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EFFICIENT PARKING SPACE MANAGEMENT USING IOT AND WIRELESS COMMUNICATION

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ABSTRACT

With the rapidly increasing urban population and their busy working schedule, people prefer private cars over public transport depending upon their requirements. This leads to the problem of finding parking spots for their vehicles, especially cars, which is a big issue everyone faces nowadays. Because of heavy working schedules, drivers hardly have time to spend in the parking lane. So, the demand is to develop a digital system that automatically detects and indicates vacant parking spots in the parking area. As the world is growing and tending to be more digital every day, this digital system will help to save time for a person in daily aspects which is a crucial necessity of today's generation. This paper shows how the information is collected from multiple parking areas nearby each other to a single acknowledged unit for an indication of free parking slots in a particular area. The nRF24L01 is a transceiver module which provides reasonable and operative full- duplex RF choices. These transmitting and receiving communication modules used in similar illustrations come on a veritably controllable as well as affordable. The aim of this paper is to easily indicate the exact location/parking lot in the particular parking area. The list of empty slots will be displayed at the entrance of the parking lot. The system consists of a controlling unit, IR sensors, an LCD screen, antennas, etc. The use of this system for car parking will reduce manpower.

Keywords: Transceiver Module, Node, Wireless Communication, MCU, IR Module, TX-Unit, RX-Unit

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1. INTRODUCTION

The design entitled Wireless Digital Parking Solution is to manage and use each parking slot efficiently. Recently there is immense growth in public transportation services. However, the increase in population and economic conditions has led middle-class families to travel comfortably by affording a private car. This is leading to an increase in the number of vehicles in metropolitan cities. Modernization of infrastructure of parking areas is being noticed using the concept of multilevel parking, podium parking, multistorey, multilane, etc.

Over the decades, vehicle parking systems and the following technologies have expanded and widened. Car parking systems have come in use from the time when cars were invented.

The traditional vehicle parking system focuses on houses, residential buildings, offices, etc. Individual parking places were made for easy entry and exit to decrease traffic jams. As the traditional parking system is manually based i.e. directly under human control, depending upon the size of the region, vast or small, car drivers must look personally for a free slot before a car park. A person spends approximately 5-10 minutes finding a vacant parking spot in a specific parking lane. Finding a free slot leads to more time and fuel consumption, which may also lead to traffic congestion inside the parking area in search of a vacant parking spot. Traditional parking systems have some the issues like monitoring the total number of cars in the parking area, the space available for new incoming cars, and maintaining the parking slots.

To overcome these problems faced by the traditional parking system, automated parking systems came into use. By analyzing these problems, automated parking systems were invented in the early 1920s. This system first appeared in American cities like New York, LA, Cincinnati, and Chicago [6]. Compared to the traditional parking system, an automated or digital parking system requires less area and can be worked under the miniaturization of the infrastructure of the parking area. The digital parking system possesses more advantages over traditional parking systems like time savior, fuel and cost-efficient, hassle-free direction, a greenhouse effect, etc. This digital system increases the efficient use of (overall) parking space, prevents extra traffic inside a parking area and on the road, enhancement of the driver's experience, and much more [4]. This paper is based on the Infrared detection sensors or Infrared object detection sensors. Other components for the project are IR-LED sources, LCD display, processing units i.e., Arduino Mega and Arduino Uno, an NRF24L01 transceiver module, and other basic components. The basic principle of working on a project is to display the exact identity of parking slots that are free to park or unoccupied by a car in the parking lot [1] [3].

A processing unit i.e., Arduino Mega, along with IR sensors, which have been allotted for each parking space in the parking zone detects empty or free slots in a parking zone. The Infrared sensors send the data towards the processing unit. According to the data received from the IRs, the processing unit transmits the information of a free slot to the display unit wirelessly using an nRF24L01, a wireless transceiver module. A display unit receives this information using the same antenna module and the information on free slots is displayed at the main gate i.e., at the main or primary entrance of the parking zone. The use of the nRF24L01 module allows us to collect parking information from different parking areas. Using the nRF24L01 module at a single receiving and a displaying unit, the information from the different parking areas can be displayed in one single place [5] [8] [9].

