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IoT Enabled Smart Emergency LED Exit Sign controller Design using Arduino

Joonseok Jung[1], Jongman Kwon[1], Joseph Mfitumukiza[2], Soonho Jung[3], Minwoo Lee[4†], Jaesang Cha[4]

[1]*IDO-LINK Co., Ltd, Seoul, Korea*
{redhina123, jkwon}@ido-link.com
[2]*Media IT Engineering, Seoul National University, of Science and Tech., Seoul, Korea*
mjosephpatient2010@gmail.com
[3]*IoT Research Center, Seoul National Univ. of Science & Tech., Seoul, Korea*
ppangppangsk@gmail.com
[4]*Graduate School of Nano IT Design Fusion, Seoul National Univ. of Science & Tech., Seoul, Korea*
[†]*alsdnya@gmail.com, chajs@seoultech.ac.kr*

Abstract

This paper presents a low cost and flexible IoT enabled smart LED controller using Arduino that is used for emergency exit signs. The Internet of Things (IoT) is become a global network that put together physical objects using network communications for the purpose of inter-communication of devices, access information on internet, interaction with users as well as permanent connected environment. A crucial point in this paper, is underlined on the potential key points of applying the Arduino platform as low cost, easy to use microcontroller with combination of various sensors applied in IoT technology to facilitate and establishment of intelligent products. To demonstrate the feasibility and effectiveness of the system, devices such as LED strip, combination of various sensors, Arduino, power plug and ZigBee module have been integrated to setup smart emergency exit sign system. The general concept of the proposed system design discussed in this paper is all about the combination of various sensor such as smoke detector sensor, humidity, temperature sensor, glass break sensors as well as camera sensor that are connected to the main controller (Arduino) for the purpose of communicating with LED exit signs displayer and dedicated PC monitors from integrated system monitoring (controller room) through gateway devices using Zig bee module. A critical appraisal of the approach in the area concludes the paper.

Keywords: *IoT (Internet of Things), Humidity sensor, glass break sensor, smoke detector sensor, ZigBee, emergency exit signs, LED, Closed Circuit TV (CCTV).*

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Corresponding Author: alsdnya@gmail.com
Tel: +82-02-970-6431, Fax: +82-02-970-6123
Graduate School of Nano IT Design Fusion, Seoul National Univ. of Science & Tech., Seoul, Korea

1. Introduction

An emergency exit signs play the main role for infrastructure and consists of regular and special exit signs for emergencies that are combined to allow for faster evacuation and safety. Most of emergency exist sign systems lack the ability to respond to a changing dangerous environment or to attract the immediate attention of people needing guidance for exiting [1]. The passive nature of the emergency exit sign system designs has contributed to the casualties of avoidable deaths in fire and other emergencies as remarked to the various cases. The potentiality of the current system design of emergency exit design, to be overlooked or to send people into harm's way makes the people inherently unreliable which they are intended [2]. As solution for current and next generation technology for emergency exit signs, this paper propose IoT based system design that can added to the existing system where by IoT enabled technology can be applied with LED to avoid the tragic consequences and incidents as have highlighted in many case.

Recently IoT technology raises significant challenges that could stand in the way of realizing its potential benefits in various domains [3]. It refers to scenarios where network connectivity and computing capabilities extends to objects, sensors, and everyday items normally considered as computers allowing these devices to generate, exchange and consume data with minimal human intervention. Nowadays, IoT is adopted into much more application scenarios, including the recent trend of combining IoT with cloud computing that will bring in new challenges to the improved and high-performance systems to build the smart infrastructures [4] [5]. IoT related sensors used for implementation of smart emergency LED exit sign, play the key important role to enable IoT technology for this particular case [4]. Smart sensors, including radio frequency identification (RFID) identify items or event, locate them and determine their environmental conditions information useful for main microcontroller to trigger the alarms and to light up the LED exit signs. Thus can provide real-time, optimal direction to building occupants during an emergency evacuation as well as the process management of historical records.

The wireless data communication sensed by various sensors in the system, is designed to operate in compliance with the Zig Bee module, and the signal processing on sensed data is made by the microcontroller through a self-adaptive weighted data fusion algorithm [6]. Considering the features of LED lighting such as remotely controlled and self-learning mode, LED lighting system can match to the smart emergency exit sign system. As a microcontroller based LED exit signs lighting system, it is operated in such a way that the aim of intelligent system as well as energy saving. In a compliance with IEEE 802.15.4, Zig Bee is a short range, low power, communication protocol with a low transmission rate between 10 and 250 Kbps which is narrow band but a low cost transmission protocol [7]. With the master/slave features, it provides bidirectional data transmission. Thus feature is useful for the proposed smart emergency exit sign system whereby the status of sensors can be transmitted and monitored from controller room. Zig Bee operates in three authorized frequency bands such 2.4 GHz ISM, 915 MHz and 896 MHz bands. It lays down a communication protocol for wireless lighting control and its features are stated as follow;

- Particular to smart emergency LED exit signs case, the operations of LED exit light signs switching and sensors are stipulated for product compatibility
- Based on flexibility of Zig Bee-based lighting control network, any controller or LED exit sign can be added or muted from a network by using a Zig Bee network coordinator [8].
- The Zig Bee technique is expected to dominate the future trend of wireless system development in short range, and applications that extended with ease into smart infrastructure automation.

