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Integrated RFIDs and WSNs and Optimization of Industrial Automation in Dairy Maintenance Warehouse

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Abstract- Radio Frequency Identification (RFID) and Wireless Sensor Networks (WSN) are two important components of pervasive computing, since both technologies can be used for coupling the physical and the virtual world. Each of them has separate research and development areas and various applications. RFID systems are used to identify objects/people; on the other hand, WSNs are used to provide environment information. The integration of these technologies has a significant impact on many industrial applications and these technologies should be suggested as a suitable complement. In this article after a brief look at WSNs and RFID systems and their applications, we described and compared possible architectures of integrated of them and provided a plan to integrate these technologies in a dairy warehouse.

Keywords- *RFID (Radio Frequency Identification); WSN (Wireless Sensor Nodes); Warehousing*

I. INTRODUCTION

Radio Frequency Identification (RFID) is a technology that has attracted a lot of attention in industrial applications. It's generally said that the roots of Radio Frequency Identification (RFID) technology can be traced back to world war. RFID consists of two main component reader and tag, it can be used to identify and track tagged object /people. RFID communication is fast, convenient, and its application can substantially save time, improve services, reduce labor cost, thwart product counterfeiting and theft, increase in productivity gains, and maintaining the quality standards. Common applications range from highway toll collection, supply chain management, public transportation, controlling building access, animal tracking, developing smart home appliances, and remote keyless entry for automobiles to locate children.

Nowadays, it plays an important role in supply chain and warehousing.

On the other hand, Wireless Sensor Node(WSN)s are networks of small, cost-effective devices that can cooperate to gather and provide information by sensing environmental conditions such as temperature, light, humidity, pressure, vibration, and sound. A sensor network is composed of a large number of sensor nodes and they can be used in various applications and installed in different places, even in the body. The evolution of RFID and WSNs has followed separate research and development paths and has led to distinct technologies. However, it may be crucial in some applications in which the information is obtained about the position of objects or reverse form. The optimal solution in these cases is the integration of both technologies because they complement each other.

Here, at first we have a look at RFID and WSN networks and study the reasons or benefits of their integration and presented possible architectures of their integration [1] at the end we will provide a system for keeping dairy products in warehouse with one of these architectures.

II. REVIEW OF RELATED STUDIES

The integration of RFID and WSN can help to increase applications of these growing technologies and fill the gap between reality and the world of research/academic. This is because the resulting integrated technology will have extended capabilities, scalability, and portability as well as reduced unnecessary costs.

A. RFID technology

A.1) RFID tag types

RFID tags based on the power source can be divided into three categories: Active tags, passive tags, semi-passive (semi-active) tags. Active tags have a battery and they use its power to transmit information, passive tags have no battery that uses RF signal from reader or transceiver to transmit data.

Every passive tag contains an antenna by which the required electromagnetic energy to wake up the tags are collected.

Semi-active tags use sender's radio waves such as passive tags to transmit information. The semi-active tags may be equipped with batteries to keep the memory tags or power added functions.

Active tags are more expensive than of two other types but they are stronger. For instance, they have larger range / memory and more functions.

A.2) Radio Frequency

RFID tags act in three frequency ranges below: low frequency (LF, 30–500 kHz), high frequency (HF, 10–15MHz), and ultra-high frequency (UHF, 850–950MHz,2.4–2.5GHz,5.8GHz).

LF tags are cheaper than tags with higher frequencies and they are fast enough in most applications. They are better in fluids or metals though; LF tags have low reading speed and short-range reading. These tags are suitable for access control, animal identification and inventory control and the common used frequencies for them are 125–134.2 kHz and 140–148.5 kHz.

HF tags have an average reading rate and reading range; they are used in access control and smart cards. The most common application among them is smart card with working at 13.56MHZ. They range from 3 to 6 meters for passive tags and more than 30 meters for active tags.

The high transmission rates of UHF tags allow the reading of a single tag in a very short time. They can be used when objects move quickly and are short time in reader range.

B) *Applications of RFID and WSNs*

The major application of RFID systems is to identify of tagged objects or people and other important application is the location of objects and persons.

We distinguish various methods for detecting the position such as: object position detection by the mobile reader based on diagnosis tags placed in a fixed and known locations and identify the tagged object based on a fixed position readers.

WSNs are mainly used for sensing the environment, positioning and identifying objects/people. WSNs are used for sensing temperature, humidity, pressure, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels, etc. WSNs can be used for sensing the environment, or sensing phenomena related to objects or people when sensors are attached to them.

C. *Differences between RFID and WSNs*

The main components of WSNs are sensor nodes and communication among the nodes is multi-hop. But RFID classical systems consist of tags and readers and Communication between the reader and the tags is single-hop. Standardization efforts in RFID networks are significant and have main standard organizations including EPC Global and ISO, each of these organizations offer a set of standards.

