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IoT based Smart Trolley for Shopping using RFID and Node MCU

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Abstract

Customers are helped when shopping by the sophisticated shopping cart system. The goal of this proposed work is to create a hardware and software implementation of a modular, affordable, and user-friendly smart shopping system. This system may be tweaked, and dealers can begin using it right now. It tries to satisfy as numerous of the end-conditions druggies as doable. Obviously, digital commerce is growing in vogue, but numerous consumers still need to see what they are purchasing and assimilate the various add-ons offered in the emporium. Still, in these situations, people are pressured to stay in lines that might grow rather long, and bearing in a line creates a variety of discomforts and pressure. Every item may be fixed with an accessible RFID label that, when inserted into a smart shopping cart, may be read automatically by a cart fitted with an RFID reader. This system can incorporate smart shelving, which has RFID scanners installed and can cover stock as well as update a central server. Another advantage of this technology is that it makes tally operations considerably simpler because an RFID reader can automatically read all effects and determine whether a product's expiration date has passed. The IoT website will be completely reconditioned.

Keywords: Smart IoT, NodeMCU, RFID, Shopping Trolley.

Introduction

In the Internet of Things (IoT) era, reciprocity between physical units appears to be a reality. Things from all over the world can now be connected because daytime objects are now capable of having computing and communications capabilities (1-5). A wireless on-demand system can now be used for a variety of purposes due to the quick development of IoT technology (6-9). Automatic electronic price tag updates, advertising based on shopping cart and display data, and automated stock/inventory organization are just a few examples. Business, financial, and environmental systems have entered a new era as a result, but data storage, wireless communication, and real-time decision-making are now faced with significant challenges (10-15). Moreover, IoT operations place a high demand on lightweight encryption techniques due to rising privacy and security concerns. A computer that functions as a specialized element of a larger mechanical or electrical system and is constantly constrained by real-time processing requirements is known as an embedded system (16-18). It is typically constructed as a part of a bigger plan that also includes mechanical and physical components (19). Today's biases are largely the result of embedded systems. Microprocessors are produced as embedded system components in 98% of cases. Low power consumption, compact size, wide operating temperatures, and low cost per unit are some features that distinguish embedded computers from their general-purpose counterparts.

Throughout time, efforts have been made to shorten lengthy lines at retail stores. Additionally, it has been discovered that customers favor details about the item's placement when expressing their opinions about purchases. Customers' opinions of optical technology and its insulation play a role in determining customer satisfaction. In order to enable effects like ROI, business growth prospects, and lead generation, it is crucial to find ways to enhance the

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shopping experience (20-22). As a result, we put forth the Smart Cart shopping system. The primary goal of this design is to protect both the remote environment and the individual products.The idea of electronic tags connected to specific products is then presented. RFID technology enables a single user to read the decoded information on the goods when he comes into contact with these tags (23). The only interaction the carts have with the user is to convey the effects the customer chooses to purchase. The shopping experience for customers will be enhanced by the cart created as part of this design (24).

Methodology

A barcode reader is used in the current system to check the product quantity. Data is transferred to a computer using Zigbee. It lacks a load detector to determine the cart's load. Because it uses Zigbee for communication and counting for billing, the system is extremely slow. Thousands of shoppers visit shopping centers and large bazaars every day to buy a wide variety of goods. Today, a cart is necessary to pick up different items from supermarkets or shopping malls. The process of obtaining the product is difficult.

Every time, a customer must pull the cart to gather the items and put them in it while also keeping track of his spending. After shopping, the customer must wait in a long line to pay their bill and have their purchases scanned. To avoid this, we are developing a clever shopping method. An RFID label is present on each and every item. An RFID reader and transmitter will be part of the smart trolley. Cost and the product's name will be shown when the shopper examines and adds any item to the trolley. The final bill will be calculated based on the total cost of all the products, and it will be stored in the microcontroller's memory. An RFID scanner is employed in the proposed system to confirm the product quantity. The maximum weight that can be loaded onto the cart is determined using the weight scanner. With the aid of the MCU node's LCD screen, which is used to show the measured details, all the measured data will be uploaded to the IoT website. The system will sound a bell if the product is out of date. There will be two additional IoT locations where the product order will be renewed.