2. PROPOSED SYSTEM

- **Components**

1) Arduino Mega-2560:

Arduino Mega-2560 (Fig. 1) is a Micro-controller board based on ATmega-2560 chip. This board is also based on AVR RISC Micro-controller that performs dynamic commands within one executing clock cycle. This Micro- controller consists of 54 digital input/output pins (pin 0 to pin 53) with 16 analog input pins (pin 54/A0 to

pin 69/A15) which can be used as digital input pins too. The board comes along with 6 ICSP pins (In-Circuit Serial Programming pins) separately which are helpful to connect to the nRF24L01 module to transmit and receive data wirelessly. The operating voltage for the board is 5 volts, however, recommended input voltage is 7V – 12V. A Bootloader, along with 8 kilobytes of Static Random Access Memory (SRAM) uses 8 kilobytes from 256 kilobytes of Mega 2560's non-volatile computer memory (Flash Memory). With E2PROM (Electrically Erasable Programmable Read Only Memory) E2PROM of 4KB. Operating at a clock speed of 16 MHz.

Figure 1

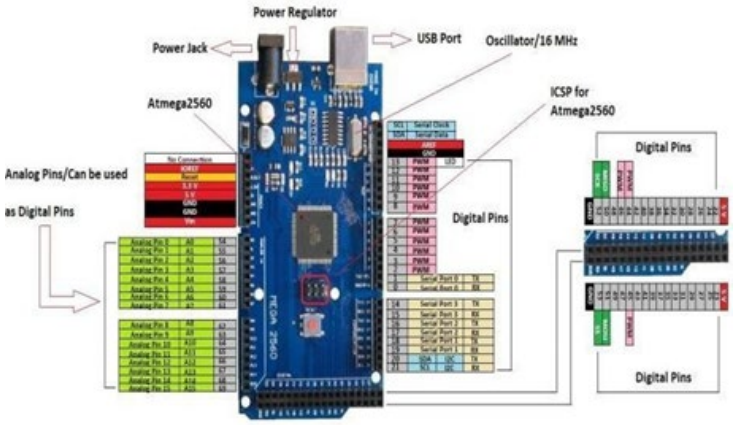

Figure 1 Arduino Mega-2560
Source theengineeringprojects.com

2) Arduino UNO:

Figure 2

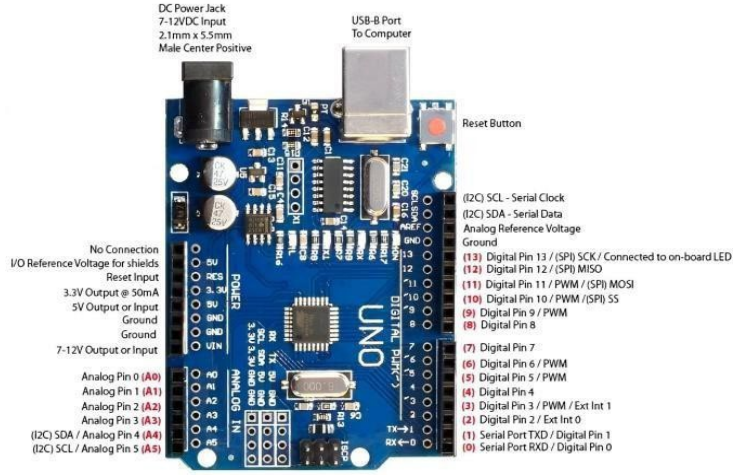

Figure 2 Arduino-UNO
Source protosupplies.com

The Arduino UNO board (Fig. 2) is based on Atmega328p. It is also a µC board. It comprises 14 digital i/o pins (pin 0 to pin 13) along with 6 analog pins (pin A0 to A5) which can be configured to use as digital input/output pins. The µC is easy to use and flexible. The voltage requirement is low for operation. It operates at 5V, recommended input voltage is 7- 12V. Its voltage limit is 6-20V. The pins of Arduino Uno are configurable. A Bootloader, along with 2 kilobytes of Static Random Access

Memory (SRAM) uses 0.5 kilobytes from 32 kilobytes of ATmega328P's Flash Memory. With E2PROM of 1KB. Operating at a clock speed of 16 MHz [5] [10].