This process is very different about WSNs where industry involved is very low. The WSN nodes can be deployed randomly or fixed but if you consider the long-range RFID readers, in order to cover all the tags in range and also to prevent interference the RFID antenna positioning should be carefully selected. There are several types of interference in RFID networks these are: tag-to-tag, reader-to-tag and reader-to-reader interference. The sensor nodes are more intelligent than RFID tags and sensor node's firmware are easily re-programmed but this is not the case for RFID tags.

Thus, RFID networks and WSNs can be complementary technology and there are many benefits of integrating these two technologies, such as: adding ad-hoc capabilities to RFID network, adding sensing capabilities to RFID tags and adding tracking capabilities to RFID tagged objects that are difficult to detect otherwise.

III. The existing architectures for the integration of RFID and WSNs

A. *The integration of RFID tags with sensors*

Integrated RFID tags with sensors or sensor-tags are divided into two main groups: Integrated sensor-tags that are able to communicate only with RFID readers and integrated sensor-tags that are able to communicate with each other and form a cooperative ad hoc network. In continue we will bring the architecture and examples of existing applications each of them.

A.1) Integrated sensor-tags that are able to communicate only with RFID readers

Add sensing capabilities to RFID tags is the easiest way to integrate RFID networks and WSNs. Many RFID tags have incorporated sensors in their design and, thus, they are able to take sensor readings and to transmit them later to a reader (Figure1).

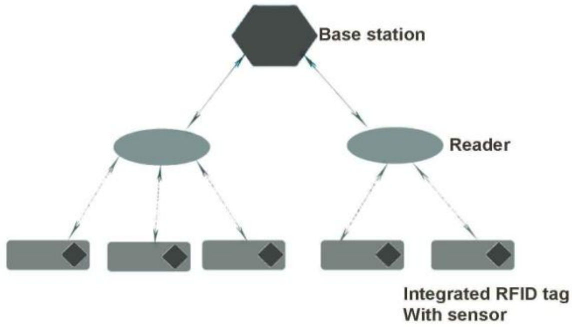


Figure1.Integration of sensor-tags, RFID Reader, Base station

In these integrated sensor-tags, RFID tags are given sensing capabilities and they function as normal RFID tags also because they use the same mechanism for reading tags and collecting data sense line between RFID and sensor networks becomes blurred. The integration of RFID tags with sensor nodes is based on converting the sensors' analog signal by the A/D module while the resulting data is forwarded by the readers to the base station [2].

There are differences in the integration of different (active, semi-passive, passive) RFID sensor- tags:

- Active Sensor-Tags

These sensor-tags use batteries to communicate. Thus these sensor-tags have a long range (30meter) and for this reason they cost and the weight is increased but has a limited life time. Active sensor-tags are used in the following applications: temperature sensing and monitoring, vibration detection, blood pressure and heartbeat rate monitoring, etc.

Deng et al. [3] proposed two different architectures for sensor-embedded RFID (SE-RFID); in the first architecture multiple sensors in a tag can be embedded. Sensors are controlled by a programmable timer. The sensors sample external data independently and periodically. The sampling of sensing data can be turned on/off and be programmed through the reader. Since the tags in the system need to be periodically turned on to sample data, they need to be battery-powered. In the second architecture, each sensor embedded a single RFID tag. Since the tag has only one sensor and the microprocessor is embedded in the reader, the tag in this architecture consumes much less energy compared with that in the first architecture.

- *Passive Sensor-Tags*

These sensor-tags have no battery and therefore have lower cost and unlimited life-time. But because sensors need to battery power, usually the sensor-tags use active or semi-active tags however; some of these sensor-tags exist and receive operating power from the RFID readers. Passive sensor-tags are used in the following applications: temperature sensing and monitoring, PH value detection, and photo detection.

Cho et al. [4] proposed a passive sensor-tag with incorporated temperature and photo sensors that can be used for environmental monitoring. The proposed sensor-tag is powered by an external ISM band RF signal and it senses ambient temperature and light.

- *Semi-active (passive) Sensor-Tags*

In these sensor-tags if the RF signal of reader is sufficient for operations, acts such as a passive sensor-tags. If not they use of their battery power and operate as a semi-passive senor-tag. Semi-passive sensor-tags are used in the following applications: temperature sensing and monitoring, location recording, vehicle-asset tracking, and access control.

Kim et al. [5] proposed an integrated passive and battery-powered semi-passive UHF RFID tag which supports the EPC Gen 2 protocol. The proposed sensor-tag functions as a passive RFID tag, when the generated RF power is sufficient to operate.

In other cases, the sensor-tag functions in a semi-active mode using battery power. The sensor-tag is also employed with a rewritable nonvolatile memory bank formed by Ferroelectric RAM (FeRAM) and an on-chip temperature sensor.