Power supplies are places where electrical energy comes from. A device that provides electrical or other types of power to an output load or collection of loads is known as a power supply unit, or PSU. Electrical energy sources are frequently mentioned in this context; mechanical and other energy sources are mentioned less frequently and less frequently, respectively. Electrical equipment uses two different types of power supplies: switching power supplies and linear power supplies. A linear power supply is a relatively straightforward design for high-current devices, which progressively gets heavier and bulkier. Voltage regulation on a linear supply can lead to below average efficiency. A converted source's size, efficiency, and complexity will vary from a linear source of equal power.

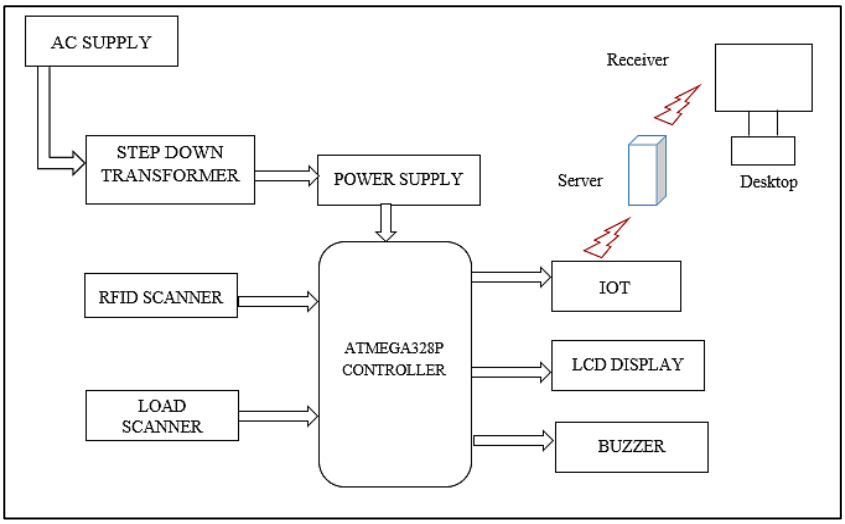

Figure 1: Block Diagram of IoT based Smart Trolley System

Transformers work well for changing one AC voltage to another as shown in Figure 1. One of the reasons why alternating current is the primary power source is because inverters can only function on it. Step-down transformers lower the voltage while step-up transformers raise it. A step-down motor is required to convert the primary voltage, which is dangerously high for larger power banks (230V in the UK), to a lower, safer voltage. The primary file is the input file, and the secondary file is the output file. The transformer's soft iron core is what generates the magnetic field that alternates between the two coils. No electrical coupling exists between the two coils.The heart is symbolized by the two intersecting lines in the diagram's center. The output power is (almost) equal to the input power because inverters don't waste much energy. Take into account the fact that current rises as voltage rises. Each coil rotates at a specific rotation rate, also known as rotation rate. A step-down transformer's secondary (output) winding, which is attached to the high-voltage power source and has fewer turns than the primary (input), enables a lower output voltage.

Four individual diodes can be used to construct a bridge rectifier, but the exact four diodes are also available in particular packages. Because it makes use of both the positive and negative portions of the AC wave, this device is known as a full wave rectifier. In the image below, the rectifier bridge, which always has two connected diodes using 0.7 volts each, uses 1.4 volts.Both fixed output voltages (typically 5, 12, and 15 volts) and variable output voltages are available for voltage regulators. They are also rated according to the largest current they can support. There are negative voltage controllers, primarily for stock dual use. At some capacities ("overload protection"), the majority of controllers automatically protect against over-current and over-temperature conditions.

