency exit path route based on the BLE beacon message, map server, and smart devices is competitive and viable.*

*Keywords: Emergency Lighting Systems, Exit Signs, LED, Building Evacuation, BLE Beacon, Intelligent Building Management System, Emergency Messages, Shortest Path Algorithm*

## 1. Introduction

The visual signs provide a means of indoor navigating for sighted people within unfamiliar locations such as offices, hospitals and other public buildings. In particular at emergency situations, emergency exit signs point the way to emergency escape routes, thus making them a legal requirement for buildings as per site constructed area. However, for people with visual impairments or fire smoke like situations, these vital visual sign resources cannot be utilized as a guidance aid to public want to evacuate on emergency situation.

The research on how people determined evacuation paths during fire emergency situations on building shows that 56.3% of people determined evacuation paths depending on exit signs when there was no smoke present and 81.8% determined an evacuation path depending on exit signs when their visibility was impaired due to smoke [1].

However the presently installed exit signs in buildings have fixed directions, there is a possibility that the signs can lead the evacuators to dangerous so the animated direction images embedded on exit signs allows the number of people who followed the correct evacuation path doubled [2]. In additions to basic features of exit signs system design, it is to add additional exit informations like directions for the nearest exits and indication of dangerous points where a fire or emergency crisis has occurred [3]. The exit sign system composed of wireless sensors with Dijkstra's shortest path algorithm to find the correct direction towards the nearest exit [4].

These results show that the role of exit signs is of the utmost importance when individuals are put in adverse situations that require an exit strategy. The smart device based location based services using Bluetooth beacons technology for indoor location [5, 6, and 7] to detect these emergency signs and output the necessary information in acoustic form can make them accessible to people who cannot rely on their eyesight to recognize visual sign objects in emergency situation inside the buildings. This approach can be helpful people who in unknown or complex buildings, when the escape routes cannot be memorized or know to them and there is no need of other person immediately available to guidance to find the right escape route in critical emergency situation.

This paper propose a novel intelligent exit sign system design built-in with BLE beacon to indicate the next emergency exit with direction information using bluetooth beacon message. In this proposed approach, exit sign system connected with emergency exit server with LTE and/or WiFi connectivity mode to work in standalone for emergency exit aiding service. The emergency exit server processes environment condition and send the dynamic path information to connected exit sign system.  The emergency exit sign system receive the exit path information and direction information from emergency exit server and broadcast the exit information through BLE beacon. The person who escape from emergency condition, gets the exit information on smart device and the emergency smart device application aid the escape route with direction interactively.

## 2. Emergency Lightings and Exit Signs

Emergency lightings and Exit signs are designed to help save lives and avoid the chance of serious injury during perilous events like fires and earthquakes in all non-residential buildings. Both are used in almost every public or industrial buildings and are intended to convey a clear and immediate message about exit pathways as shown in Figure 1.
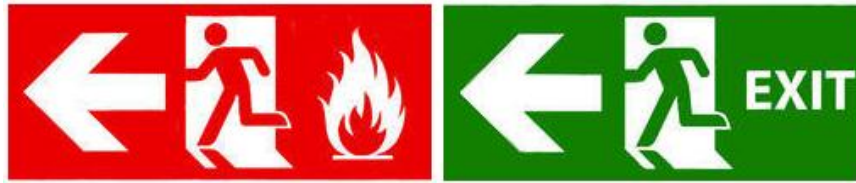
**Figure 1. Emergency Lighting and Exit Sign**

The codes and standards governing the configuration of the sign, its brightness, and where and how it is placed in the building are complex and vary by jurisdiction. In the past, incandescent lamps were used for exit signage. Most exit signs currently in place are probably lit by incandescent. Incandescent sources also have a disadvantage beyond their high power consumption in that they can fail when subject to shock and vibration, such as when a door is slammed.
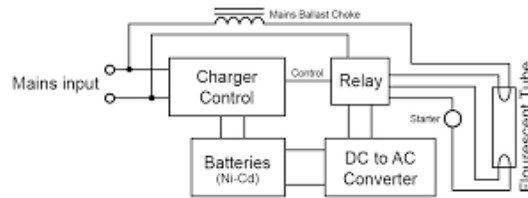