2. Related work

The project entitled “Gateway project”, which ran from November 2011 to October 2014, was undertake to develop and demonstrate an innovative emergency signage system. The research conducted by Fire Safety Engineering Group (FSEG) concerning way-finding behavior during a simulated emergency evacuation demonstrated that most people have difficulty perceiving and hence utilizing signage information [9]. As shown in figure 1 of the implemented intelligent active dynamic signage system (IADSS), some people perceive the standard (green running man) emergency exit sign positioned directly in front them. While most other people are blind to standard emergency exit signs due to learned irrelevance in which being continuously displayed without ever needing to use them [5] [10], that influence the brain to ignore the signs.

Figure 1. Implemented ADSS within the standard green running man exit sign

3. Proposed system design and architecture

IoT enable smart emergency LED exit signs using Arduino is proposed in this paper in order to upgrade the existing emergency exit sign system to make more sensitive, noticeable and more effective to direct individuals away from the dangerous area and could effectively drive them along the intended route. The system consists of sensors (Fire detector sensor, smoke sensor, glass break sensor, humidity sensor), Microcontroller (Arduino), Alarm, LED patch display and LED down light, Zig Bee (Pro Bee ZS10) modules and PC monitors. The overall system design architecture is illustrated in figure 2.

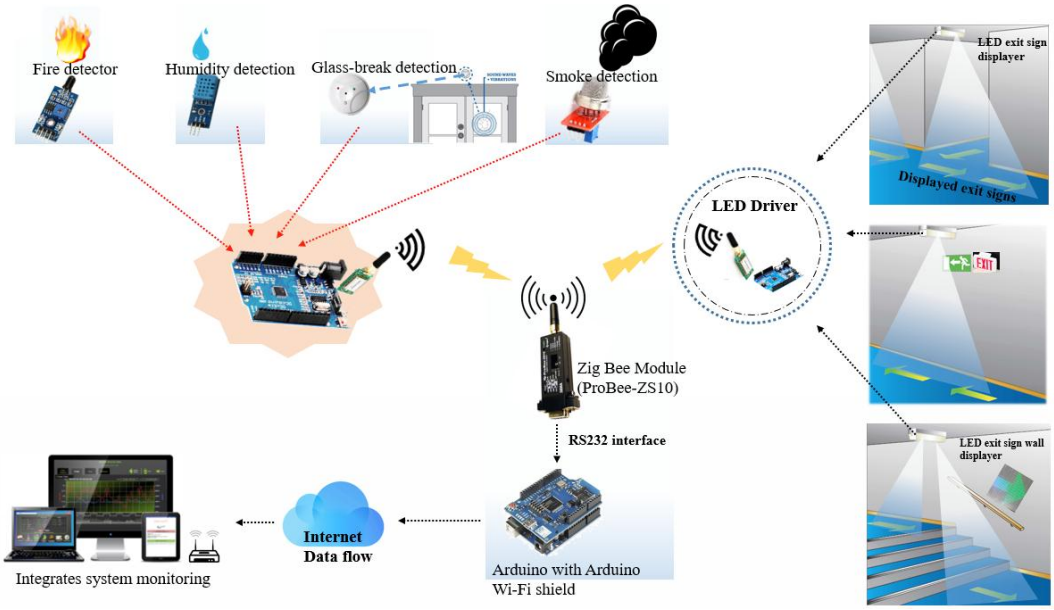

Figure 2. IoT enabled Emergency LED Exit Sign, System Design Architecture

3.1. Features of the system design architecture

The Above mentioned system design architecture, have made significant contributions to the existing emergency exist sign by developing of IoT enabled smart emergency LED exit signs controlled by the Arduino. However, the emergency exit signs related works were mainly focused on the detection rate for emergency exit signs, the results show that only 76% of the individuals detected Active Dynamic Signage System (ADSS) with 80% of them following the guidance offered by the exit signs [11]. Compare to the upgraded system design of IoT enabled smart emergency exit signs displayed using LED and controlled by Arduino, an increase of 97% in detection rate as well as in guidance capacity is proven. The individuals required an average of 0.5 to 1.0 seconds to decide on a route for exiting while for the previous ADSS based designs system the participants required an average of 1.8 s to decide the route [2] [10] [12] this shows the quality of the system design is improved significantly. The main key point in this system design is that the exit signs are dynamic and displayed depending on the information form the sensors in real time processing and it controlled which increases the reliability of the system. As nowadays IoT technology based smart infrastructure is growing up fast the proposed smart emergency exit signs system design controlled and monitored could be more noticeable as well as increase the level of safeness of the infrastructures.