3) nRF24L01 Transceiver Module:

Figure 3

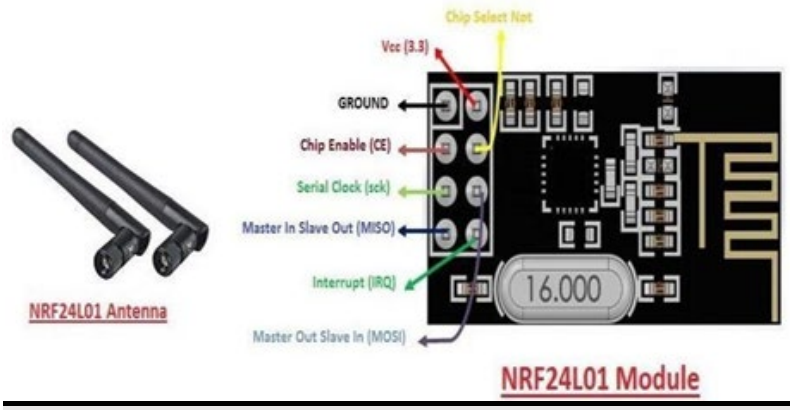

Figure 3 NRF24L01 Transceiver Module with Antenna
Source theengineeringprojects.com

The nRF24L01 module is a wireless transceiver module. This transceiving property that nRF24L01 possesses, helps the system to use the individual antenna module for both transmission and reception purposes. The single antenna module can communicate in the 2.4 GHz frequency range, making the nRF24L01 module one of the legal Radio Frequency communicators in modern applications. This module's channel frequencies extend from "2400 MHz" to "2525 MHz". That means for the very first channel, the assigned frequency is "2401 MHz", for the second channel, it is "2402 MHz", for the third, it is "2403 MHz", and so up for the 125th channel it is "2525 MHz". The nRF24L01 transceiver module (Fig. 3) has a built-in oscillator of "16MHz" and the built-in antenna named "On board antenna" or "Embedded PCB antenna". This antenna possesses the pattern of "Meander Line Inverted-F" and is able to transmit data up to the range of "50-200 feet". This transceiving model makes use of a Serial Peripheral Interface i.e., SPI communication protocol, and provides a data rate of up to 1Mbps and a baud rate of up to 2Mbps using 125 channel ranges. The module has a channel range of 1MHz and it makes use of ISM (Industrial Scientific Medical Board) frequency band. This module acquires a channel range of 125 which provides the property of operating these channels in distinct networks in one place. For transceiving the data, it utilizes the "GFSK" i.e., Gaussian-Frequency Shift Keying modulation technique with a wavelength of up to 0.1249 meters. The nRF module is able to make it possible to collect information from multiple transmission areas to a single reception center due to its characteristics [7]. It is capable of communicating with a maximum of 6 nodes in a network consisting of nRF transceiving modules at one time. The nRF24L01transceiving module operates at 3.3 volts and it requires an operating current of 50-250mA [5] [9].

4) LCD Unit:

The LCD is an abbreviation for "Liquid Crystal Display", and instead of emitting light, it works on the principle of blocking the light. These liquid crystals are fabricated of both liquid and solid substances that are able to "depraved" screen area of 47.1*26.5 mm. This driver has a built-in controller named "STM8S005KBT6" with an operating frequency of up to 16 MHz. It requires a supply voltage of 4.5-5.5 volts (5V to GND) and a logic voltage for SDA-Serial Data Line and SCL-Serial Clock Line in the range of 2.8-5.5 volts [12].