RFID tags are scanned by an RFID reader to operate. When using radio interrogation, line of sight is not required because the reader and the tags are so close together. An RF module that can send and receive radio frequency signals is built into the readers. An oscillator produces the carrier frequency, a modulator adds data instructions to this carrier signal, and an amplifier amplifies the signal until the label is activated. These three components make up the transmitter as shown in Figure 2.

A demodulator and an amplifier are both included in the receiver to prepare the signal for processing and to extract the data that has been received. The control unit consists of a microprocessor that stores and processes data using memory and an operational network. The data is currently being prepared for transmission to the network.An RFID tag is a substantial package with an antenna and a microprocessor that can be attached to a target object for tracking. RFID stands for radio frequency identification. An RFID reader or scanner sends signals to the tag antenna, which then typically responds with new data (like a unique serial number or other personal information). The size of a large grain of rice, in fact, is about how small RFID tags can get. Some might be no bigger than a small booklet as shown in Figure 3.

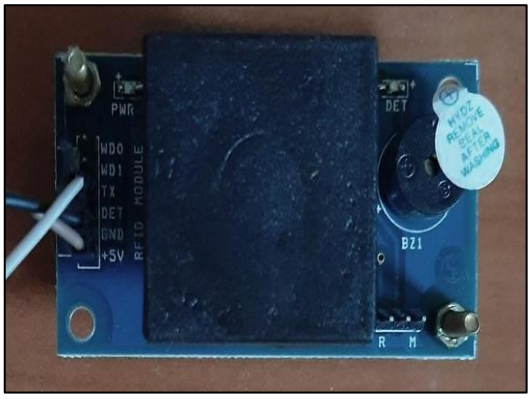

Figure 2: RFID Reader for proposed method

Figure 3: Sample RFID Tag

One of the most crucial advantages over the other technologies mentioned above is the fact that the RFID device does not need to be positioned precisely with respect to the scanner. We are all aware of the difficulties a grocery store cashier occasionally encounters when attempting to read a bar code. It goes without saying that a particular reader is required to swipe ATM and credit cards. Unlike high-frequency bias scanners, RFID devices can function up to 6 meters away from them.For instance, you can just pack a bag with all of your groceries and put it in the scanner. It will be simple to quickly add your requirements and get more information about each RFID device. (Read a more thorough comparison of RFID and barcodes.) Since RFID technology became widely accessible, more than fifty years have passed. The production capabilities of RFID readers have only recently decreased to the point where they can be used as a "disposable" controller or supply.

The RISC-based Atmel 8-bit AVR microcontroller features a programmable serial USART, serial SPI port, byte-aligned 2-line cyclic interface, 6-channel 10-bit A/D converter (with 8 TQFP channels and 32 general-purpose work registers), dual-channel SRAM KB, 1 KB EEPROM, 23 input lines, and three movable clock/counters with compatible modes. The voltage range for the device is 1.8 to 5.5 volts. The device achieves transfer rates of 1 MIPS per MHz, which equates power consumption and processing speed, by processing the majority of instructions within a single timer cycle. A single-chip microcontroller from Atmel's enormous AVR series is the ATmega328 as shown in Figure 4.

The Arduino physical computing platform is open source and based on a straightforward I/O board. It has an update environment that supports the processing and interacting programming languages. The Arduino can be used to build interactive standalone objects or to connect to software programs.

The NodeMCU is an interactive LUA-based firmware for the ESP8622 Wi-Fi Express SoC that costs less than $3 and is as straightforward as an open source hardware board. The board's compatible ESP8266 Wi-Fi modules come with a CP2102 TTL to USB chip for programming and debugging. The only source of power for them is a micro-USB port. Motion Networks created the Wi-Fi SOC (Network on a Chip) known as NodeMCU. The ESP8266-12 E Wi-Fi module contains it. It is a highly coupled chip made to deliver complete Internet access in a compact form factor. It can be directly programmed using the USB interface by using the Arduino programming IDE or LUA.