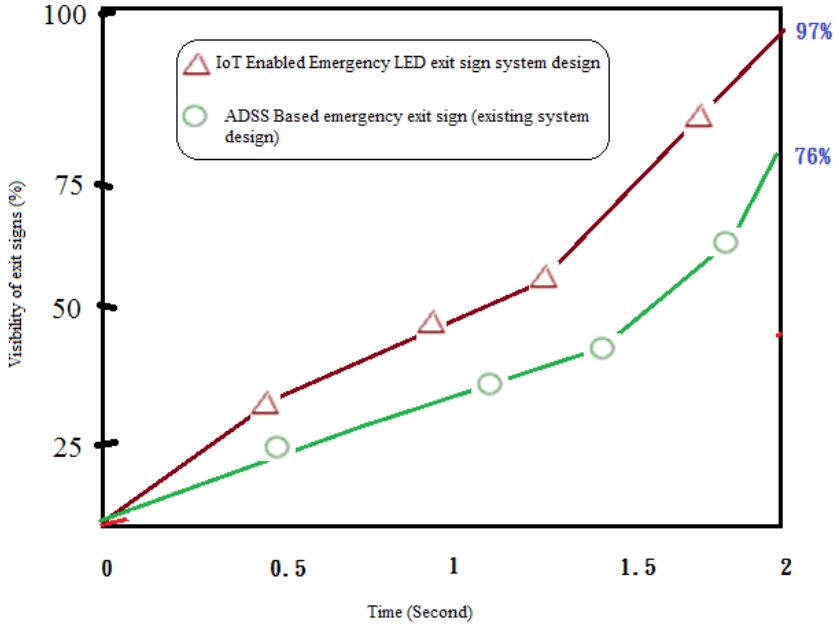

Figure 3. Emergency Exit Sign Visibility Performance

3.2. Description and limitation of the system design

The system design architecture shown form the figure 2 describes the upgraded smart emergency LED exit signs based on IoT enabled technology and controlled by Arduino. Such as IoT in general sense is a network that consists of a variety of things or objects, from the system architecture, the information about the environment status is sensed and collected by various sensors presented in the system are directly interfaced with Arduino that will trigger the related emergency exit sign to the related LED display. At the same time that information from the sensor is received to the PC server monitors (control room) which have the main task of manage, control and monitor system components. Thus enables hardware interface modules to successfully execute their assigned task. In this case an emergency response system comprises a group of objects that communicate with each other to form an ad hoc object network, which is connected to the

infrastructure network through gateway devices using Zig Bee modules. In addition, Closed Circuit TV (CCTV) camera can be added to the system to provide the visual information from field to monitoring system.

The system design of IoT enabled smart emergency LED exit sign using Arduino, have made a significant contributions to the design and development of emergency exit sign system whereby can provide various information to rescue individuals not only fire related disaster but also other harmful events related to the types of sensor used in the system. However Zig Bee based module gateway devices used from design can operate in short range of communication.

3.3 Description of Hardware implementation

The test proof of the concept, low cost and off the shelf electronics hardware is used to implement the test bench in order to confirm the performance of the system. The Arduino Uno and Arduino Wi-Fi shield are used to implement the gateway that interfaces sensors connected with Arduino and Zig Bee module. The Arduino Uno is an open source microcontroller that uses ATmega 328/ATmega 2560, an Atmel AVR processor which can be programmed by the computer in C/C++ language and the program loaded to the Arduino via USB port. Arduino Uno has on-board both analog and digital pins for input and output operations and supporting SPI and I2C that is used to interface with sensors and other devices [13]. The Arduino Wi-Fi shield module acts as a bridge to connect the gateway to the sensors with Arduino and Zig Bee and the PC monitor to the LED exit signs displayers.

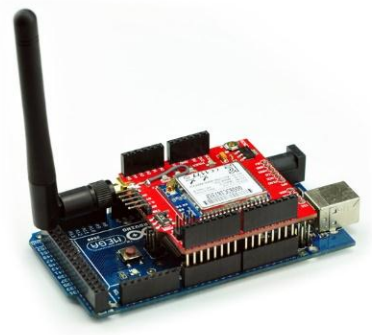

Figure 4. Designed Emergency Exit Sign Harware

The hardware implementation presented is flexible and can be extendable with other devices such as alarm devices, closed circuit TV cameras and others, to be seamlessly integrated with minimal changes.

4. Conclusion

The work presented in this paper, is validated as a very effective approach to the performance upgrade of IoT enabled emergency LED exit signs by using Arduino under various circumstances harmful for people such as fire detection, glass breaking detection, humidity detection, temperature detection so that identifying the optimal evacuation route. From the results of implanted test proof, the optimal evacuation route to the safety was selected and presented from the controller within 19 seconds (maximum). The main concept of this work, is to make emergency exit signage not only more conspicuous but also more likely visible and reducing the time people spend in way finding them.

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