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INDOOR TRACKING PERSONNEL FOR RFID WITH FPGA

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ABSTRACT

These days, tracking has become one of the most important issues dealing with public security, and the term has been used is Global positioning system (PGS). In order to track personnel anytime within a building, an indoor localization system is required. It should at least able to know the current location of the personnel in terms of floor level or room location. Besides, it should be able to track the movement direction of personnel inside the building. This indoor localization system should be a real-time system that has minimum response time to get the location information and easy accessible by users. Quartus Prime 15.1, Arduino IDE 1.8.1 and Android Studio are used in this project as development CAD tool. The system is implemented on FPGA DE1-SoC board by integrating with WiFi modules and Radio-frequency Identification (RFID) system. The system has the ability to add new client data onto FPGA memory for next time tracking purpose. The localization information can be obtained by accessing the mobile application where someone can key in the client name, employee ID or floor number to get the corresponding result. Moreover, the designed system achieved high operating frequency up to 1.6GHz and on chip resources of 188 logic elements and 143 registers.

Keywords: RFID, FPGA system, mobile application, DE1-SoC, tracking, NodeMCU.

INTRODUCTION

In order to track personnel anytime within a building, an indoor localization system is required It should at least able to know the current location of the personnel in terms of floor level or room location. Besides, it should be able to track the movement direction of personnel inside the building. This indoor localization system should be a real-time system that has minimum response time to get the location information and easy accessible by users.

At present, indoor localization system can only be used to track a person's location at one time. The directionality of a personnel's movement cannot be recognized by the system. This will cause less characteristic of the localization system as user may not able to know whether the personnel are just entering the area or leaving the area. Hence, the indoor localization system is no capable for extra feature except for tracking personnel within building. Besides, there has no mobile application designed for everyone in the building to access to the system for searching a personnel's location and track his last stayed location simultaneously.

Thus, for the purpose of improving current indoor localization system, an indoor localization system with the ability to track the directionality of personnel's movement with easy search function by anyone concurrently instead of just tracking a person's location at one time is strongly recommended.

RELATED WORK

The fundamental of field-programmable gate array (FPGA)

According to [3], FPGA is defined as a re-configurable hardware platform which composed of configurable logic blocks and interconnect. FPGA consists of the main features which are flexibility and easy development. FPGA is suited for hybrid system implementation because its availability of soft-processor cores in form of RTL implementations [3]. There are composition of processor framework and programmable logic on a single chip of the latest FPGA architectures.

FPGA development flow

The first step for designing an FPGA is to design an entry. The design functionality is specified by utilizing instruments for instances Hardware Description Languages (HDLs), schematic entry or utilizing a high level block diagram technique such as Simulink [3]. After that, the design is compiled to determine the available of syntax errors and later simulated to evaluate the functionality of the design. Debugging is needed if the design does not meet the functional requirements, otherwise a timing-intensive simulation can be run. After both requirements which are functional and satisfied timing are met by the design, the bitstream can be downloaded onto the FPGA [3]. Figure-1 shows the high-level view of the design flow in implementing FPGA.

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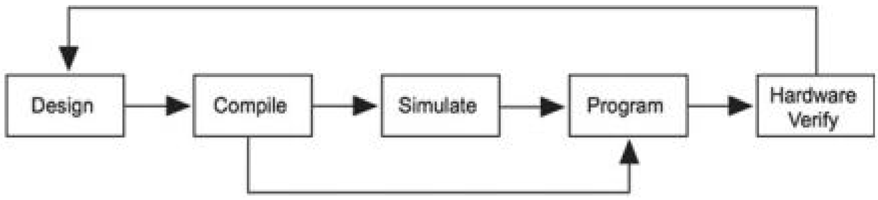

Figure-1. High-level view of FPGA design flow.

Phase locked loops (PLLs)

A PLL [4] is defined as a closed-loop frequency-control system based on the phase difference between the input clock signal and the feedback clock signal of a controlled oscillator. Figure-2. illustrates the main blocks that made up the PLL which are phase frequency detector (PFD), charge pump, loop filter, voltage controlled oscillator (VCO) and various types of counters for instances feedback counter (M), pre-scale counter (N) and post-scale counters (C) [4].

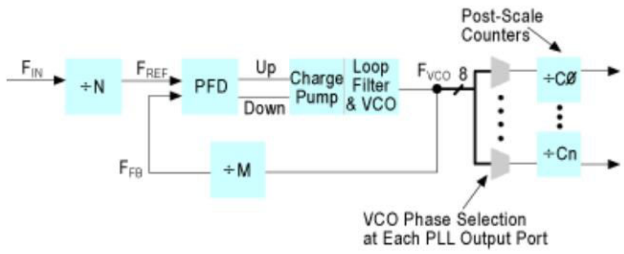

Figure-Fehler! Kein Text mit angegebener Formatvorlage im Dokument.. Simplified block diagram of major components in PLL [4].

The rising edge of the reference input clock is aligned by the PLL to a feedback clock by utilizing the PFD. On the other hand, the duty-cycle that designed by the user will be used to identify the falling edges. The difference evaluated by the PFD between the reference clock and feedback clock will be utilized to generate logic high or logic low control signal depends on the phase-lag or phase-lead by the feedback frequency to the reference frequency.

After that, the control signal will be passed to a charge pump in order to differentiate the signals that are needed the current to be sent to a loop filter. Current will be passed to loop filter when there is a logic high control signal received by the charge pump, otherwise the current will be drawn out of the loop filter. Furthermore, the signals that used for biasing the VCO are converted into control voltage by the loop filter. The VCO will oscillate at different frequency according to the control voltage received. From other point of view, the frequency of VCO oscillations is higher if the PFD sends out a logic high control signal to the next stage, otherwise, vice versa.

The VCO will be stabilized if the phase and frequency of the reference clock and feedback clock are the same. The jitter will be filtered out by the loop filter through the removing of glitches from charge pump and the voltage over-shoot can be prevented [4]. Divide counter (M) is used to increase the VCO frequency in order to make the VCO frequency over the input reference frequency. Besides, the PDF input reference clock (F_{REF}) will cause the feedback lock (F_{FB}) that applied to the other PFD input to be locked. A harmonically related output frequency will be produced by the feeding the post-scale counters with VCO output. The calculations involved are shown as below equations.

$$F_{REF} = \frac{F_{IN}}{N} \qquad \text{Equation (1)}$$

$$F_{VCO} = F_{REF} \times M = F_{IN} \times \frac{M}{N} \qquad \text{Equation (2)}$$

$$F_{OUT} = \frac{F_{VCO}}{C} = \frac{(F_{REF} \times M)}{C} = \frac{(F_{IN} \times M)}{(N \times C)} \qquad \text{Equation (3)}$$

where:

F_{VCO} = VCO frequency
F_{IN} = Input frequency
F_{REF} = Reference frequency
F_{OUT} = Output frequency
M = Multiplication counter, part of the clock feedback path
N = Division counter, part of the input clock reference path
C = Post-scale counter (divider)

Design and challenge of various types of indoor localization and tracking system

Indoor localization and tracking of personnel have become as a popular research topic recently as people spend most of their time mainly within a building such as house or working office. Furthermore, the implementation of indoor localization and tracking system will be useful for monitoring and management purposes. There are various types of technologies have been developed for the purpose of tracking and localizing personnel within a building with their advantages and disadvantages present respectively. Thus, in this section, a number of indoor localization and tracking methods will be discussed in terms of implementation method, benefits and drawbacks.

Indoor tracking personnel by using infrared beam scanning

Infrared (IR) beam sensors are a basic approach to distinguish movement. They function by having an emitter side that conveys a light emission of undetectable IR light by human, at that point a receiver opposite the route which is also delicate to that same light. In this paper

[5], a brand-new infrared beam scanning sweep method is proposed in order to browse a room for user by depending on the coded infrared beams. A class of infrared emitting diode that embedded with the transmitters respectively which are divided by directional reflectors is used to establish the infrared beams.

