THE INTERLINK BETWEEN RFID OF THINGS AND INTERNET OF DOMESTIC THINGS

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ABSTRACT
Radio frequency identification (RFID) technology application spans across numerous industries. Due to its automatic and unique identification capability through radio frequency signal. Although advance applications such as logistics, access control, security, etc are center focus of research so far, domestic things such as personal belongings (bags, shoes, kitchen utensils, furniture's, clothing's etc) yet to find their fit. These things are lot more than the current numerous applications of RFID system. For instance, each individual can have more personal belongings such as shoes, cloths, mobiles phones, furniture's, automobiles etc. therefore expanding the future of RFID beyond scientific and industrial applications to domesticated applications tailored toward securing personal belongs. Furthermore, this can increase the scope of internet of things to internet of domestic things (personal belongings). This research paper presents the description of a future RFID application scope beyond industrial applications to domestic application suited for personalization, identification, and tracking of personal belongings. This is termed RFID of things, which further enhances the prospects of internet of things into domestic things (personal belongings: cloths, shoes, shirts, bags, furniture, kitchen utensils, electronic gadgets e.t.c) being connected over the internet, termed as internet of domestic things.

1.0 INTRODUCTION
Internet of things is defined as addition to applications of networks such as the internet that utilizes sensor technology and smart gadget for discernment to interact with the physical world (Ran and Jinfeng 2016). Also Internet of things is a terminology that describes a network that connects everything together (Zhu and Yang, 2010). This portend a great applications enabling services opportunity for electronic and none-electronic items to become connected, using information technologies (Ran and Jinfeng 2016). Following the advancement of internet of things between 2008 to 2010 (Kurt, 2012), which has experienced tremendous growth due to the exponential number of things connected over the internet, as shown in fig1 below. Internet of things research is concerned with a future of everything connected to the internet. Several research evidence exist showing its practicability. Internet of things application spans cross variety of domain, amongst which includes (1) in healthcare, IOT promises identification of pharmaceutical items and medical instrument (2) in public safety and emergency response, IOT promises effective surveillance of emergencies (Sun and Zhang, 2012) such as public safety and emergency response.(3) In automotive industry, IOT can to simplify diagnosis through leveraging on attached sensor data monitoring various parts of the automobile such as tire pressure, engine temperature, oil level, fuel level etc (Hank, et al., 2013). (4) In logistics and public transport, IOT provide an alternative effective means of transportation of people, goods and services such as intelligent ticketing and luggage management (Ran and Jinfeng, 2017).

Despite all these research, there has been little or no research effort towards connecting domestic things such as none digital items (shoes, cloths, kitchen utensils, etc) and electronic items (TV set, refrigerator, microwave oven etc) considering their vulnerability to theft and need for unique identification as an anti-theft solution. In addition to the large quantity of domestic things in terms of their presence and number available to person and per home, there will also be need for unique identification of such things. Therefore, connecting things requires sensors capable of collecting unique identity things effectively as well.

It is in this basis that RFID technology stands as a significant component for enhancing internet of things application with unique identification. Therefore, RFID of things follows the same concept of connected things with focus on identification of things, especially domestic things (personal belongings: furniture, shoes, bags, kitchen utensils, clothing etc). With the overall promise that all humans and things will privately interact and indentify themselves uniquely. We propose a future where personal belongings identify their owners and each person identifies their personal belongings.