Figure 4

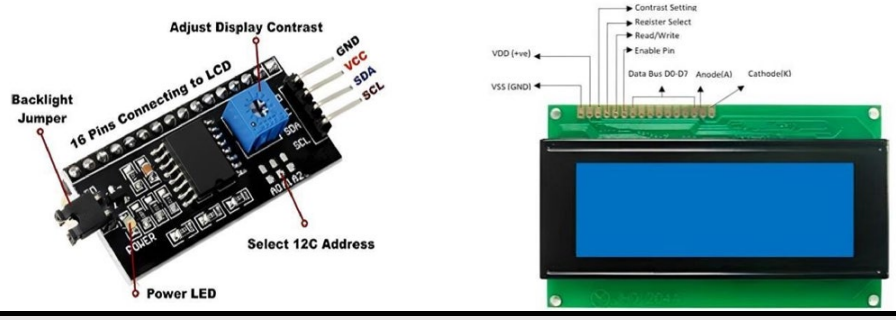

Figure 4 a) I2C LCD Driver
Source aitendo.com

b) 20x4 LCD Display
Source quartzcomponents.com

When an electric voltage is applied to them. Unlike LEDs, LCDs are incapable of emitting their own light. Thus, resulting in less power consumption and radiation emission. To display the light, it uses the method of polarization of light using two polarizing plates.

This system makes use of a "20x4 LCD Display" (Fig. 4(b)), which contains four rows each consisting of 20 characters. So, with this up to 80 characters are possible to show in a single display. The code required for interfacing the LCD is easily attainable, which requires 11 I/O pins. The input supply voltage of 3-5 volts is needed for this module with other components like Arduino, Raspberry PI, PIC, etc. [11] The I2C LCD driver (Fig. 4(a)) is a display unit. This driver is used to provide a connection between the µC and the LCD display which tremendously reduces the number of pins from 8 to 2 for transferring the data from the controller to the display. I2C is an abbreviation for Inter- Integrated Circuit. I2C LCD is a user-friendly module, which reduces the difficulty level of makers while doing the core work. It comes under the category of BUS. This module is a serial communication protocol that originated from “Philips Semiconductor” in 1982. Though this serial communication needed only two wires for the connection, it is also identified as TWI (Two Wire Interface). The I2C LCD driver has a dual-color LCD screen type i.e., white text with blue backlight. It supports 128 levels of backlight adjustment and 64 levels of screen contrast adjustment using the potentiometer. This driver is very energy efficient and has an address of ‘0*27’ or ‘0*3F’. In a 20*4 module, ‘20’ indicates “characters” and ‘4’ indicates “lines”. The screen resolution of this module is 128*64 Pixels and has an active.

5) IR Sensor Module:

Figure 5

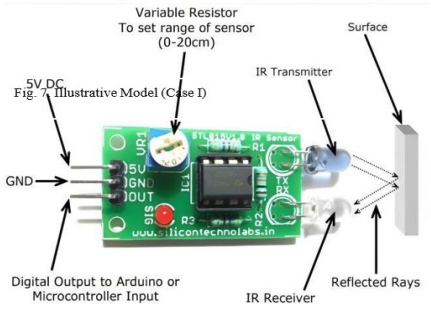

Fig. 7. Illustrative Model (Case I)

Figure 5 IR Sensor Module
Source nerdyelectronics.com

The IR sensor, i.e., the Infrared sensor is a basic and well- known electronic device used for object detection. The module is based on wireless technology which uses IR rays for transmission. IR light wavelength ranges between 700nm to 1mm. As this range is very high than the visible light range (ranges from 400nm to 700nm), it is invisible to human eyes. This is the type of sensor module that comprises both the emitter and receiver and is hence also known for the transmitter and receiver. It consists of IR LED and Photodiode. The IR LED works as a source, i.e., for emitting IR rays, and the photodiode is used for receiving the transmitted rays which get reflected back from the object. The obstacle detection range for this module is up to 20-30 cm with an angle of detection ranging between 30^0- 40^0. The module shown in "Fig. 5" has a built-in trimmer (a type of potentiometer) used to calibrate the sensing range which makes the module adjustable and easy to modify. It also has a built-in "Ambient Light Sensor" which makes the module provide very appropriate and steady responses in ambient light or in complete darkness. This module consists of OPAMP (Operational Amplifier) which is used as a comparator chip named "LM358N". This comparator is integrated with two OPAMPs in a single chip and has a wide bandwidth of 1MHz [10]. The IR sensor module operates on a DC voltage of 5 V and has an active high output of 3.3 V at data pins. This module requires a supplying current of 20mA [1] [2].