A.2) Integrated sensor-tags that are able to communicate with RFID readers and each other

In previous architecture the communication capabilities were limited whereas, in high-end Applications, it is possible to integrate RFID tags with wireless sensor nodes and wireless devices, and be able to communicate with each other as well as with other wireless devices which are not limited to readers (Figure2).

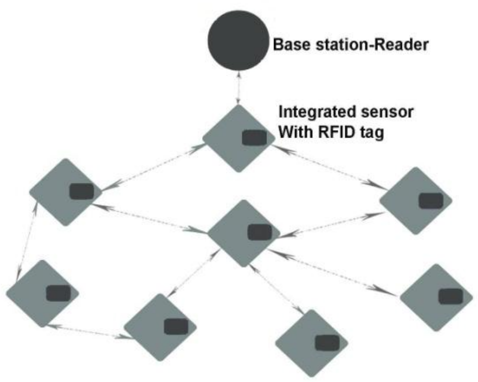


Figure2. Integrated sensor-tags that form a cooperative ad hoc network

Sensitech has released an RFID-sensor integrated device called Temp Tale RF-enabled (TTRF) [6] temperature monitoring device. TTRF is built into an active RFID tag and it is composed of a temperature sensor, a radio chip, and an antenna. The sensor records and stores temperatures periodically while the active tags transmit the sensed data to RFID readers. This data is collected centrally and it can be used to trigger alarms when, for instance, there is a danger of perishable goods to go off because of too high or too low temperatures. This integrated sensor-tag has battery power and a microprocessor and it is able to operate within an RF mesh networking environment. It operates in the 915 or the 868 MHz ISM band and the temperature measurements range from -30°C to 70°C.

B. Integrating RFID Readers with Wireless Sensor Nodes

RFID readers with WSNs are integrated in this model of integration. In this architecture that was introduced at first with Zhang et al. [8] three types of devices exist: the integrated RFID readers/sensor nodes, simple RFID tags, and the sink/base station. (Figure3)

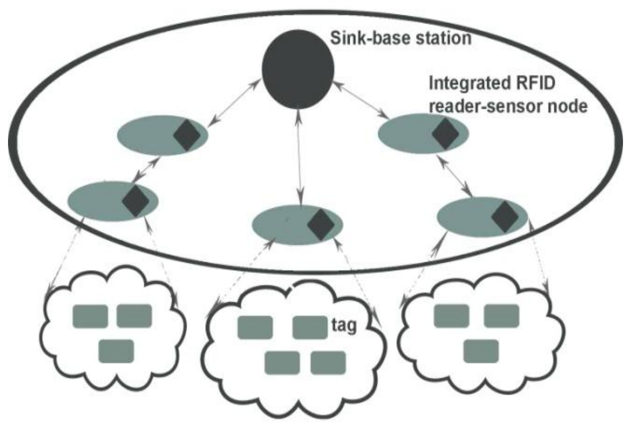


Figure3. Integrating RFID Readers with Wireless Sensor Nodes

They are called the integrated RFID reader/sensor node “a smart node”. Smart nodes are able to communicate with each other through creating ad hoc communicate networks. They can act as a router and deliver message to the right destination. These nodes collect data from their range and transfer them to the Base station/Sink where all data is collected and processed by human.

Yang et al. [9] identified that in this type of integration since the smart nodes have a fixed transmission range; the amount of traffic that is required to be forwarded will increase considerably as the distance to the base station becomes shorter. Next, smart nodes that are nearer to the base station will run out of battery early and areas of the network will remain unmonitored. They are considered this type of integration and propose a strategy that can be used to balance the energy consumption of the network and lengthen its life-time. Their proposal for balancing the load among the readers is based on adding more readers in the area near the sink.

C. *Mix Architecture of RFID and WSN*

In contrast to the previous cases, RFID tags/readers and sensors in this architecture are physically separated. Mixed architecture proposed in [8] which consist of three devices: the smart stations, the normal RFID tags, and the normal sensor nodes (Figure4).

Since in Mix architecture tags and sensor nodes are separate physical devices there is a possibility of communication interference. But due to this separate physical state, there is no need to design an integrated hardware.

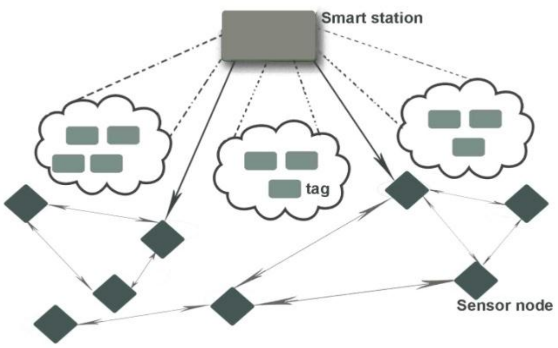


Figure4.Mix Architecture

Some commercial solutions able to support the integration of RFID and WSNs according to the mix architecture have already been proposed. For instance, RFID Anywhere [9] is a commercial platform which includes rich features; broad hardware, standard and protocol support, and architecture flexibility that developers and integrators need to produce integrated RFID/sensor applications. In the next part we have one of the best applications of this integration.