These infrared emitting diodes (IREDs) structure zone framed light emissions of infrared light over the room. The position of the zone relies upon which IRED is transmitting [5]. The location of a people can be resolved precisely by interpreting the zones accepted by the individual equipment (collector). This data is then sent to a personal computer (PC) for computation and graphical portrayal of the individual's position. A representation of tracking a client in a room by methods for coded laser shafts from a point source is presented in Figure-3.

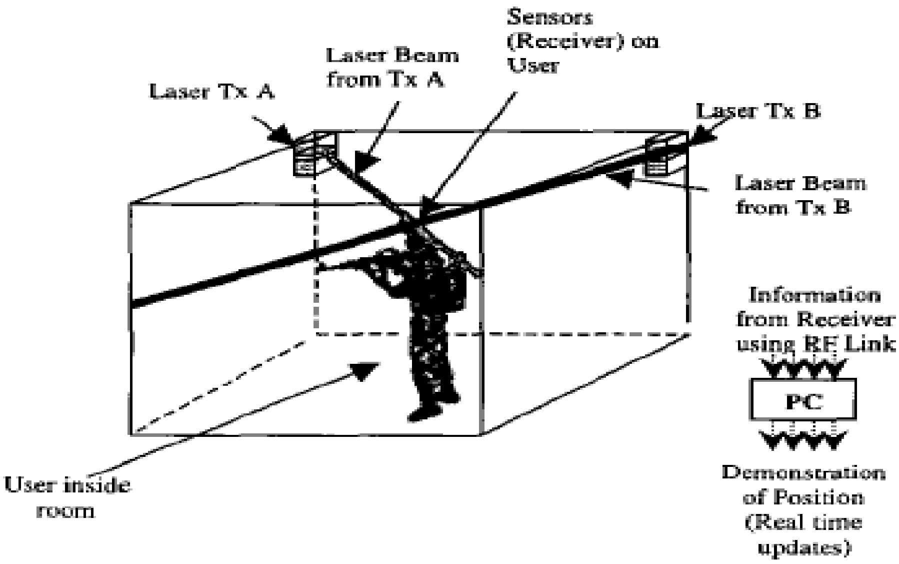

Figure-3. Illustration of positioning a client by utilizing coded laser beams[5].

According to Figure-3. two transmitters are attached in two neighbouring corners of the room and the recipient unit is situated on the client. The position of the client is given by the cut off mark of shafts from the transmitters. The computation for the location is executed by a PC by utilizing the information acquired from the recipient unit, for example, reports of those shafts collected at every player. Once the location of a particular individual can be retrieved precisely, the PC programming can be stretched out to pinpoint others in numerous rooms [5].

Implementation of IR in indoor tracking system

The theoretical of tracking a client in a room by utilizing infrared shafts is shown in Figure-4.

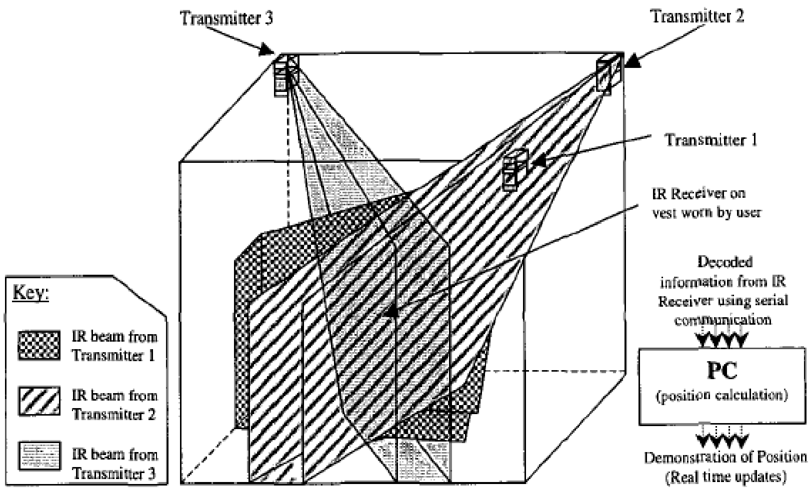

Figure-4. Theoretical layout of presenting triangulation method in 3D to retrieve client's location in a room[5].

Infrared beam scanning sweep method

First of all, the coded infrared shafts are emitted from the transmitters that have attached at the corner walls. Then, the recipient hardware on the client will collect the shaft if there is people within the room. The retrieved data is decrypt and communicated to the PC [5]. For the reasons of this tracking framework evolution, a long serial connection has associated the User with PC. Matlab is used to computing the client's location based on the codes collected in 250ms time frames. The people's location can be shown in 2D/3D forms by utilizing Matlab Graphical User Interface (GUI) after computing the cut off points of shafts from various transmitters.

Localization of client

Coding of infrared beams[5]:

During the infrared emitting diodes are provoked by voltage pulses, the laser shaft will be emitted. Only a restricted scope of pulse widths can be retrieved or determined by the collector on the client therefore the laser shafts which are coded with pulses can be decrypt by the recipient unit accurately. Each beam will be designated with specific code in order to differentiate the infrared shafts. The coded data through pulse position modulation (PPM) is consisting of a start bit, transmitter ID code, port code and IRED beam code 5]. The start bit demonstrates the begin of a code, the transmitter code shows which transmitter unit the shaft is discharged from, the port code determines the dynamic port on the microcontroller that is utilized to stimulate the power diode and the IRED code shows precisely the diode whose shaft was recognized by the client. The port code is comprised as intrinsic of coding the shafts to empower more IREDs to be added to each current transmitter unit.

Infrared beams decoding [5]:

Once the start bit of coded shaft is determined, the timer is initialized in order to evaluate the distance between the start bit and the start bit of following pulse. Then, computation is executed in microcontroller first when the pulse and compartments between pulse are recognized to figure out the received code that indicating the received shaft. Furthermore, the location of client can be determined and shown on monitor after the recognized shaft data is being transmitted to PC through serial communication.

Calculation of POSITION [5]:

The diverse shaft discrepancy angles and the uneven compartment between the infrared emitting diodes are considered by aligning the beams. The procedure includes the deciding of point coordinates on each boundary of each shaft. Along these lines, each shaft has to collect the coordinates of two points. Each transmitter unit has to made alignment at least once to avoid distraction by cause of the shaft from different transmitters. Two points which are one of them is gained when a specific code is started to be acknowledged by the recipient unit and another of them is collected when there is no code to be received, are collected from every shaft and transmitters. After the alignment results are sent to the PC, location computation can be evaluated.

Various calculation techniques can be used however some of them are ineffective or inaccurate. Thus, line equations are selected to calculate the cutoff point of the shaft received. When observed from tip of room the shaft will be arose as lines. A particular line has to be retrieved in the computation mechanism to estimate and denote the amount of shafts collected by individual hardware from each transmitter. The mean of the coordinates of the calculated cutoff points is computed to determine the location of client. If only one shaft has been received, the shaft will be summed up together with the previous position and get the new cutoff point then the mean of coordinates of points is evaluated to estimate the client's location.

Wall unit

A cone formed shaft is composed by infrared emitting diode with discrepancy angles of 30^o. Yet, confined shafts with utmost vertical discrepancy are needed to facilitate the calculations for retrieving the location of client in the room as shown Figure-5.

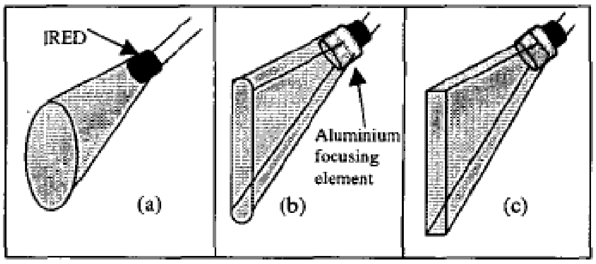

Figure-5. Beams from IRED, (a) Without focusing component, (b) Beam shape with focusing component used, notice the rounded upper and lower end boundaries, (c) Beam shape used for computation – flat boundaries.[5]

Benefits and drawbacks

The main benefit of implementing infrared beam scanning technique for indoor localization and tracking system is once in stated, the position of people can be ascertained rapidly with a basic rationale calculation. Besides, the transmitters are not needed to be associated with the PC as the data is transmitted to the PC by particular hardware only which is IR receiver, therefore simple installation is implemented. The drawbacks of utilizing infrared in an indoor localization and tracking system is there is a probability of weakened achievement in the existence of direct sunlight. In addition, there is possible perceptivity of transmitters inside the room where the client is put on night vision accessories.

