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Applications on Secure Smart Shopping System

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Abstract - *In this Era of Internet of Things, interactions among physical objects have become a reality. Every objects in this world are on the verge of getting connected together with the help of Internet [1]. For Example as in this paper we have introduced a new smart approach in shopping system. Here we introduce a new concept of billing the items of the customer without even having to wait in the long lasting queue. We use RFID (Radio Frequency Identification Tag) which would attached on every purchase of a item. So overall the tag is less expensive, anyways this technique will solve to get rid of waiting in long Queues. So every people must arrange their items in their respective carts, because the carts would be having an individual RFID reader, this prevents the customers rambling around in search of RFID readers. Due to this all the information like the cost of the item would be stored in the cloud or the Server so that the people would pay for their items instantly. To the best of our knowledge this is a smart system and this works on a smart basis using IOT. Hence this system should solve the current real time crisis.*

Key Words: Internet Of Things (IOT), Security, Cloud Computing, RFID, Smart Shopping, Zigbee Adapter.

1. INTRODUCTION

Internet Of Things has brought a new revolt in industrial, financial and environmental systems. So let's make things clear IOT refers to the network of physical devices, vehicles, home appliances [2] and other items embedded with electronics, software, sensors, actuators and connectivity which enables these objects to connect and exchange data between the Devices[3].

In this paper we try to focus on a Smart Shopping System[4] using ultra high frequency RFID tags which have not been well implemented in the past. The major advantage of such system is that people can get rid of standing in long queues waiting for their turn for billing the items. So here we introduce RFID meaning Radio Frequency Identification Tag which uses electromagnetic fields to automatically identify and track tags attached to objects [5].

In the implementation we have couple of components such as the Ultra High Frequency RFID Tags [6] which is very inexpensive and has a range up to 12m followed by the Micro Controller which is primarily used for Data Processing.

LCD Touch Panels which are equipped with User Interface, Zig Bee Adapter with is used to communicate with the Cloud or the Server and most significantly a Weight Sensor which is used for weighing the items

The next thought that come to our mind is that Why are we using cloud or the main server .Well, the answer is for storing all the updated prices of the items, this prevents sticking or writing the cost of each product on all the items.

So the moment the customer grabs his byte, the cart will search in for the price of the item from the cloud and display it on the LCD panel. Due to which the customer can decide whether their item is worth for his penny or not.

1.1 EXISTING

The existing system of shopping is a long process and consumes lot of time like choosing the products, waiting in the queues, scanning the products and checking out. This is a lengthy process and we can use the trending cutting edge technology of IOT to reduce the time and solve the problem. Most of the time is wasted in a never-ending queues and billing of the items which creates a havoc in the shopping malls. These are the points where we can target to reduce the time in the existing system.

Hence if we reduce time in scanning by automating long queues problem can be reduced. More significantly the dynamic range of the RFID's [7] has been increased when compared to the past. These minor tweaks help us to move further and solve the problem.

1.2 PROPOSED

Smart shopping cart is the solution for the above existing problem, this cart is equipped with sophisticated microcontroller and sensors which reduce the time in billing as it would be scanning the items instantly as and when the item is added to the cart and this would totally eliminate the queues in the shopping centres.

Sensors and microcontrollers is easily available at a very cheap rate and could be equipped to each and every cart and at the exit a scanner would be placed for security which would alert if payment has not been processed. This would overcome the difficulties currently present in the market.