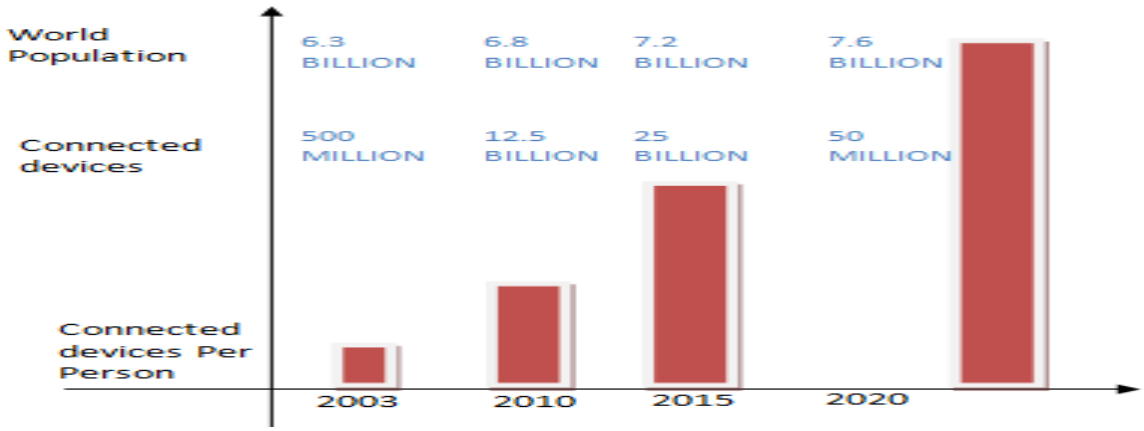


Figure1. Internet of things growth between 2003 and its vision 2020 projection

This research paper is divided into five sections. The first section is a brief introduction, while the second section is dedicated to related literatures, the third section delves into an overview of RFID systems and Internet of Things and the interlink between RFID application growth and Internet of things application. The third section presents numerous industrial applications of RFID technology connected over the internet. The fourth section is a description of RFID of things architecture and application, advantages of RFID of things. Finally the fifth section

2.0 RELATED LITERATURE

Numerous researchers and authors has been investigating the principles and applicability of RFID systems in various domains connected over the internet (internet of things), as evidence in the empirical study conducted by (Dave Evan (nd)) which outlined industrial applications of RFID across several industries. In (Mandeep, et al., 2011; Linda and Samuel, 2007), a quick primer on the RFID working principles was done, alongside concluding on the numerous current and envisaged application of RFID systems connected over the internet was understudied, considering many domains. Also highlighting the advantages of RFID systems, communication protocols. In addition to (Mandeep, et al., 2011; Linda and Samuel, 2007). Arun (2009) developed a guideline for expediting literary content analysis and points at

future directions of RFID technology application research domain. Also, (Friedemann Mattern (nd)) evaluated the use of ZRFID systems in six major areas in a production industry for internal operations and for supply chain management. RFID application has also been successful in various industries. The tourism industry has experienced it fare response to RFID applications but not without challenges. Although (Kurt, 2012), proposed some mitigation strategies useful, when developing RFID applications in tourism and hospitality industry. Furthermore, RFID application in library management has also been successful. In (Paul and Vanesa, 2008) the application of RFID in library management was explored, considering numerous technical hitches, including electromagnetic interference etc. the results were obtained from experimentation with 200 books. This further showed the effectiveness of RFID application in library management. In addition, the Health sector has not been left out, as (Kamran, et al., 2010) developed a mobile technology based hospital patient movement activities. But they primarily focused on the components of an RFID technology system with the sole objective of identifying suitable RFID components for hospital patient movement activities monitoring. In agric-food industry RFID application has been research by numerous researchers, amongst which include; the projection of a fruit tracing system for fruit warehouse management using RFID technology (Gandino, et al 2007). And (Hu, et al., 2013) developed a system for tracing vegetables through the use of RFID tags storing information such as date of harvest, farm section number, and order of harvest. These information are retrieved from through the web using each unique identification number. This is to make information about the vegetables to become easily accessible to consumers.

Based on existing research on RFID applications which has always leverage on the network for connectivity as part of a complete system, we believe that as internet of things and RFID of things are both interleaved terminologies that complement each other to achieve the goal of unique identification and remote operations/accessibility of things. However evidence exist that the future of RFID technology application is interleaved with internet of things as examined in (Chunling, 2012), specially focusing on logistics management. The study highlighted the promising feature of RFID as a cost effective solution, with n-number of opportunities in applications that will enhance internet of things applications greatly.

However little literature exist on the application of RFID and internet of things of things on domestics things. Therefore, it is on this basis that we propose our study which investigates the interlink between RFID and internet of things applicability on domestic things.

3.0 OVERVIEW OF RFID COMMUNICATION SYSTEM HISTORY AND ARCHITECHTURE

History of RFID dates back till 1990s where its application is highly restricted, amongst which includes, access control, animals application etc (Kurt, 2012; Manpreet, et al., 2016). This is due to the cost and lack of standardization of transponders (rfid tags). Till date, RFID has experienced steady growth in being present in numerous system, due to MIT's Auto-ID Center immense research contribution which began in 1999, developing low cost effective RFID microchips. The Auto-ID Center which later became EPC global followed the same goal of making high quality transponders at an affordable cost that identifies billions of everyday objects. However, the Internet birth date far earlier than the RFID technology, though served as a basis for most of the success of RFID application as a sensor leveraging on the internet connectivity for tracking, and identification.