With my project of using passive RFID reader and tags, the limitations of using infrared can be overcome because the data transmission between RFID reader and tag is not in form of laser but is based on radio frequency so the transmission is invisible at whatever situation. Moreover, the performance of RFID reader and tag will

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not be affected by the presence of sunlight which may cause the infrared laser used for the project discussed above to be interference.

WiFi fingerprint technique

WiFi fingerprint method is one of the well-known approach to be implemented in an indoor localization system. Location fingerprinting [2]is a method used to pinpoint the position of client by distinguishing the radio signal ambience of the client. The procedure can be classified into three stages as following.

A. Stage 1

This stage is described as alignment stage, offline stage or training stage. In this stage, every reference spot's location is linked to a fingerprint that retrieved from received signals features in order to build a radio plan. Among the signals characteristics, Received Signal Strength (RSS) calculation is the utmost technique utilized for indoor localization system. It is denoted as the strength of RF received signal and utilized for appraising the signals nature.

B. Stage 2

During this stage, locating algorithm is produced to accord online calculation with the pre-recorded radio plan [2]. There are various types of approaches to be used for creating positioning algorithms such as deterministic approach, probabilistic approach, K-nearest-neighbour (KNN), artificial neural networks, support vector machine (SVP) or their combinations [2].

C. Stage 3

This is the stage where the client's location can be determined by implementing the positioning algorithm. The Figure-6. following depicts the overall layout of fingerprinting based positioning.

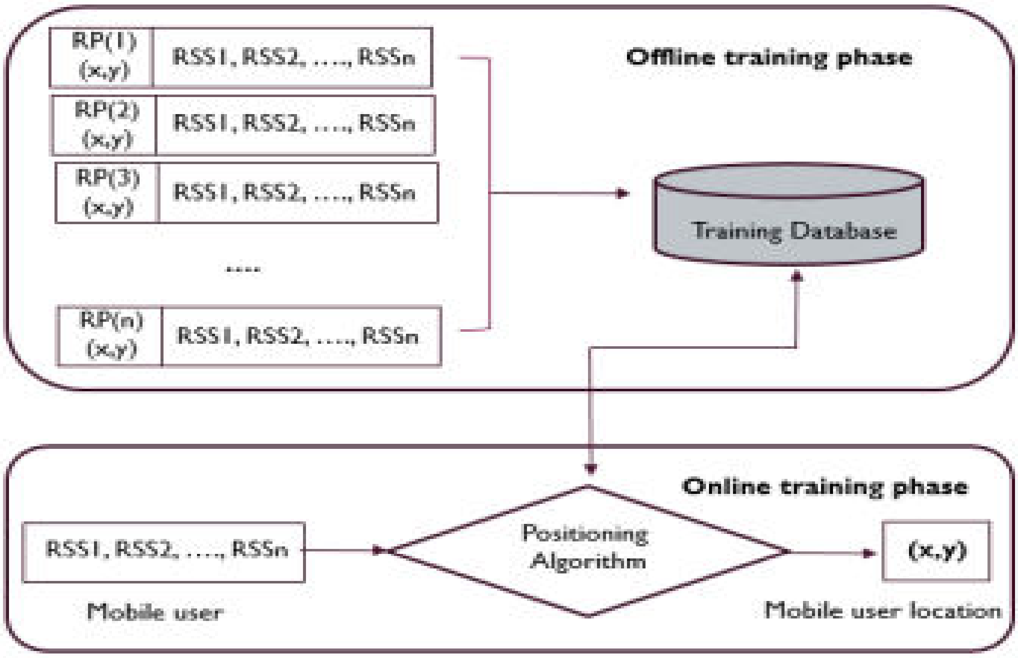

Figure-6. Fingerprinting based positioning [2].

Benefits and drawbacks

The benefit of utilizing WiFi fingerprinting approach in the localization system is that line-of-sight evaluation of access points (APs) is not required thus the coverage area for positioning is greater compared to other technologies that require line-of-sight. This is because of without pre-known the real AP locations, none of the distance or angle calculation is required in WiFi fingerprinting approach, which may lead to high practicability in the indoor localization system [6].

In contrast, WiFi fingerprinting approach has its deficiency in establishing an indoor localization system. It needs harsh, time consuming database creation procedure and interference from human [2]. Furthermore, RSSI is sensitive to environmental changes such as multipath issue and temporal intervention, for instance, human movements, door switch problem and also the chronical changes such as light divergence, humidity and weather circumstances [7].

By using passive RFID readers and tags, the collection of data will not be affected by natural environmental changes such as light variation and et cetera, in addition, with the small coverage range of the RFID readers, there will be absence of coverage interference with others readers or factors. Furthermore, the data collection is done by four times faster through WiFi modules to the processing unit, FPGA with the implementation of Phase Lock Loop (PLL) which can increase the clock frequency based on requirements.

Lightweight indoor localization system by using simultaneous localization and mapping (SLAM) approach

According to [8], an indoor localization system is proposed by implementing a simple WiFi-based approach with low computational complexity and does not require any extra specific groundwork, map or internet connection. The system is basically depending on IEEE 802.11 Received Signal Strength Indicator (RSSI) values, a dead reckoning module to accumulate walking path and graph-based technique in order to construct and represent a sensor map later. The only hardware needed is the smartphone as it composed of variety of sensors that need no complex calibration steps and possessed by people nowadays.

By using SLAM approach, time and cost saving are achieved as both localization and mapping are done without an isolated start up stage. Prior site survey for data collection on the indoor space is not required as the survey is done when users are utilizing the system within the building with their device on hands. Therefore, users can able to be localized simultaneously regarding an indoor floor plan (if show) or to the ways that they have gathered. Even though the WiFi access points (APs) are needed to be in place, but there is no requirement from accessing to internet or utilizing extra groundwork for the system [8].

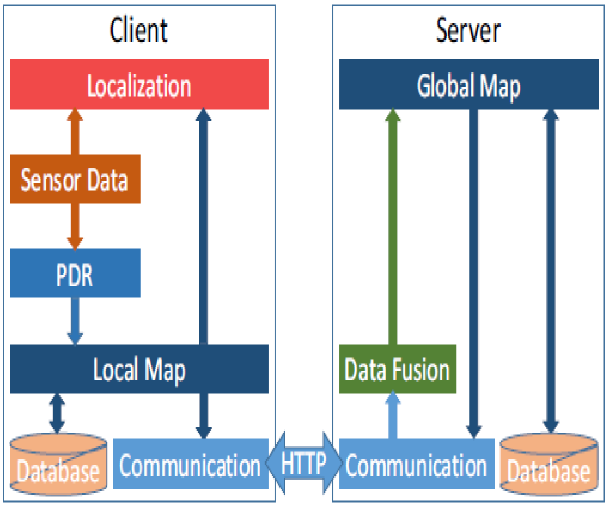

Figure-7. System overview. The sensor data that collected by the user will be utilized as input for localization and to amend the local map constantly. When there is connection being established between the local map and the server, the local map can be merged with global map that build by other users.[2].