2. SYSTEM ARCHITECTURE

The Components of the Smart Shopping System from the below shown figure 2.1 include:

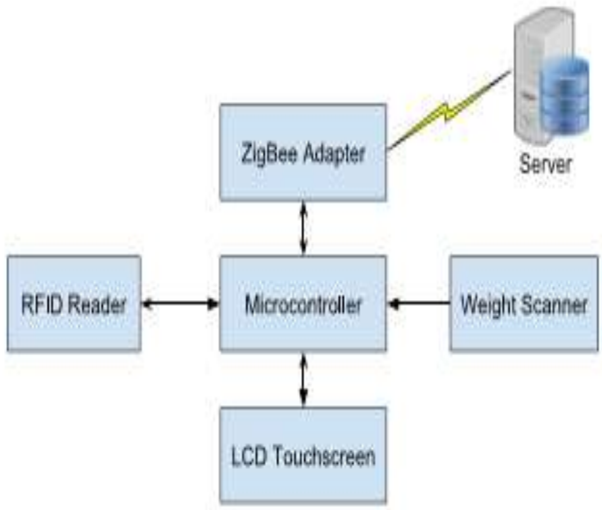

Figure 2.1: System Architecture of Smart Shopping System.

1) **Server**: All items are registered to the server before moved to the shelves. The server stores all items' information, such as location and price, in a database. The server communicates with all the other entities in the smart shopping system through Zig-Bee.

2) **Smart Cart**: As shown in Figure above, the following components are equipped on the smart cart.

- **Microcontroller**: Coordinates with the RFID reader, Zig-Bee adapter, weight scanner, and LCD touch screen to perform computing functions.
- **Zig-Bee Adapter**: Zig-Bee is a low-cost and low power protocol that costs much less energy than Wi-Fi
- **Weight Scanner**: The weight scanner can weigh items that are put in the cart to ensure the tag corresponds to the correct item.
- **RFID Reader**: UHF RFID reader is used which allows a reading range up to 10 m. By tuning the transmission power of the reader.
- **User Interface (LCD Display):** Displays product information, possible navigation choices, billing information, and coupons, etc.

3) **Smart Shelves**: Installed with RFID readers that monitor the status of the item.

4) **Smart Checkout Point**: The checkout point is installed with PoS for the customer to make a purchase. After making the payment, a customer has to go through a lane, where an RFID reader can read all the items.

2.1 BUILDING FUNCTIONAL SMART CART

Figure 2.2: Smart Cart

The prototype is built to test our design and functionality. Figure 2.2 shows the components of our designed smart cart. According to our tests, when putting an item into the smart cart or removing an item from the cart, the smart cart is able to accurately read it.

One surprising result is that, the metal outside the cart blocks the signal to a pretty high extent that, when the reader is inside the cart, no item outside the cart can be read. This clearly indicates that an item put into a smart cart will not be read by a nearby cart accidently.

It is also possible to test how to set an RFID reader at the checkout point so that the items in the cart can be accurately read. In the design, information such as price, location and coupon are stored in a database of the server, rather than in the tags, because such information might change over time, and it is more convenient for the server to manage them.

In the above figure 2.4 there are some components present with the labels 2a, 2b and more where the details of all components could be found in the table 2.1

2.2 WORKFLOW OF THE SMART CART

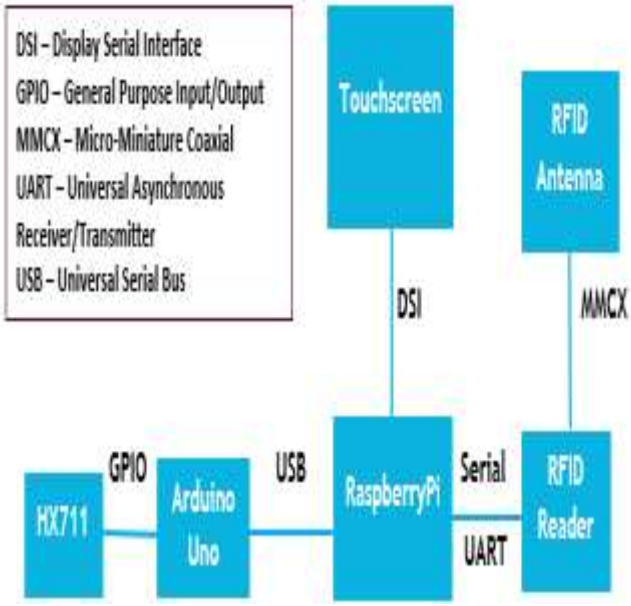

Figure 2.3: Workflow of the Smart Cart

The workflow of our smart cart is illustrated through Figure 2.3 which shows how various components are connected to each other. Significantly it indicates how the Workflow takes place between these components.