IV. Proposed System for Maintaining Dairy in Warehouse Based on Mix Architectur

A. *Measured and calculated results*

Our research and analysis carried out two types of products (milk and yogurt) and got the following results:

t=Temperature , v=volume, p=package

h=humidity, T=Time life , $T \alpha \ t^{-1} h^{-1} v \ p$

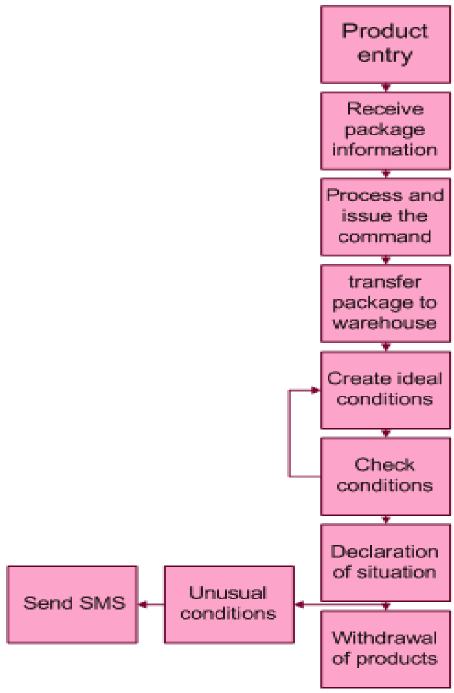


Figure5. The flowchart of proposed system

According to conducted surveys temperature control is one of the factors that its control plays an essential role in controlling the life-time and consumption time of these products.
As standard, these products should be kept at a temperature of 0 to 4 ° C and reach to the consumer demand after 2 days.

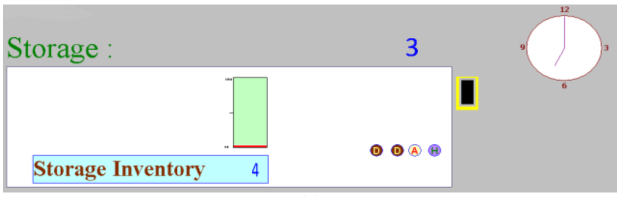
As can be seen to have an automation warehouse system that don’t need to control with human power.
Along with the use of RFID that contains information such as weight, production date, expiry date and etc also is the needs to control environmental conditions (temperature) .We provide a system by using the Mix Architecture which is shown in the flowchart of the process in continue.

The system is designed so that it centralizes the management of the warehouses and makes it more efficient. This is done through an information system based on GSM that reports the stock statues of environmental conditions. (Figure5)

B. *Simulation and Results*

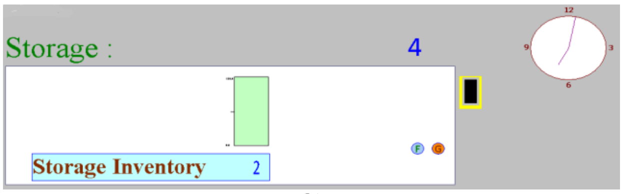
The plan proposed by arena software has been simulated in factory inventory for 20 days. As an example one day of the proposed plan is described below:

-Beginning of the third day, Products are observed.



(a)

-At the end of the third day and beginning of fourth day, older products are transferred out of the inventory and newer products remain.



(b)

And also an alarm with a T message in bad environmental conditions, transfers products out of the inventory.

(C)

(d)

FIGURE4. (A) WAREHOUSE IN THIRD DAY,(B) WAREHOUSE IN FOURTH DAY,(C) PRODUCTS WITHDRAWAL IN BAD ENVIROMENTAL CONDITION,

(d) Dairy warehouse

In this simulation those products that a board is used for modeling them are shown as a circle, with random letters. Using this simulation, the proposed model is analyzed and satisfying results are obtained, reducing the existing problems in these factories. In the next publication, this model is implemented in a dairy factory and results will be reported.

V. CONCLUSION

The integration of the promising technologies RFID and WSNs will maximize their effectiveness, give new perspectives to a broad range of useful applications, and bridge the gap between the real and the research/academic world. The essential advantage of using the proposed system of Mix architecture is that it doesn't require the construction of new hardware and it is the best integration architecture of these two technologies to control stock and environmental conditions in dairy warehouse. However, in the proposed architecture there is the possibility of communication interference between the RFID tags/readers and sensor nodes because in that case they are all physically distinct devices. But the made efforts to eliminate this issue and this novel system is appropriate alternative for traditional warehousing.

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