The system can be either utilized as classical client-server architecture as shown in Figure-7. or utilized as client architecture on the left part of Figure-8. For both client-server or client architecture, the sensor data will be firstly accumulated through the Pedestrian Dead Reckoning (PDR) module in order to obtain the step counter value, step length and the orientation [8]. The RSSI data of vicinal APs for every step is collected and saved. After that, user may able to update the local sensor map of regarding area by using the information collected. Later on, the accessible information is consolidated through the local sensor delineate and just a small amount of the deliberated information is saved, this phenomenon is known as Clustering and Merging**.** After every step information is accumulated, the localization algorithm is implemented so the best corresponding coordinates of local sensor map are sent back to user, this step is known as Localization [8]. In case of building client-server connection, the local sensor map can be merged together with global sensor maps that contributed by other users through the communication between user and server over HTTP and map data exchange.

Benefits and drawback

The benefit of this project is the capability of the proposed localization system to be embedded to difference devices such as smart glasses. This is due to the proposed system is utilizing simple SLAM approach to build the local sensor map and it is able to fuse with global sensor map when it is connected to a server. Besides, the lightweight localization system can still collect data from the walking paths of users to create sensor map to be used in localization system even though there has no internet connection [8].

On the other hand, although the local sensor map can be merged with global sensor map for sharing of the localization information, however there is no capability of quick searching on the current location of a personnel. The deficiency of system can be improved in my project by designing an Android application with quick search function that able to get the current location information of the personnel easily and efficiently.

FM based indoor localization and mapping system with real-time implementation on FPGA

An indoor localization and mapping in terms of real time which is using FM and ASK wave transceivers that are implemented by using Phase Locked Loop (PLL) and Field Programmable Gate Array (FPGA). Three FM transmitters are tuned at different frequencies in order to acquire localization. The object locations which obtained from solving the family of circles for a common point where the radius of each circle represents “Received Signal Strength Indicator” (RSSI) are installed with customized FPGA core and three FM receivers tuned to transmitter frequencies respectively. FPGA procures and processes RSSI values received from the FM receivers via three parallel I2C buses which are providing real time response after resolving into four bit digital values [9].

FM based hardware implementation system for indoor localization and mapping is cheaper and power efficiency, furthermore there is less affected by multiple-path fading and a high gradient of signal attenuation which is essential for short distance accuracy is provided. Besides, FM signals are easier to penetrate solid objects if compared to WiFi or GSM and more flexible to human intervention. Thus most of the small indoor objects are translucent to FM waves due to its wavelength of 3 to 5

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meters. The FM based indoor localization system with hardware implementation on FPGA is using primitive wave transmitters and receivers which is designed for parallel data procurement with less alteration from real time response.

Three transceiver modules which consists of FM transmitter and ASK wave receiver are the low cost integrated circuits to be planted on each sub regions of an indoor region with dimensions 70m x 70m. Object can only exist in one of the sub regions in a particular time therefore ASK receiver is used to trigger the set of three transceiver modules simultaneously. The object can be localized in the whole test area if the object is localized in any sub region without using the rest of transceiver modules in the remaining sub regions. This condition is helpful in preventing unwanted continuous FM waves emission and making power efficient system.

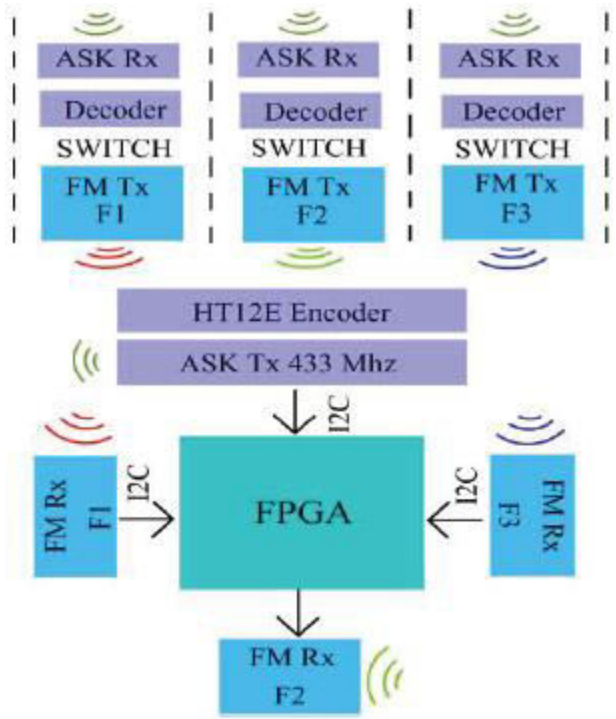

Figure-8. System block diagram[9].

Any three of the ASK wave receiver are selected by 12 bits digital code produced by FPGA, thus activate FM transmitters that correspond to them. Three RSSI values are processed by FPGA core via parallel I2C data buses simultaneously to achieve real time response with minimum dormancy by accelerating the system. FM signal strength is achieved by using TEA5767 FM receiver module which is a versatile low power peripheral SoC as shown Figure-8. Three FM modules are responding to three different FM transmitter frequencies where the transmitters are connected to ASK receiver which is controlled by onboard ASK transmitter that interfaced to the processor core.

I2C core is implemented on the FPGA processor to having interface with the TEA5767 and the I2C cores are accommodated for parallel data procurement. Thirteen bit of PLL frequency parameter is used to determine the tuning frequency of TEA5767 by using the formula below:

$$\text{PLL frequency} = \frac{4(\text{frequency}*10^6+225000)}{32768} \qquad \text{Equation (4)}$$

The configured TEA5767 returns 5 bytes word the upper nibble of fourth byte composes of RSSI value that will be conveyed to the FPGA processor core. Accelerated data acquisition is provided with decreasing of latency for real time response.

In brief, FM based technique theoretically has better performance compared to other techniques used due to its simplicity and inherent characteristics. Therefore, inexpensive resources are used to build a hardware setup in order to demonstrate the application and to estimate the accuracy and precision of the technique. The method of using ASK transmission to control FM transmission is set up alongside in order to avoid unnecessary EM radiation. From the perspective of disadvantage, in order to improve the result gained, the number of transmitters needs to be increased, however the computation power cost will also be increased. In contrast, by using passive RFID technology, the computation power needed is lower because it only be activated when there is a tag scans on it, power wasting can be avoided thus cost saving is achieved.

Researched technologies used for indoor localization system

Based on the researches that have been done, the advantages and disadvantages of the technologies that have been used for indoor localization system are tabulated into Table-1.

Table-1. Comparison of current used technologies for indoor localization system.

Author	Technique/ Technologies used	Advantage	Disadvantage
S. Sayeef, U. K. Madawala, P. G. Handley, and D. Santoso, "Indoor personnel tracking using infrared beam scanning," PLANS 2004. Position Locat. Navig. Symp. (IEEE Cat. No.04CH37556), pp. 698–705, 2004.	Indoor Tracking Personnel by Using Infrared Beam Scanning	Once instated, the position of people can be ascertained rapidly with a basic rationale calculation. Transmitters are not needed to be associated with the PC	Probability of weakened achievement in the existence of direct sunlight. There is possible perceptivity of transmitters inside the room where the client is put on night vision accessories.
L. R. S. L. Systems, "The Next Generation in Personnel/ People Tracking," no. october, pp. 122–124, 2017.	Real-Time Locating Systems (RTLSs) by Using Active RFID Technology and BLE Techology	Manually scan tag is not required. Short link radio transmission is used instead of wired connection.	Active RFID readers and tags are expensive and not usage efficient. Flexible hardware architecture is not available in this system.
C. Basri and A. El Khadimi, "Survey on indoor localization system and recent advances of WIFI fingerprinting technique," Int. Conf. Multimed. Comput. Syst. -Proceedings, pp. 253–259, 2017.	WiFi Fingerprint Technique	Line-of-sight evaluation of access points (APs) is not required. None of the distance or angle calculation is required in WiFi fingerprinting approach, which may lead to high practicability in the indoor localization system.	It needs harsh, time consuming database creation procedure and interference from human. RSSI is sensitive to environmental changes and chronical changes.
M. Bace and Y. A. Pignolet, "Lightweight Indoor Localization System," Proc. - 2015 8th IFIP Wirel. Mob. Netw. Conf. WMNC 2015, pp. 160–167, 2016.	Lightweight Indoor Localization System by Using Simultaneous Localization and Mapping (SLAM) Approach	Capability of the proposed localization system to be embedded to difference devices. Utilizing simple SLAM approach to build the local sensor map and able to fuse with global sensor map when connected to server. Data collection is still available even though there has no internet connection.	No capability of quick searching on the current location of a personnel.
A. Dubey, A. Kulkarni, A. Paras, and A. Deole, "FM based indoor localization and mapping system with Real-time implementation on FPGA," vol. 1, pp. 176–181, 2015.	FM Based Indoor Localization and Mapping System with Real-Time Implementation on FPGA	Better performance due to simplicity and inherent characteristics. Inexpensive resources are used to build a hardware setup. Unnecessary EM radiation is avoided.	Number of transmitters needs to be increased to improve the result obtained, however the computation power cost will also be increased