- **Working:**

"Fig. 6" represents the proposed system's block diagram, consisting of IR sensor modules, µCs, antenna, and display.

Figure 6

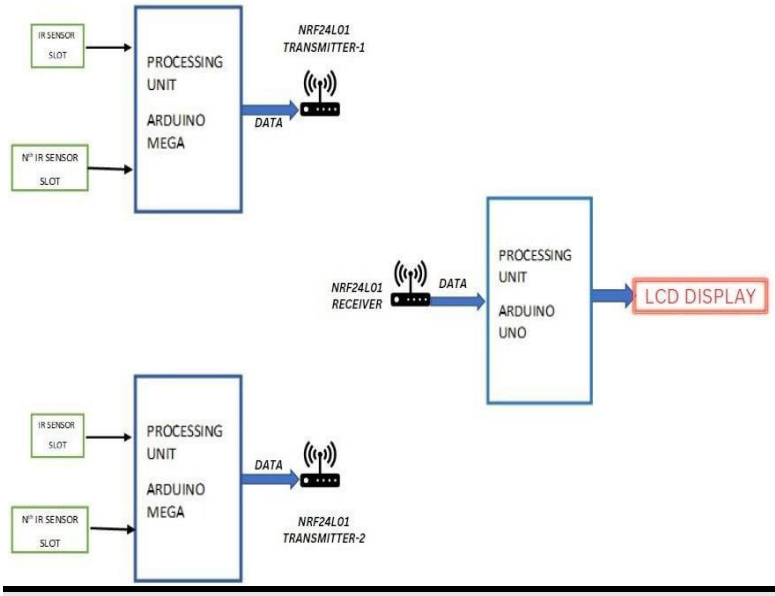

Figure 6 Proposed System's Block Diagram

The solution proposed in this paper can be divided into two major parts, one the transmission unit and the second the receiving unit. The transmission unit consists of an IR module (line sensor), a µC unit (MCU), and an nRF antenna module working as a transmitting antenna. The receiving unit consists of the display unit, MCU, and nRF antenna module working as receiving antenna. The proposed solution can consist of a number of transmitting units, which increases the capacity of the whole system.

As the primary concept of the proposed system is to display the specific vacant slot at the main entrance from different parking areas which can be understood by the below figure "Fig. 7"