Table 2.4: Specifications of the Components.

	Function	Components	Description
1	Cart	Shopping Cart	Standard Metal Frame
2	Micro-processing	a) Raspberry Pi 3 b) Arduino Uno as an interim solution for weight sensor	1.2GHz 64-bit quad-core ARMv8CPU; 802.11n Wireless LAN; Bluetooth 4.1 Bluetooth Low Energy (BLE); 1GB RAM; 4 USB ports; 40 GPIO pins; Full HDMI port; Ethernet port; Combined 3.5mm audio jack and composite video; Camera interface (CSI); Display interface (DSI) Micro SD Card slot (now push-pull rather than push-push); Video Core IV 3D graphics core.
3	Display	Raspberry Pi Foundation 7" Touchscreen LCD Display	RGB 800480 display @ 60fps; 24-bit color; FT5406 10 point capacitive touchscreen; 70 degree viewing angle; Metal-backed display with mounting holes for the Pi;
4	Weight Sensing	a) HX711 ADC b) 4xHalf Bridge Load Sensors	Signal Amplifier; Analog-to-Digital Converter;
5	RFID Reader	a) Cottonwood Long Range UHF RFID Reader b) Circularly Polarised Antenna (5dB)	EPC Gen2 Compatible; Global Frequency Capable (840-960MHz); 20dBm Max Antenna Power, 1.5-2W Power Consumption; GPIO Programmable; UART Serial Interface;
6	Power Supply	Polanfo 1200mAh Power Bank Universal Ultra Compact External	Charge input 5V/1 A; Two USB output ports (2.1A and 1A)

The Specific Description of each and every component can be found in Table 2.4 as shown above. Wherein we get a clear picture about the requirements of the components.

3. IMPLEMENTATION

Figure 3.1: The System Model

The above Figure 3.1 depicts the system model. The server communicates with the smart shelves, smart carts, and the checkout points. The smart shelves are able to monitor the items on the shelves by reading the RFID signals from the tags; the smart carts are able to read and retrieve information of the items inside the carts; finally, the checkout points can validate the purchase made by a customer.

The combination of symmetric and asymmetric cryptographic systems is used. The server is assigned with a pair of asymmetric keys Ps and Ss. Each smart cart is assigned a unique ID i and a pair of asymmetric keys Pi and Si. Each checkout point is assigned a unique ID j and a pair of asymmetric keys Pj and Sj.

For asymmetric encryption and decryption, we denote the encryption to cipher text c of data d with public key P by c=EP(d), and decryption of cipher text c with private key S by d =DS(c).

For symmetric encryption and decryption, we denote the encryption to cipher text c of data d with key s by c=Es(d), and decryption of cipher text c with key s by d =Ds(c).

4. APPLICATIONS

Applications of this system would be a smart shelf. Intuitively this brings the following benefits.

1) Items put into a smart shopping cart (with RFID reading capability) can be automatically read and the billing information can also be generated on the smart cart. As a result, customers do not need to wait in long queues at checkout.

2) Smart shelves that are also equipped with RFID readers are able to monitor all stocked items and send item status updates to the server. When items become sold out, the server can notify employees to restock.

3) It becomes easy for the store to do inventory management as all items can be automatically read and easily logged.

5. CONCLUSIONS

The secure smart shopping system utilizes RFID technology. This is the first time that UHF RFID is employed in enhancing shopping experiences and security issues are discussed in the context of a smart shopping system. The detailed design of a complete system and its working is shown.

It involves building a prototype to test its functions. It also consists of a secure communication protocol and present security analysis and performance evaluations. It is believed that future stores will be covered with RFID technology and our research is a pioneering one in the development of a smart shopping system. Our future research will focus on improving the current system, for example, by reducing the computational overhead at the smart cart side for higher efficiency, and how to improve the communication efficiency while preserving security properties.

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