SUGGESTED METHODOLOGY

Integration of WiFi module with RFID readers

By referring to online open source on pin assignment between RFID MFRC522 reader and NodeMCU V3 WiFi module, the connection circuit is built as shown in Table-1. and Figure-3.8. Then, the example Arduino coding which is get from GitHub is modified in order to suit with the project's requirement, to read two byte data from RC522 card. The code is flashed into NodeMCU V3 as the firmware to carry out the activity. The output can be monitored through the serial monitor of Arduino IDE 1.8.1 or Pcomm emulator as shown in Figure-9.

Table-2. Wiring connection between RFID reader and NodeMCU.

NodeMCU	MFRC522
D1	RST
D2	SDA
D5	SCK
D6	MISO
D7	MOSI
GND	GND
3V3	3V3

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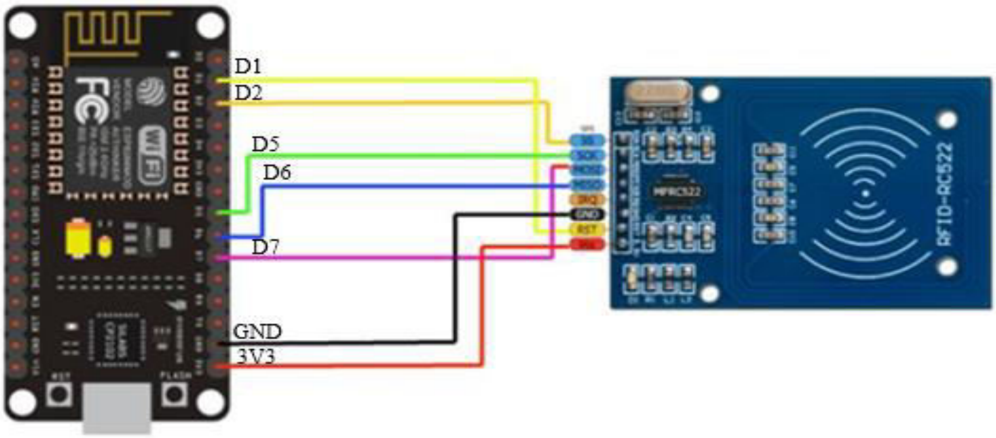

Figure-9. Connection circuit of RFID reader and NodeMCU V3 WiFi module.

Integration between NodeMCU V3 WiFi

A. Modules and FPGA board

FPGA board (DE1-SoC) uses UART interface to communicate with NodeMCU through the wiring mapping shown in Figure-10. There are two NodeMCU V3 WiFi module are connected to the GPIO pins of the board. One of the NodeMCU sends data through the TX pin to the GPIO_1 [0] pin on the DE1-SoC board which acts as RX pin from the FPGA side. On the other hand, RX pin of another NodeMCU is able to receive the data sent from FPGA through GPIO_0 [1] which acts as TX from FPGA side. An UART module is designed in FPGA to make a communication with the NodeMCUs. During the receiving process, a logic high data valid signal is triggered to indicate the received data is ready for processing. In contrast, data send signal has to be triggered in the module in order to start the transmission and the busy signal is triggered high to block the next transmission until the current transmission is done. The module is made up of transmitter module and receiver module which are discussed in following sections.

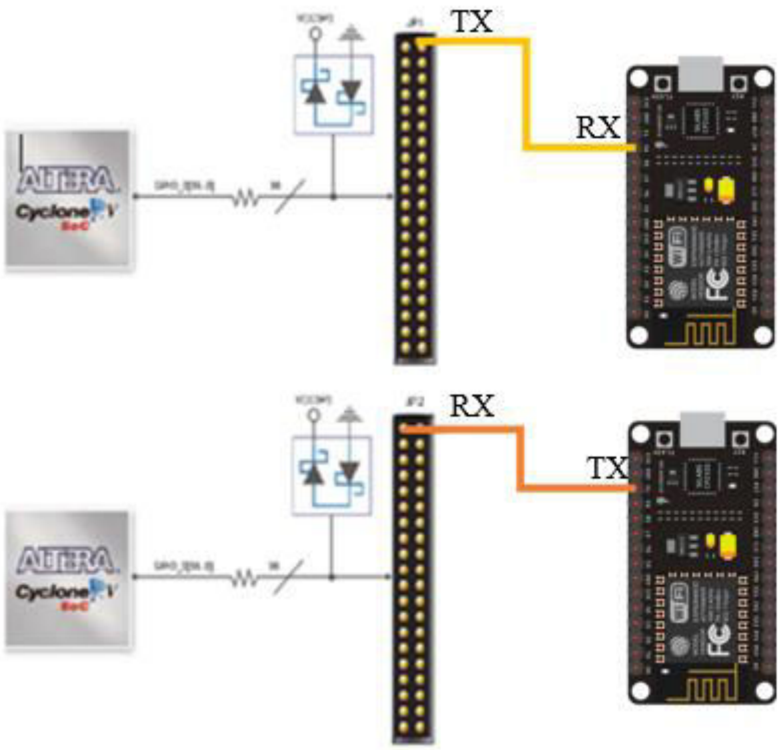

Figure-10. Wiring connection between GPIO pins of FPGA and TX/RX pins of NodeMCU.

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B. Transmitter module

Transmitter module is an individual module designed for transmitting data from board to WiFi module. The data is sent to WiFi module through serial transmission which means the data is sent out bit by bit. Thus, a start bit and a stop bit are required to indicate the beginning of transmission and the end of transmission. The transmission of data is from lower bit to upper bit. A clear figure is shown as Figure-11.

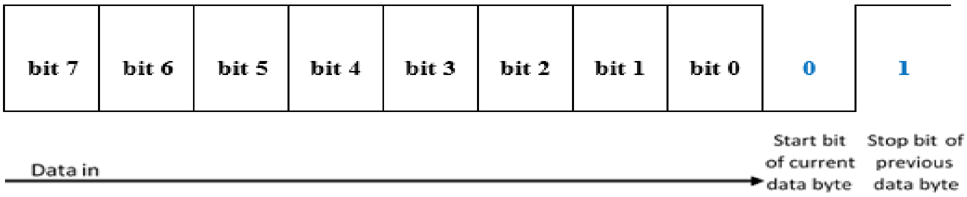

Figure-11. Illustration of data transmission.

When a start bit is detected which is a logic low bit, the condition indicates the transmission of data is started. The transmission is done in 9600 baud rate. Baud rate is the number of symbol transmitted per unit time. The data is in byte thus after the 8 bits data is finished transmitting, then a stop bit with logic high needs to be sent so the transmission now is end. There will be a data enable logic so whenever it is logic high together with presence of start bit, the transmission will start, otherwise, vice versa.

C. Receiver module

Receiver module is also an individual module which is designed for receiving data from WiFi module to the board. The data receiving process is similar to transmission process and both of them are correlated. Their operation is dependent on each other. When the module is going to receive data from WiFi module, the data enable will be set as logic low which means the transmitter now is stayed as idle since serial communication can only carry out one operation at one time.