**Figure 2. Emergency Lighting and Exit Sign**

Newer technology exit signs can significantly conserve energy, reduce labor demand, and save money. Light Emitting Diode (LED) exit signs are presently the preferred choice for both new exit signs and retrofitting existing exit signs. Exit signs are a perfect application for the use of Light Emitting Diodes (LED's), which are excellent for exit sign illumination. LED's are made of a semiconductor material in which light is produced when an electron within the semiconductor material travels from a high-energy state to a low-energy state. The emergency lighting and exit sign system consist of LEDs, LED driver, controls, and battery as shown in Figure 3.
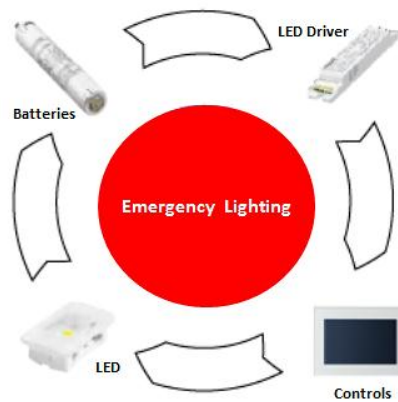


**Figure 3. Emergency Lighting and Exit Sign**

In many lighting applications, LED's are not adequate devises in all the applications to which they are used, however, the low amount of light emitted from LED's suites exit sign applications very well. LED exit

signs can be found with low input wattages of two watts or less, compared to 40 watts for an incandescent exit sign. Although the savings in energy consumption seems rather miniscule compared to other lighting sources, it is important to realize that exit signs run constantly.

## 3. BLE Beacon Enabled Emergency Exit Sign Controller

The proposed exit sign system designed with BLE beacon controller for local connectivity with user to broadcast the emergency exit information and LTE and/or WiFi connectivity with remote emergency exit server to get optimum safety exit path information to guidance to find the right escape route in critical emergency situation.

The proposed a convenient and user-friendly emergency management system that includes an emergency exit server, emergency exit sign, and a mobile application accompanying map designed for disaster relief people evacuation aid. The overall system diagram is shown in Figure 4.

The emergency exit server receive the building emergency condition information using building wireless sensor network (WSN)  and  processes environment condition and find the optimum safety information using Dijkstra's shortest path algorithm.  The dynamically estimated real time emergency exit path information transmitted to available emergency exit sign system using available LTE and/or WiFi connectivity according to the emergency condition.



**Figure 4. Emergency Exit Management Overall System Architecture**

The proposed emergency exit system with bluetooth and LTE and/or WiFi connectivity for smart escape exit evacuation path aiding through smart device is shown in Figure 5.
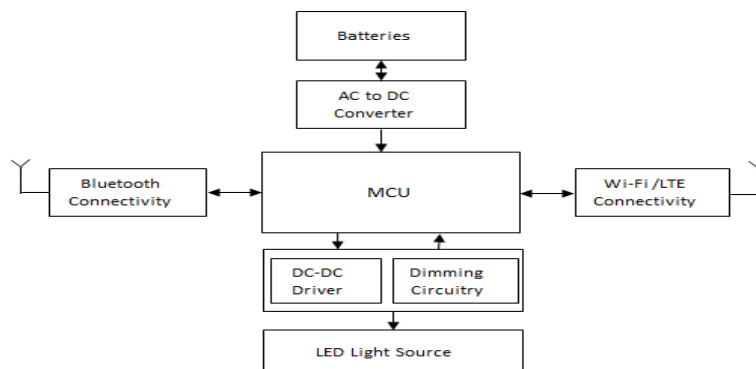


**Figure 5. Proposed Emergency Exit System**

The emergency exit sign system receive the exit path information and direction information from emergency exit server using available LTE and/or WiFi network connectivity. The exit sign system configured internally based on the received information from remote emergency server and display the visual exit direction sign as well as broadcast the exit information as a BLE beacon message using built-in bluetooth controller.

The people want determined evacuation path to escape from emergency condition, gets the exit information on smart device with bluetooth wireless connectivity. The smart device emergency exit application receives the BLE beacon broadcast messages and shows the routing path with direction to move based decoded emergency exit system BLE beacon message. The emergency exit application built with building emergency exit floor map to give the exact safety exit path information to the use to evacuate the building without any other personal aid.