With a little bit of code, the Arduino can be made into a web server, connected to Wi-Fi, defined with custom input/topic elements to suit your needs, and much more. The NodeMCU is a Wi-Fi module that resembles Ethernet. It combines the advantages of a terminal microcontroller and a Wi-Fi access point. These features make the NodeMCU a crucial piece of hardware for Wi-Fi networking. It can function as a terminal or access point, a web server, and a connection to the Internet for data download and upload.

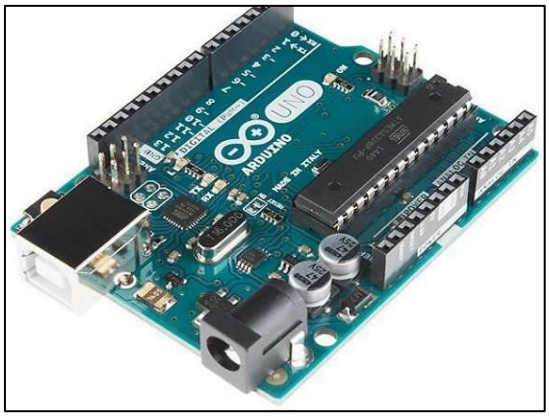

Figure 4: ATMEGA328

Figure 5: Arduino IDE software's user interface

A flat panel display, electronic visual display, or video display that makes use of the LCD technology known as liquid crystals is called a liquid crystal display. Light does not instantly come from liquid crystals. LCD displays can be used to show random images (like in multi-function computer displays) or specific images that can be viewed or displayed, in a manner similar to how predefined words, integers, and seven-member displays are used in digital watches. It makes use of the same fundamental technology, but these jumbled images are constructed from a large number of tiny pixels as opposed to other displays, which use larger building blocks. The LCD screen is a compact and reasonably priced display. The built-in regulator (the black dot on the back of the board) makes it simple to connect the microcontroller. The Arduino is one of many microcontrollers that have files that make it easy to display transmissions by simply pressing one key row. This regulator (HD 44780) can be found in many monitors.

A buzzer, also referred to as a whistle, is a typical electrical signaling device used in cars and home appliances like microwave toasters and game consoles. The console is typically connected to a number of controllers or detectors that determine whether a button has been pressed or whether a timer has expired. The appropriate button or control panel light then naturally turns on while the device vibrates or buzzes as a warning.

Results and Discussion

Development Arduino IDE,Real-world objects can be handled by Arduino. The boards have digital and analog input and output pins. For downloading software from personal computers, the boards come with serial communication ports, some of which even support USB. The programming languages that Arduino supports are C and C++. An integrated development environment (IDE) is offered as a compiler as shown in Figure 5.

Proteus Program code written in zeros and ones can be understood by the microcontroller. The assembly language used to create these programs. Machine code is another name for compiled software. An "executable file," also known as a "HEX data file," is the type of data file that is used to store developed programs. Proteus is widely used to emulate digital devices like microcontrollers and processors. It can simulate a USB connection, LED, and LDR, among other things.

Utilizing the cloud-based tool ThingSpeak, you can integrate, view, and assess real-time data streams. Your data is categorized into channels by ThingSpeak. Up to eight data fields can be stored in a channel. For your application, you can create as many channels as necessary. ThingSpeak is accessible from any Internet-connected device as shown in Figure 6.

The system connected to NodeMCU uses RFID cards and an RFID reader module. The LED screen shows a list of items with their prices set to zero prior to adding any additional items. The item is added to the invoice and the total is shown when the RFID tag for the product is in close proximity to the reader unit.