On the other hand, there will be a bit counter to calculate the number of bits that have been received. When the counter reaches 9 means the data byte has been completely received and ready to transmit through the transmitter module by setting the data enable as logic high. Furthermore, there will be a testing procedure to check whether the falling edge of the clock is the falling edge of the start bit. If the previous received data is logic high bit while the current bit that would like to receive is logic low bit, then the baud rate count will be loaded up with half of the count so the sample can be taken in the middle of the bit. Figure-12. shows the flow of data receiving module.

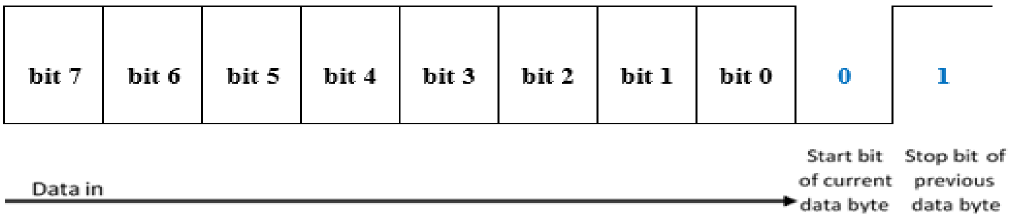

Figure-12. Illustration of data receiving.

Online database and android application

An online database, Firebase Database is used to build a personnel database which is used to store the personnel information and location status. The action ID produced by the comparator module in previous section is used to call out different commands in order to update in the online database.

A part from this, an Android application is designed using Android Studio for easy designing purpose. The application is designed to have a login function by using the email and password registered for those personnel with valid tag. In order to have the function, Firebase Authorization is used along with the designed application. Besides, there is functions to allow client to search the name or employee ID of personnel inside the building to know his/her current location status and his/her details. Furthermore, there is another function of displaying the number of personnel at that floor and the personnel name by key in the floor number. The functions are implemented by retrieving the information from the online database.

Layout design of the indoor localization system and FPGA chip

In this section explain overall layout design indoor localization system which have been used design DE1- SoC and interface connect all the components of the modules as shown in Figure-13 and Figure-14.

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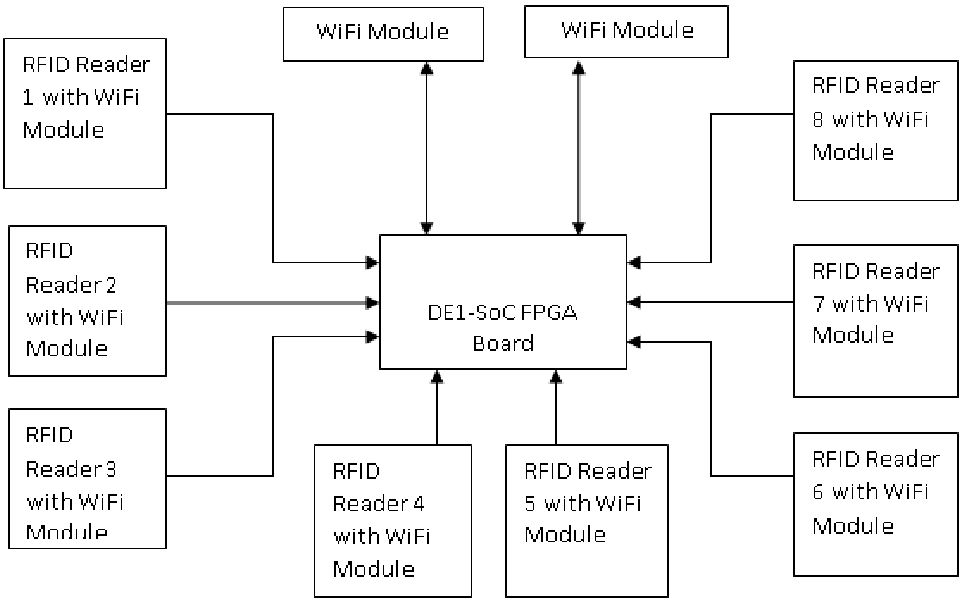

Figure-13. Overall layout design of indoor localization system.

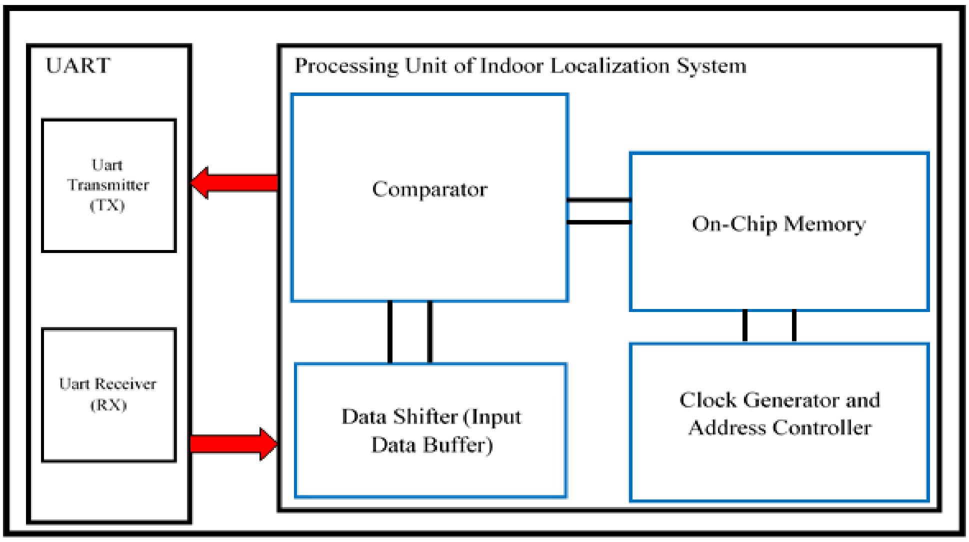

Figure-14. FPGA chip layout design.

RESULT

Demonstration of mobile application

Figure-14. depicts the login page of the mobile application which the client is allowed to sign in to the tracking system or the new client is able to register an account. Thus, there are two sub-sections to discuss on two condition where one of them is for old client and another one is for new client.

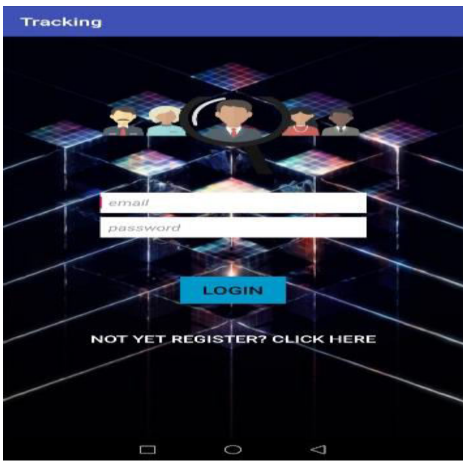

Figure-15. Login page of indoor personnel tracking system.

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Mobile application of personnel tracking system by old client

Step 1:

Client keys in the registered email and password in the corresponding dialog box. Then click on the "LOGIN" button.

A. Condition 1: Login success

If the email and password entered are authorized, the main page is displayed for the tracking purpose according to requirements. There are three types of tracking which are track by name, track by employee ID and track by floor number. Figure-15. shows the client is redirected to the option page of the application after login success by using the correct email and password.

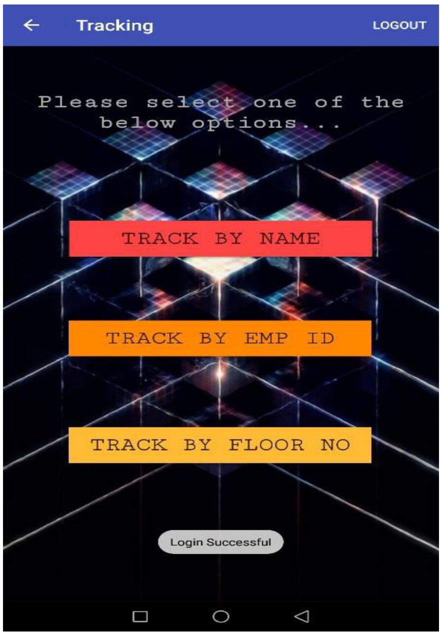

Figure-16. Option page is displayed after successfully login the application.

