ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 9, September 2015

Smart Warehouse: An RFID-IoT Approach

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Abstract: Efficiency of a warehouse plays a pivotal role in the product delivery cycle, both in terms of cost and time. With the advent of RFID in this field, though the efficiency has increased by the use of RFID in locationing and tracking of the items, general functioning of the warehouse has not utilized the concept of RFID in its entirety. The system presented here attempts to use the RFID technology in order to include the basic functions like temperature, light regulation, etc in the existing infrastructure. Also, the paper covers IoT view to connect the devices to the web by exploiting the uniqueness of the RFID identifiers (EPC).

Keywords: RFID (Radio Frequency Identification), IoT (Internet of Things), EPC (Electronic Product Code), AC (Alternating Current), DC (Direct Current), I2C interface (Inter Integrated Circuit), Internet Protocol version 6 (IPv6).

I. INTRODUCTION

The system presented here consists of three main parts. Firstly, a RFID sensor node is introduced, which consists of an ordinary sensor connected to a passive RFID tag over the I2C interface [1] of the microprocessor present inside the tag. This node takes power from the incident RF and provides a multipurpose platform to interface all sensors.

Next, we present an entire scenario where the presented sensor node is employed in warehouse for different functionalities and the sensing information is then collected by an overhead RFID reader. In doing so, we make use of the present infrastructure which includes the deployed overhead RFID readers those are used for the locationing of the items inside a warehouse. The Data from the readers is relayed to different platforms depending upon the requirements.

Lastly, we propose an idea, which makes use of the uniqueness of the objects provided by the RFID identifier, EPC, and the sensor node, to build an IoT ecosystem for warehouses that can be extended to multiple domains. The idea justifies the address and the cost limitation that are essential for the development of IoT devices.

II. PROPOSED SYSTEM

The three main working parts of the system are presented as follows:

A. RFID Sensor Node:

The sensor node presented here, serving as means to collect the information from the sensors and relaying them over RF to be read by RFID reader is based on the work presented in [2]. The block diagram for the same is presented in the fig [1].

The sensor node consists of four parts:

i) Microchip: This forms the core of a tag and mainly consists of a microprocessor chip which is used by a RFID tag for its functionality i.e. to backscatter the encoded information present inside the memory of a tag. A typical Microchip is shown in fig [2].

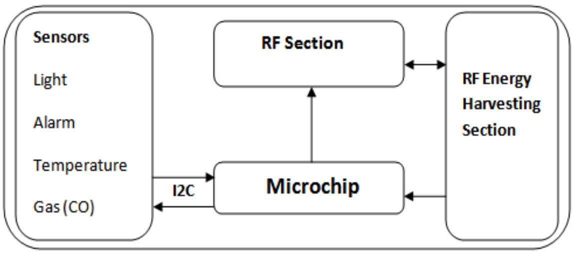

Fig 1.Block Diagram for RFID Sensor Node

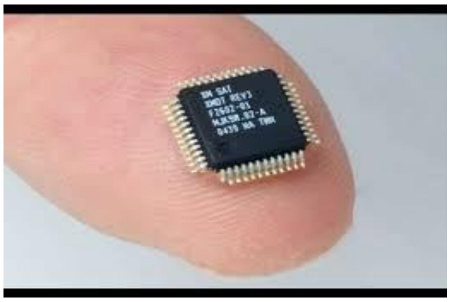

Fig 2. A microchip

ii) RF section: This consists of the coiled antenna which serves as a source for the consumption of incident RF. The RF section produces an AC as output which is then used by the subsequent section to convert into the desired level of power to be used by the microchip.

iii) RF Energy Harvest System: The energy from the RF section is in AC form which is converted to DC by the use of a rectifier circuit. Subsequently, the voltage levels are then raised to the required value of 2.4V (in most cases) by the use of the voltage multiplier circuit.

iv) Sensing Unit: The sensing unit consists of sensors like temperature sensor, smoke sensor, ambient light sensor, etc which are interfaced with microchip over an I2C interface. The sensors transfer the data to microchip which, in turn backscatters [4] the data to the RFID reader.

As any RF wave form a reader is incident on the node, it gets energized i.e. the RF section produces an alternating current and voltage. Subsequently, this power is then

ISSN (Online) 2278-1021
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IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
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rectified and amplified to produce desired level of voltage and current in the energy harvesting system. The power produced is thus used to energize the microchip which then reflects the data back to the reader through the phenomenon of backscattering. The prototype of the RFID sensor node presented in [2] is reproduced in fig [3].

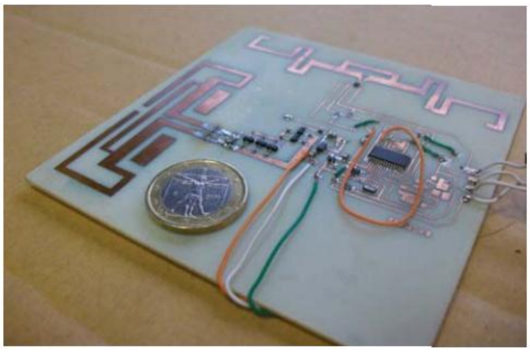

Fig 3 .Prototype for RFID Sensor Node

B. Smart Warehouse Ecosystem:

The smart warehouse ecosystem is an extension to the existing framework of the RFID readers expanded to include the RFID sensor nodes so that the same reader also works as a monitoring unit for all the sensors present inside the warehouse. This increases efficiency of the readers and hence brings down the cost substantially.