Figure 7

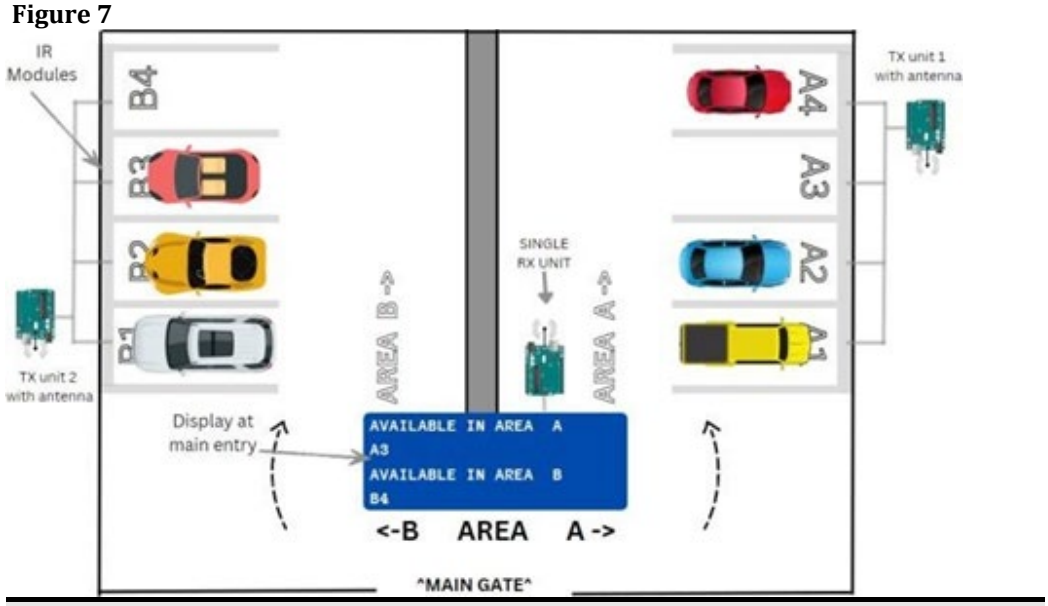

Figure 7 Illustrative Model (Case I)

As we can see in "Fig. 7", two different parking areas, "A" and "B", consisting of slots "A1 to A4" and "B1 to B4" respectively, each parking slot has provided with individual IR detectors respectively. IR LED in the IR sensor emits the IR light (ranges between 38 KHz to 57 KHz). This IR light gets reflected from the body of the car and IR sensitive photodiode on the IR module (as shown in Fig. 5) detects it. The IR modules detect the car on slots A1, A2, and A4 and give high input to connected pins of the MCU. The MCU creates the list of those slots for which there is no input to the assigned pin for slots, here "A3". This µC creates the list of free slots consisting of "A3". This MCU is connected with the nRF24L01 antenna module forming a "TX-Unit-1" for the "Area A" as shown in "Fig. 7". While encoding the µC the same address is being provided for both the "TX-Unit" and "RX-Unit" over which transmitter and receiver will be communicating. A unique header is being added to the list of free slots, so it identifies that this list is for "Area A", and this list is broadcasted on air. The "TX-Unit-2", which is placed in parking "Area B" follows the same process. The IR sensors do not sense the presence of t h e cars for the respective slots and send low input to the µC. The µC creates the list of free slots in "Area B", in this case, "B4". A unique header is added to this list so the receiver can identify the list consists the information of "Area B". Once again same address is being provided for "TX-Unit-2" and "RX-Unit" for communicating through the RF channel. Since thenRF24L01 module can behave as a transceiver in this system, the "TX-Unit-1" and "TX-Unit- 2" antennas are configured to work only as transmitting antennas. So, the data transmitted from "TX-Unit-1" does not affect the antenna and functionality of the "TX-Unit- 2" antenna and vice versa. Hence, there is no misplacement of messages on the air. The antenna at the "RX-Unit" is configured only for the reception of messages i.e., only as a receiving antenna. The message in the air transmitted by "TX-Unit-1" received by the "RX-Unit" is stored in the buffer. The antenna captures this message and passes the required data for processing to MCU. The MCU reads the data with the help of header and this unit is trained/encoded to identify the message

for the particular area. It comes to know this message consists of the information (the list) of "Area A", and send this list to the display unit to present it on the desired location of the display.