B. Condition 2: Login failed

If the email and password entered by client are incorrect or unauthorized, client is unable to sign into the main page of the application. Besides, login fail is occurred when client click on "LOGIN" button without enters the email, password or both of them. Client is required to re-enter the correct email and password in order to sign in the application. Figure-16. depicts the result of login failed.

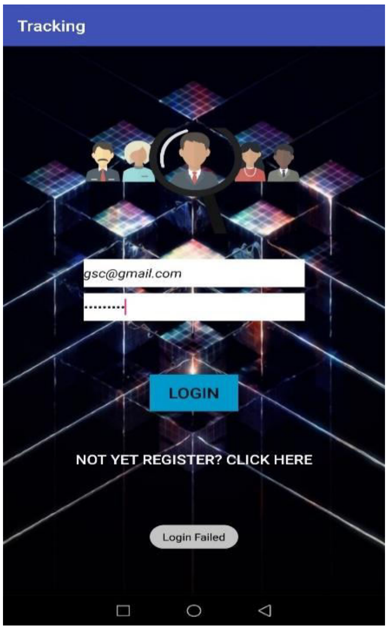

Figure-17. Login failed due to incorrect email and password.

Step 2:

After client log in to the main page successfully, he can select any one of the tracking option as shown in previous Figure-16. and client is redirected to the search page as shown in Figure-17. Then, client can choose to click on the search icon. Details of the personnel is displayed if "TRACK BY NAME" button or "TRACK BY EMP ID" button is pressed as shown in Figure-17. If there has no record in database, "No record" is shown on the application as shown in Figure-19.

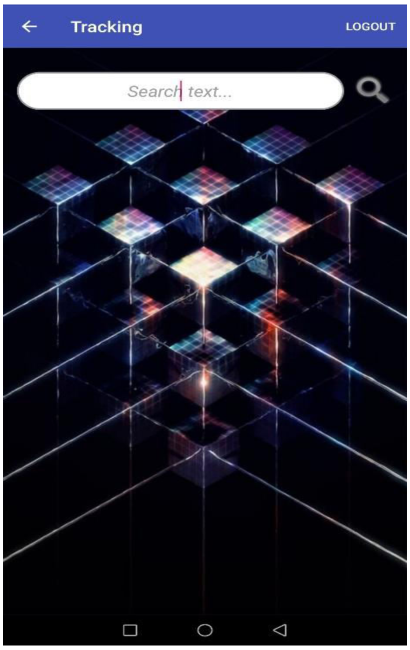

Figure-18. Search page after select any one of the options in option page.

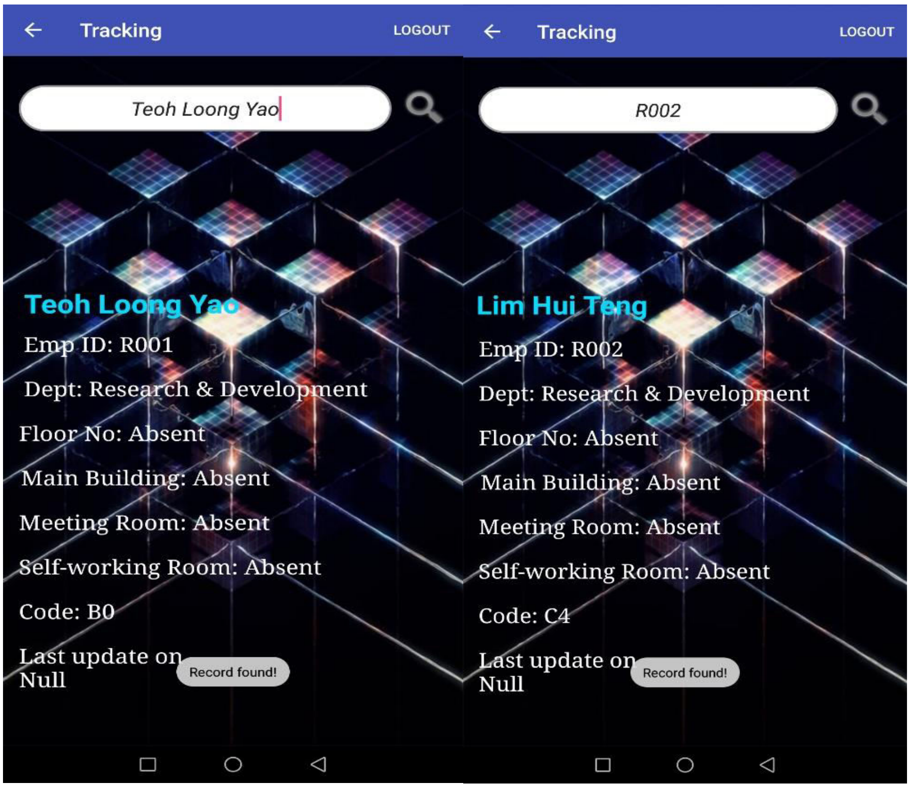

Figure-19. Location information is displayed either track by name or track by employee ID.

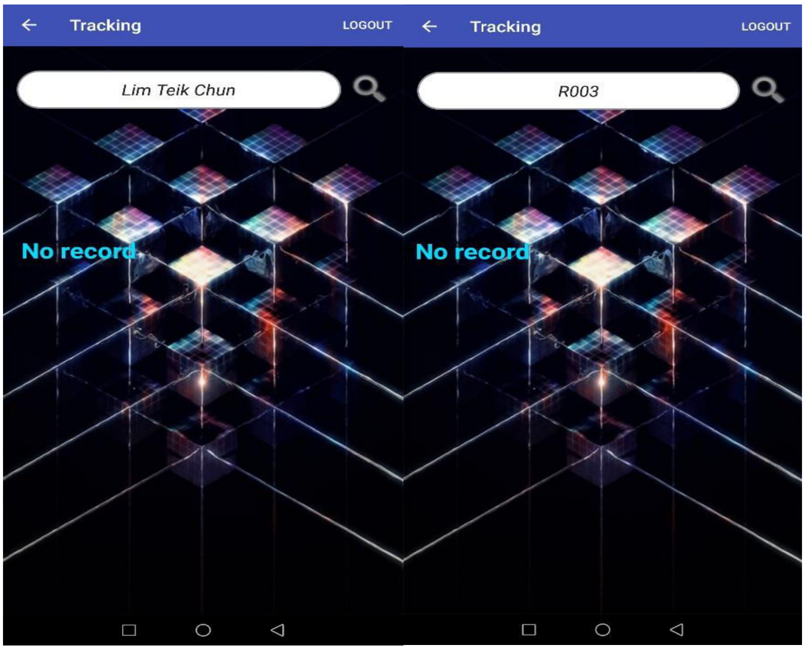

Figure-20. Display "No record" when there is no record in database regarding the text key in.

Moreover, the number of personnel exists at the floor number and the name list of personnel at the floor number are displayed if "TRACK BY FLOOR NUMBER" button is pressed as shown in Figure-21.