The different sensors that are used in normal warehouse situation are as follows fig [4]:

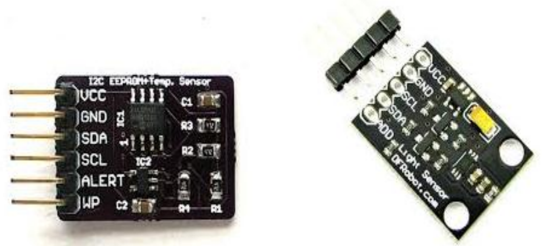

Fig 4. Temperature and Ambient Light sensor

Temperature Sensor: This is used to maintain the temperature of the warehouse in case of temperature specific items including perishable goods like food and vegetables and inflammable objects like petrol, kerosene, etc. The sensor gives an indication if at any time the temperature falls or rises beyond specified threshold level.

Ambient light sensor: This sensor measures the amount of the light present inside the warehouse and indicates if there's wastage of the energy in case of sufficient lighting conditions.

Smoke/Gas (e.g. Carbon Monoxide) Alarm: For warehouses storing the petrochemical and other liquid or gaseous material, this alarm gives an indication if there's a leak in any gas tank.

Also, there are other sensors like pressure sensor, proximity sensor, movement detector, etc, which are used for different purposes in a warehouse.

All these sensors when interfaced with the passive tags forms the sensor nodes as explained in the previous section. While interfacing the sensors it is made sure that all the sensors have a unique EPC ID so that it is uniquely identifiable. After having tagged all the sensors are deployed at different positions in the warehouse.

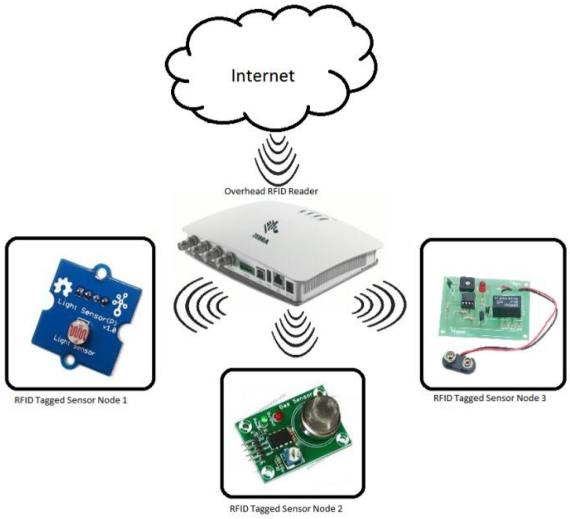

Fig 5. Pictorial Representation of Smart warehouse

On the reader side, the reader is periodically configured to do an inventory operation on all the tags in the view field. The data that is obtained from the sensor nodes, distinguished and sorted on the basis of the EPC is fed to the controlling unit which can be a local machine or in our case, to the cloud. The actions to be taken on the basis of the information are then carried out. The pictorial representation of the system is presented in fig [5].

C. IoT Extension:

The senor nodes presented here are a part of an RFID system. An RFID system facilitates IoT by solving the problem of unique identification of large number of items and cost of creating an IoT interface. This is done by the use of the EPC as a means of unique identifier rather than using IPV6. The total number of address bits which can be programmed in EPC is 240[5], that is much greater than the total number of addresses (128 bits) that IPV6 has to offer.

Secondly, once the sensors are uniquely identifiable, they are accessible beyond the network domain of a dedicated reader that is present in the warehouse. Rather, these sensor nodes can be read by any reader and will still represent a unique sensor globally.

For example, a sensing node S1 having an EPC ID EPC1, present inside a warehouse W1, can be accessed by any reader that may or may not be present in the network domain of W1 as shown in fig [6]. The same applies for all the objects being tracked in the warehouse i.e. the information about the objects becomes global as soon as they are RFID tagged.

Lastly, the sensor nodes with a common reader forms a local sub-system which further reduces the problem of large addresses as this entire network can be then accessed using a common network ID.

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Fig 6. Typical global access of Sensing Node

Major advantage of making available the information about the sensors on the web is that it makes the information more easily accessible and reduces the time delays that can be otherwise caused due to the constraints on the free flow of the information. Also, the sensor nodes here proposed are made out of RFID tags which are very cheap as compared to other counterpart technologies like Bluetooth/Wi-Fi modules. This cost factor also plays a major role in deciding the success of an IoT device.

III. CONCLUSION

This paper presented how the present RFID infrastructure can be extended to achieve the functionality of a smart warehouse. It theorizes using the passive RFID tags with microcontroller unit to interface with various sensors present in the warehouse through I2C protocol. The data populated in the tag's memory banks through the sensors could be read by an overhead reader. Then the data is proposed to be managed locally or communicated to the cloud using web services. The data communicated via any network topology can be used to control the environment of automated warehouse with increased convenience and efficiency while subsequently reducing the cost. We also proposed that the RFID used in conjunction with IOT solves the problem of limited addressing imposed by the use of IPV4/V6 addressing systems. More can be explored about how the data can be utilized to further enhance the automation of warehouse through the use of various sensors.

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BIOGRAPHIES

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