Typically, an RFID system consist of RFID reader and RFID tags (Manpreet, et al., 2016; Yimin, *et al*., 2007). The RIFD reader also referred to as the transceiver performs two function, communicating with tags and communicating with other larger long range networks through additional circuitry (Manpreet, *et al*., 2016). The readers can passive or active depending on the application. While the RFID tags also referred to as the transponder is an electronic circuitry that hold unique identification number for each tag. It can self dependent powered tags and non-self dependent powered tags depending on the application (Manpreet, *et al*., 2016).

RFID systems are applied in identifying short distance objects, through a static reader interacting over a radio frequency wireless network with miniaturized non-self power dependent transponders (tags) integrated to objects. There by enhancing the uniqueness and security of things (objects) (Manpreet, et al., 2016), however, the internet of things brings a seamless interaction irrespective of location space.

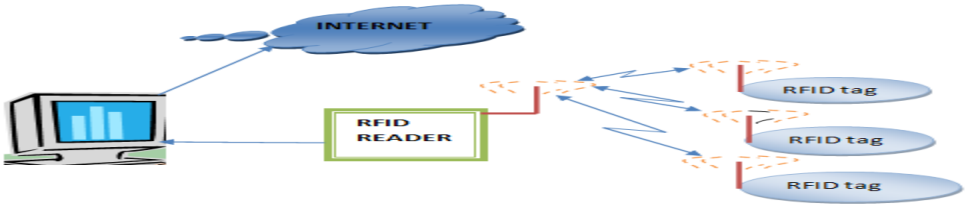


Figure 2: Typical RFID communication system model (Yimin, et al., 2007)

4.0 RFID OF DOMESTIC THINGS INTERLINK ON INTERNET OF THINSG IMPLEMENTATION FRAMEWORK

The proposed conceptual model of domestic things identifying people and people identifying things consist of two-layered implementation architecture. The third layer is the internet and advanced circuitry adding connectivity and further computation layer

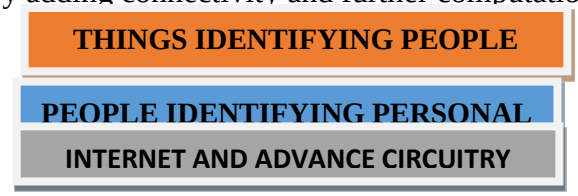


Figure 3: Implementation layers of RFID of things converging on internet of things

1. PEOPLE IDENTIFYING PERSONAL THINGS: attendance, access control, homes, cars, mobile phones, security and pass key are all things that identify people for authorization and access, in a seamless manner. This is achieved through RFID readers integrated into things, with embedded database of RFID tags. Similarly, furniture's, home electronic appliances, e.tc equipped with embedded RFID reader will be operated by identifying the registered user of the appliances through the RFID tag issued to the owner by manufacturers, as shown below. A refrigerator, fan, air-conditioner, television are all operated by persons having the registered RFID tag. All the above layers (things identifying people and people identifying things) implementation described below, depends on the third

layer (internet and advance circuitry things) for seamless location space independent interactions.

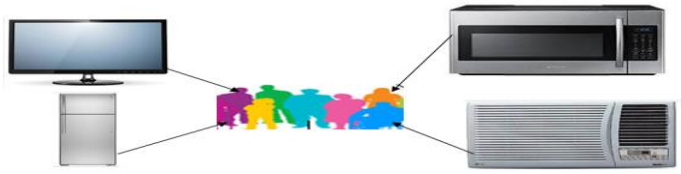


Figure 4: RFID of things implementation layer: things identifying people

2. THINGS IDENTIFYING PEOPLE: scenarios where personal belongings can be tracked this can be achieved through the use of a wearable RFID reader system, enabled with embedded data store to keep

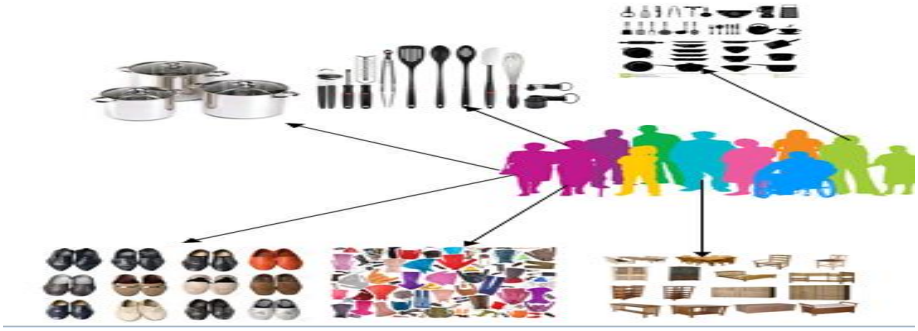


Figure 5: RFID of things implementation layer: people identifying things

5.0 RFID OF DOMESTIC THINGS

The unique identification feature of RFID makes it suitable for identification of domestic things, which when combined with internet of things, its applicability in domestic things are as follows