Figure 8

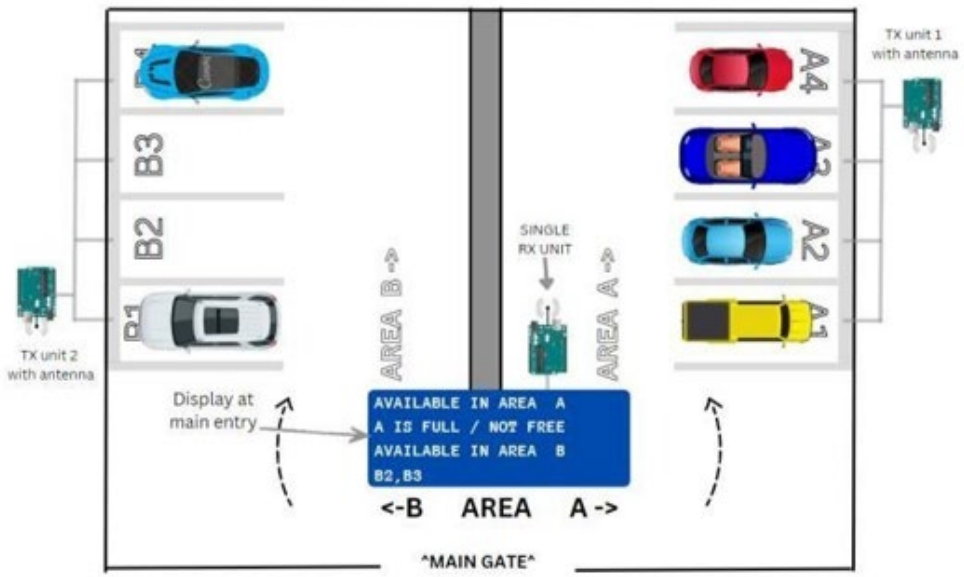

Figure 8 Illustrative Model (Case II)

Simultaneously, "TX-Unit-2" transmits information about vacant slots in "Area B". Similarly, the "RX-Unit" receives the message from "TX-Unit-2" and stores this message in the buffer. After processing this message, the MCU sends this information of free slots from "Area B" to display at the entry as shown in "Fig. 7".

The "TX-Unit-1" and "TX-Unit-2" transmit the updated list every second. As we can see in "Fig. 8", the list of empty slots is updated on the display at the main entrance as there are changes in the location of cars in both parking areas.

- **Flowchart:**

The following flowchart (Fig. 9(a)) shows the program flow/ process flow for the MCU of the transmission unit. The flowchart is dedicated to all transmission units. When the system is booted up or the power supply for Arduino is given, it starts running the encoded function.

In the setup function, the MCU defines the pins assigned for the respective slots next creating the radio object for nRF communication, defining the address for communication between the "TX-Unit" and "RX-Unit". The address here is "00001". It can be any string of five characters like "node1". Setting the payload and data rate as the same as the "RX- Unit". Then set the radio for transmission only, i.e., calling the function "radio. Stop listening ()". Now nRF acts as a transmitter only. The above-discussed process is being executed once when the Arduino (MCU) is set as a setup function.