## 4. System Implementation and Results Analysis

To evaluate the proposed system, the emergency exit sign system designed with Raspberry Pi 2 built-in with Wi-Fi and Bluetooth connectivity. The Raspberry Pi is an open source hardware used to design many electronics engineering research evaluation model. The WiFi connectivity used to connect the emergency exit server built-in with WSN sensor interface wireless connectivity to access the building environment condition and emergency exit system to configure & control according to building emergency condition. The bluetooth connectivity used to connect the people with smart device to support independent evacuation aid by individuals. The designed demo model of emergency exit sign system design shown in Figure 6.



**Figure 5. Proposed Emergency Exit System Emulation Model**

The Android based smart device application build with building emergency sign map interface to show emergency safe evacuation path aid. The smartphone based emergency sign building emergency sign map is shown is Figure 6.
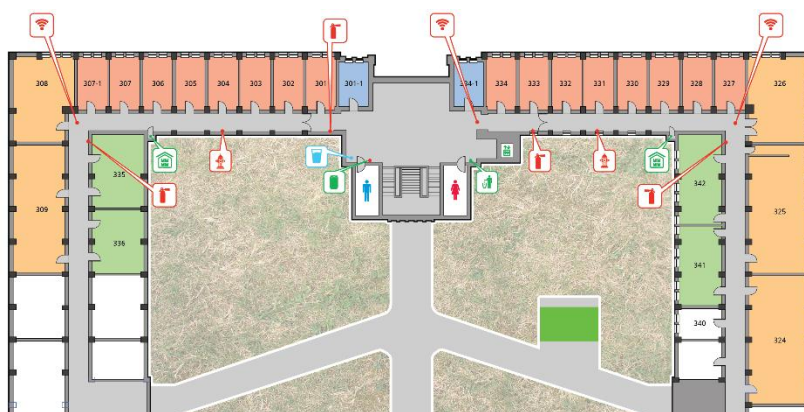
**Figure 6. Emulated Smart Device Map Interface Model**

This research shows that emergency exit sign evacuation paths during fire emergency situations on building shows that less than 60% of people determined evacuation paths depending on exit signs but the proposed approach increase the emergency exit sign evacuation paths during fire emergency situations more than 90%. In addition, user having smart dive with emergency exit application no need to lookout another human aid when the try to escape on emergency condition.

## 5. Conclusion

In this paper, the proposed emergency exit sign built with BLE enabled beacons to locate the exact emergency evacuation path and direction through smart device application. The user who measured the exit path and direction through the beacon message and map to the path on smart device with moving direction. The proposed system to guide by the emergency exit map server, which provides map information, calculates the safe evacuation route and indicating the path to the user with direction information using shortest path algorithm aided by measured building environment conditions. The path calculated using the respective drawing of the building in a portable device image view graphical information format. To make it easier to user and understand easily, the smart device drawing and path display lines are located based on the direction, and use arrows to indicate which direction of user move as well as high QoE.

### Acknowledgement

### References

[1] Kobes M., Helsloot I., de Vries B., Post J. G., Oberijé N., and Groenewegen K., "Way finding during fire evacuation; an analysis of unannounced fire drills in a hotel at night", Building and Environment, 45 (3):537-548, 2010.

[2] Choi J., "A study of the intelligent evacuee guidance of pictogram", Master, Graduate School of Urban Sciences, University of Seoul Seoul, South Korea, 2013.

[3] Kim D.-O., Mun H.-W., Lee K.-Y., Kim D.-W., Gil H.-J., Kim H.-K., and Chung Y.-S., "The development of the escape light control system", Journal of the Korean Institute of Illuminating and Electrical Installation

Engineers, 23 (6):52- 58, 2009.

[4]  Kim Y.-W., Boo J.-P., and Kim D.-H., "A scheme of active refuge guide based on Dijkstra`s algorithm, Korean Multimedia Society Spring Conference, pages 341-345, Daegu, South Korea, 2008.

[5]  Marcel Estel and Laura Fischer, "Feasibility of Bluetooth iBeacons for Indoor Localization",Digital Enterprise Computing, 2015

[6]  Meera Radhakrishnan, Archan Misra, "Rajesh Krishna Balan, and Youngki Lee, "Smartphones & BLE Services: Empirical Insights", IEEE 12th International Conference on Mobile Ad Hoc and Sensor Systems, 2015

[7]  Faheem Zafari, Ioannis Papapanagiotou,"Enhancing iBeacon based Micro-Location with Particle Filtering", Global Communications Conference (GLOBECOM), IEEE, 2015