Home access key: we hope to see a future where the need for physical mechanical locks and other conspicuous access lock cards will be replaced with body born RFID tags, which acts as key for accessing our homes. Through the integration of RFID reader/writer with internet capability in every access door lock. Hence creating a world of free movement without concern for loss of access key and location independent access control. That is, access to a room or building can be granted from another room door or building in same or different building

Power supply management: switching ON/OFF of power supply meter can be controlled with RFID system, we believe that when this is integrated into power metering and supply system, it can put the control of the entire power supply into the hands of the users, as when card is present in the vicinity, its assumed the legitimate owner is present and the power is supplied else power is cut off. Also, more than one power supply meter in the same or different building can be controlled with a single RFID tags when internet of integrated. This

will greatly reduced the wastage of power energy. It is expected that more research will be carried out in the near future on the applicability of RFID in power management.

Power billing: RFID tags can act as stored value cards which can be recharged at any point of payment and can act as smart electricity meter card. Each meter having an RFID reader which reads the data portion of the RFID tag and then reduce the value by every kilowatt consumed. Other cards solution exits, yet the RFID application possibility and feasibility is greatly expected to penetrate the market with more economically cost effective products. In addition to the integration of internet creates the possibility for several electricity meter in varying locations to chare a single RFID tag as billing reference card.

Printer: the concept of network printer, has been around for years, and its operation in organizations has been more economical and fascinating. Through its reduced cost of operation and maintenance. Although the primary method of controlling access to these network printers are primarily password, we believe that the use of RFID reader/writer chip embedded into every network users personal computer, and some authentication software, which checks for valid RFID tags number read and supplied during every print request, if tag number received in valid print request is granted else it is rejected. In the case of a non-network printer can be embedded with an RFID reader/writer chip and antenna, which controls its switch ON/OFF, as well as authenticate print request from valid authorized RFID tags in close proximity. When RFID technology is embedded into printer system, it will create automatic identification (security) and control.

Personal computer: as the term personal computer implies, its use is primarily restricted to an individual, while maintaining the scalable possibility of enabling its shared usage. Several personal computer system security mechanisms has been proposed and integrated into personal computer for secured usage. The use of RFID is yet to be considered when integrated with internet. This has the capability of further enhancing the security of personal computer in a more secured and personalized form, than other existing security mechanisms in place, when implemented.

Refrigerators: future refrigerators, will no longer switch ON/OFF automatically once power is supplied, instead, it will strictly be controlled by identification of owner through the embedded RFID reader/writer chip and the RFID tags. In addition to refrigerator access control provided by RFID system. However when internet is integrated, power supply control and access control of refrigerators will be location independent. Also, this will further enhance the safety of items stored in the refrigerators, controlling access

Gas and electric cooker: there will be no need for mechanical switch ON/OFF for Electric and Gas cooking system, since they are prone to failure due to wear and tear. Hence, we envisage an RFID control system for switching future cooking system ON/OFF, while sensors or buttons will control regulation of heating intensity. However, the integration of internet will enable location independent operations of gas and electric cooker when necessary.

Air-condition: Air conditioning system switching ON and OFF will be completely done by RFID system. The owners will be having a universal RFID tag attached to them, in the form of neck chain locker which when brought close to the air conditioning system fully integrated with an RFID reader module, will switch ON, and also can be switched OFF in same way. However, when internet is integrated, it will enable location independent operations of air condition using unique RFID system

Fan: cooling fans in the near future will be enhanced through RFID technology with wireless automatic ON and OFF, while increase and decrease in speed will be controlled by temperature sensor. This will be possible through the integration of RFID reader in every fan system, replacing the conventional switch. Each individual owners will possess an RFID tag, which when brought close to the fan, it switches ON /OFF vise-versa, while its speed will be controlled by the temperature sensor automatically. Hence we believe the future fans can be switched ON /OFF and controlled wirelessly with miniaturized RFID tag chip which can be body born. However, the integration of internet will provide a remote operation of fans leveraging on their unique identity provided by RFID system.

Microwave: future microwave system will be switched ON/OFF with strict identification of legitimate owner, and authorized users. Through the integration of RFID reader/writer chip into the microwave system, which reads RFID tags in close proximity to switch ON/OFF depending on the authorization of the card read. However, the integration of internet will enable remote operation of microwave ovens using the unique identity from the RFID system.