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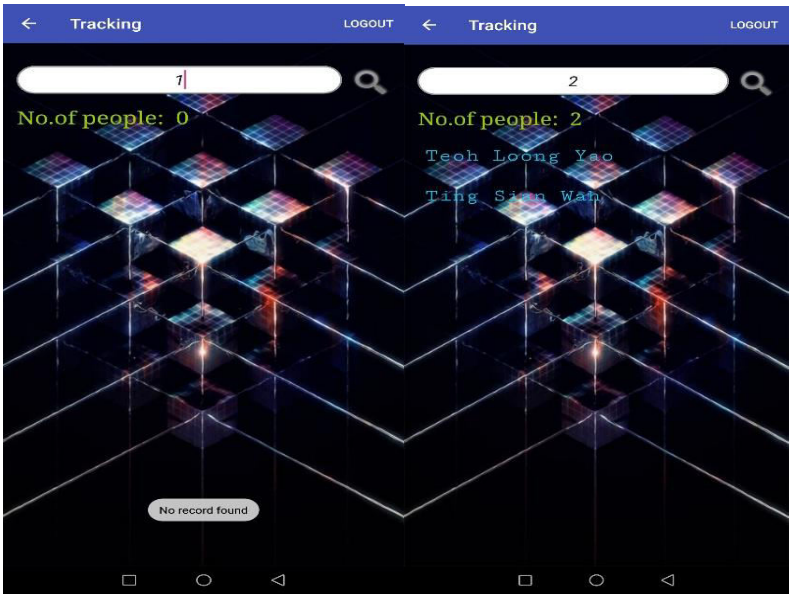

Figure-21. The current status at the floor number that key in by client.

Step 3:

Client can log out the application back to login page by clicking the "LOGOUT" button. Furthermore, client can back to the previous activity by clicking the "BACK" icon. Figure-21 and. Figure-22. shows that an alert dialog is popped out whenever client would like to logout or exit the application.

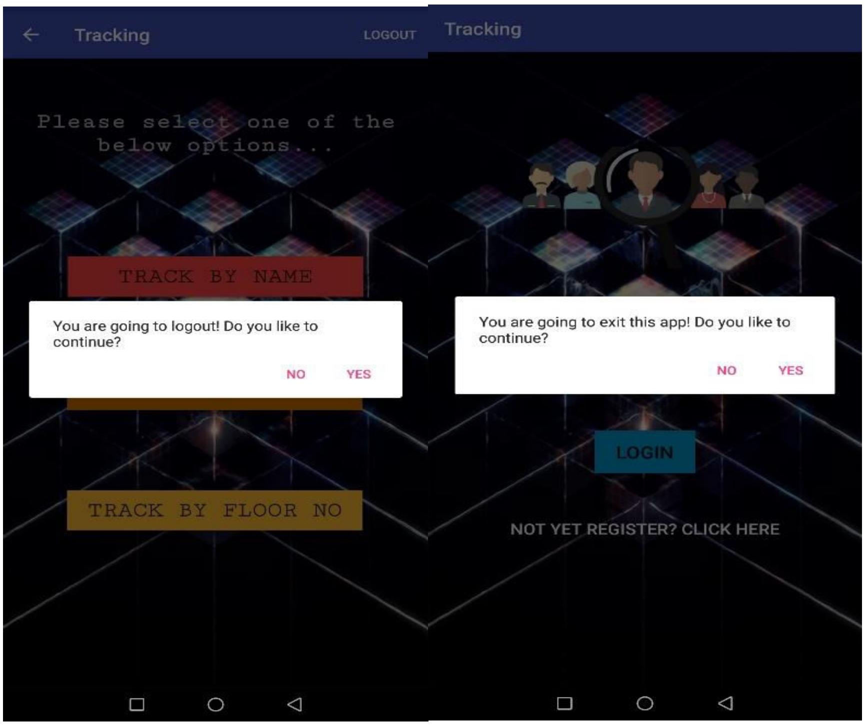

Figure-22. Alert dialog is popped out whenever logout activity is selected or exit the application.

New registration on mobile application by new client

New client is required to register an account through the application before he/she can use the tracking function. Thus, on the login page, new client is required to click on the "NOT YET REGISTERED? CLICK HERE" to direct him/her to the registration page as shown in Figure-23. New client is asked to fill in all the details according to the instruction without leaving any blank dialog box. After all the details are key in properly and correctly, the "REGISTER" button is clicked on by the new client. By now, the new client's information is added into database as shown in Figure-24.

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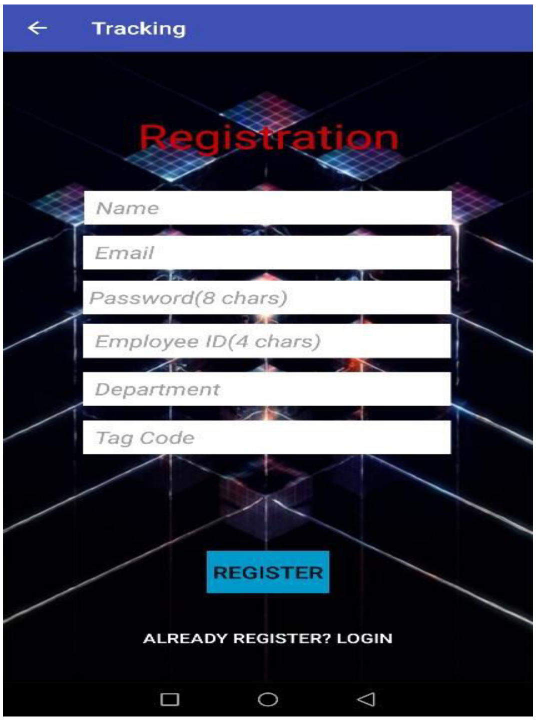

Figure-23. Registration page for new client.

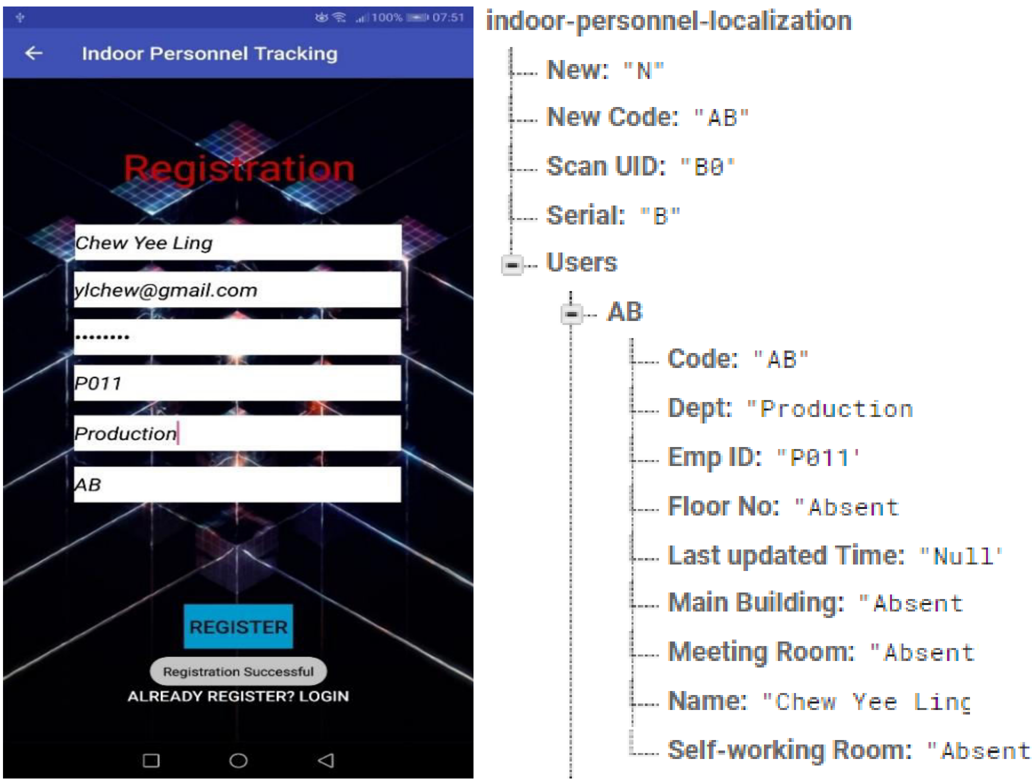

Figure-24. New registered client's information is registered successfully and added into online database.

CONCLUSIONS

In this work, overall knowledge of FPGA had been improved by learning new advance tools in Quartus. The skills in developing the online database and Android application had been learned and implemented into the work it have been achieved successfully

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