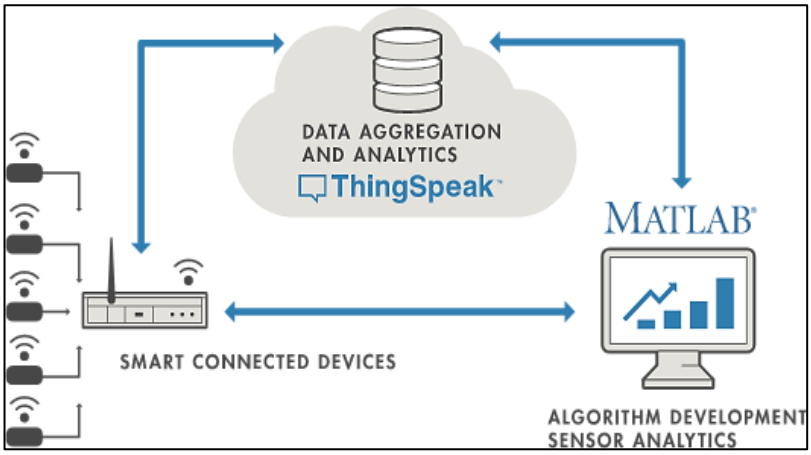

Figure 6: Thingspeak IoT

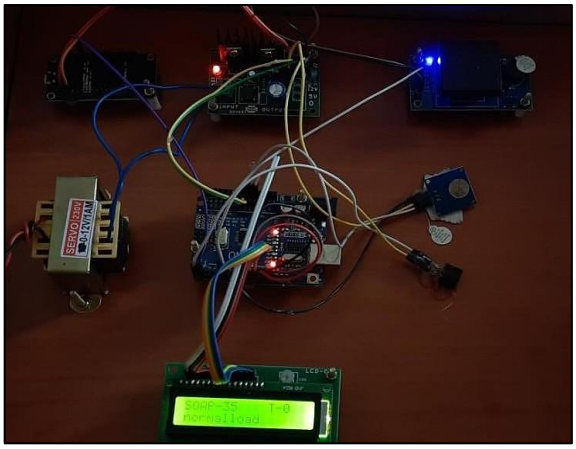

Figure 7: LCD displays the product expire

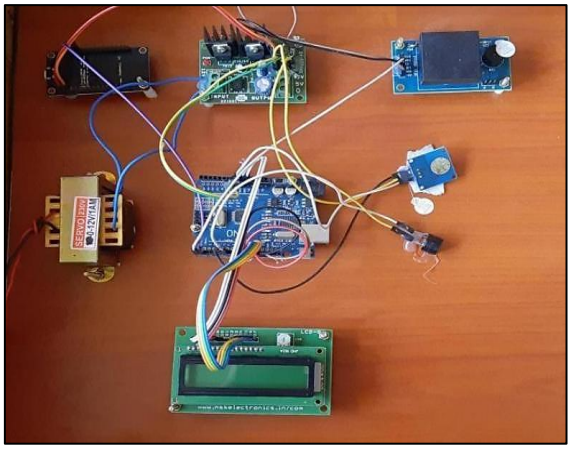

Figure 9: Hardware implementation of smart trolley system

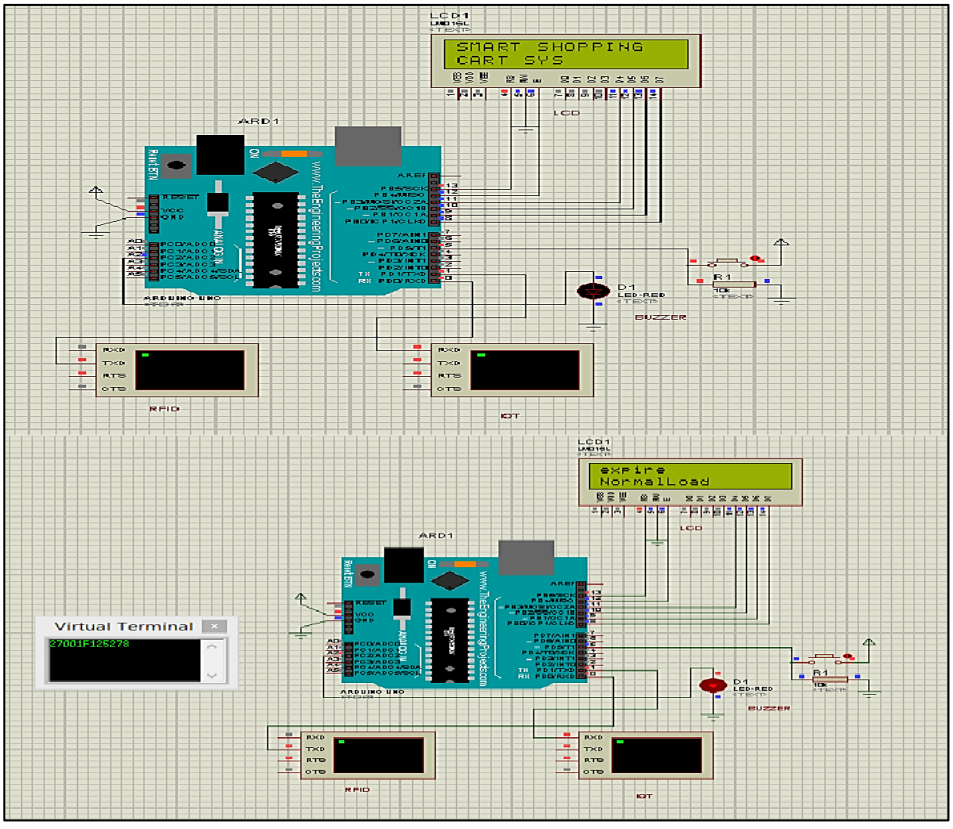

Figure 8: Software development of proposed circuit design

The system connected to NodeMCU uses RFID cards and an RFID reader module. The LED screen shows a list of items with their prices set to zero prior to adding any additional items. The item is added to the invoice and the total is shown when the RFID tag for the product is in close proximity to the reader unit If we put an RFID product on display, the scanner scans it and the LCD screen shows the price. Simply scanning an item with RFID tags allows us to add it. For instance, Figure 7 illustrates how the RFID tag in our paper was scanned using soap. The soap price value is added to the soap that is shown on the LCD screen.

Other cards with the names of different items, such as biscuits, shampoo, or anything else you specified in your code, may also be scanned during scanning. The cost is calculated each time an item is added by multiplying the cost by the previous value. If you want to take an item off the list, hold down the reset button while scanning it. The item will be removed from the system, and the price will be automatically adjusted. Figure 9 demonstrates how the buzzer will sound and the LCD screen will display the product's expiration date if it is past its prime.

Conclusion

In this trial, we present an RFID-based, secure, and intelligent purchasing system. For the first time, UHF RFID is being used to enhance the shopping experience, and security concerns are discussed in relation to a smart retail system. We carefully defined the design of the system and built a prototype to test its functionality. We also offer performance assessments and security analyses while developing a secure communication protocol. Our research introduces RFID technology as a component of developing a smart shopping system, which we anticipate will be used to cover future stores. Our upcoming research will concentrate on enhancing the existing system, for instance, by reducing computational flow on the smart cart side to achieve advanced efficiency and discover how to improve communication.

Abbreviation

RFID: Radio Frequency Identification
IoT: Internet of Things
MCU: Micro Controller Unit
LCD: liquid crystal Display
PSU: Power Supply Unit
USART: Universal Synchronous/Asynchronous Receiver Transmitter
IDE: Integrated Development Environment
AVR: Advanced Virtual RISC
LED: Light Emitting Diode
LDR: Light Dependent Resistors
UHF: Ultra High Frequency

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Not applicable.

Authors contribution

All authors contributed to the study conception and design.

Conflict of interests

The authors declare that they have no competing interests.

Ethics approval

Not applicable.

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