Figure 9

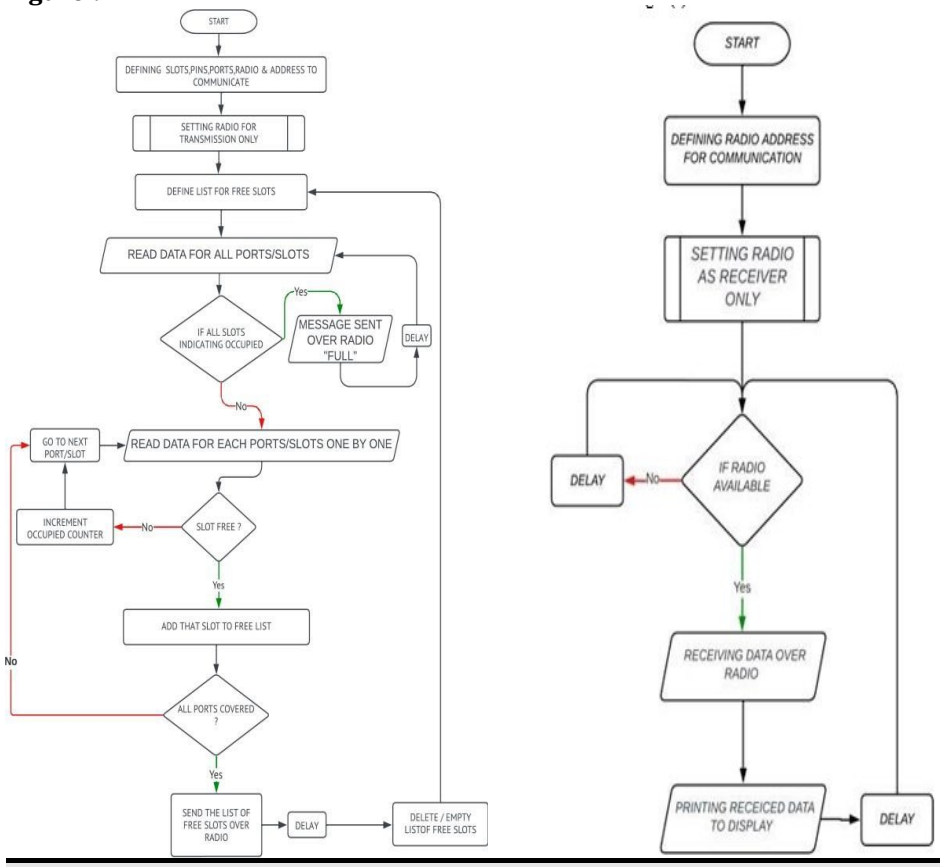

Figure 9 a). Flowchart for "TX-Unit" b). Flowchart for "RX Unit"

The MCU creates the array for the list of free slots. Once the array is created as defined in a program, MCU read inputs from all the ports assigned for slots. Thus, ANDing all the inputs from these pins, if the result for this is true, it indicates all the slots are occupied. That means cars arebeing detected by all IR modules, and the message "FULL",is sent from the "TX-Unit". If the result of AND is false, indicates that there are some IR modules giving output as "0", indicating no car detected. In this condition; inputs for each assigned pin, are read one after one. If the car is detected, MCU increments the counter of occupied numbers. If no car is detected, IR gives a '0' output at its data pin and no input to MCU indicating no car detected andMCU adds this slot number to the array of free slots. Then it goes to the next pin, follows the same process, covers all the pins consecutively, and adds those to the free slot list. After all the pins are covered the list of free slots is broadcasted via the nRF antenna module using radio waves. After transmitting the array of the list of free slots, MCU clearsthe elements in an array and all the other counters used inthe program, and follows this process in a loop again and again until the system is powered on.

The above flowchart (Fig. 9(b)) shows the program flow for receiving unit. In the setup function, we define the radio object with CE and CSN pins for nRF module. Next set up the address as the same as the transmitter '1' at data pipe '0' for communicating with the TX unit 1 address. 0 to 5 pipes are available for simultaneous communication with 6 different TX units, i.e., pipe '1' is assigned to TX unit 2, and so on. By calling the function "radio.startlistening()", the module is configured as a receiver only. By calling the method "radio.available()" in the loop,

it checks if there is data is available to be read or not. If data is available, it returns "TRUE", otherwise "FALSE". In the "TRUE" condition, the data is retrieved from a radio. The same process is followed for all pipelines in use. After retrieving the message, it is ready to be displayed on the screen. And the RX unit follows the above process in a loop till the system is on.

3. RESULTS

Figure 10

Figure 10 a). System Model b). Empty slots detected on LCD display

The results obtained for the prototype model are represented in Figures, "Fig. 10 (a)" and "Fig. 10 (b)"., we can see that slot details of vacant spaces are successfully displayed on the single display at the main entrance. The "Area A" and "Area B" are separated from each other and have distinct MCUs with antennas. We can observe that when there are movements of cars, changes in the vacancy of slots are updated on the main screen.

4. CONCLUSION

The consequence of the huge enlargement in population, and rise in the number of personal vehicles, especially cars, nowadays people are experiencing the issue of parking their own vehicles in a rushing environment. To overcome such a big problem, there is a need for providing a simple digital system for finding vacant slots in a particular parking area. This paper explains the system developed for detecting and indicating the free or vacant slot in a specific parking lane. An individual person can easily find or discover an empty slot to park a car. As this system is adaptable and provides a digital solution for the indication of vacant parking slots in the particular parking lane at the main entrance only, which ultimately helps to save more time and energy for an individual in daily aspects. The system consists of an nRF module which has the characteristic of transceiving functionality that helps the system to be implemented for N number of parking slots which can be multiple parking lanes, multilevel parking, podium parking, etc. A distinct IR sensor module is used for each slot to detect empty slots. This data is transmitted to the LCD display at the entrance of the parking area. This system is very versatile and can be used in any sector like malls, residential buildings, corporate apartments, etc.

CONFLICT OF INTERESTS

None.

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