Cooking wares (pot, plates, spoons etc): locating cooking ware such as pots, plates and others will soon be scan and beep, with the help of embedded RFID tag chips on all cooking ware. That is accessible by each owner having a wearable or handheld/fixed RFID reader/writer chip which helps in identifying and locating cooking ware in our kitchen and entire home, when misplaced or stolen. This will help brand protection between cooking ware companies as well. In addition to the integration of internet capability in the wearable or handheld/fixed RFID reader/writer chip system, will enable remote search and identification capability of cooking wares.

Water heater: Electrical water heating device are commonly used often in kitchen, operation can be enhanced with RFID system for automatic identification and control (ON/OFF), through RFID reader/writer chip which is embedded on this device that reads RFID tag of legitimate owner and switches ON/OFF, also with temperature and level sensor to prevent fire outbreak. Also, location independent operation can be provided when internet is internet is integrated.

Furniture (chair, table etc): identification of personal furniture's such as chairs and table with stickered RFID tags is possible. This will be most suitable for locating and identifying furniture's in a store/warehouse. Also in case of stolen furniture, this helps in locating and identifying them. However, the integration of internet on RFID system will enable seamless localization of smart furniture's (furniture's equipped with RFID tags)

Books: future book stores, libraries, individual book catalogues faced with the challenges of locating and identifying some books in the midst of thousands of others will no longer experience this, as all books will be tagged with stickered RFID tags from various authors and publishers, which can be read by handheld RFID reader/writer for easy identification and

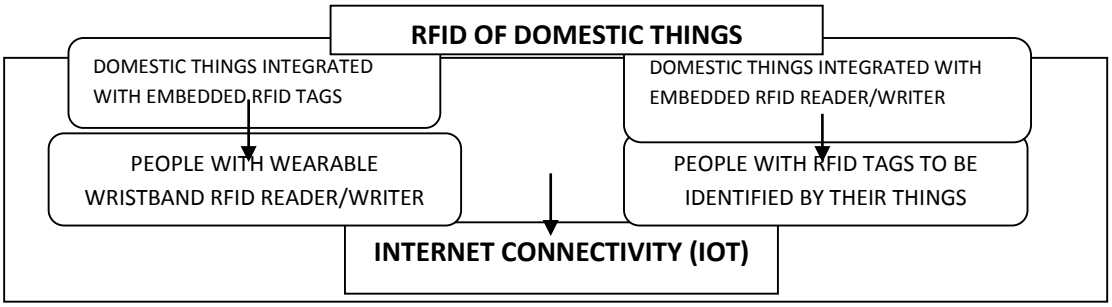
location. Individuals or organizations can use this application. However, when integrated with internet, it will enable seamless localization of books.

Bag: our future bags will be tagged with RFID tags from brand manufacturers, which can be read by handheld or wearable RFID reader/writer. This is suitable for locating bags at airport baggage handling, to ease identification and location of passengers' bags. It can also be used for mail sorting and processing for courier mail handling companies. In addition to domestically locating our bags at homes when misplaced. In addition, when internet is integrated, it will provide remote location of bags at home or wherever it's misplaced.

6.0 FUTURE OF RFID ON THINGS AND INTERNET OF THINGS

RFID of things unique identification and tracking of domestic things will bring more things that are yet to be considered on the internet of things agenda to become connected to the internet. When RFID of things becomes well implemented, there are lots more opportunities for internet of things in the domestic sphere, such as remotely locating domestic items for individuals at home through RFID connected over the internet. The fig6 below presents a typical RFID of things connected on internet of things

First layer is the RFID of things which comprise of people identifying their things and things identifying people, through the use of rfid tags and reader/writer. While the second layer is the internet connectivity layer that further connects the domestic things on the RFID network to the internet to enhance functional accessibility. This is depicted by the fig 6 below.



7.0 DISCUSSION

Every human has one or more things, personalized or shared, electronic or non-electronic. Also, humans comes in contact with a number of things, which aids them in having a hitch free dialy activity. Hence things and human existence are inseparable, such as domestic things (cloths, shoes, bag, refrigerator, microwave oven etc). Therefore, things identifying people vise-versa is an important societal issues. RFID technology automatic and unique identification capability makes it suitable solution for identifying and tracking of things and people through radio frequency near field communication signal. Although RFID application spans several industry application, we present the domestic application of RFID and interesting interactions in the context of people identifying their things and things identifying their owners, which is termed RFID of things. RFID of things is a concept exploring the future applicability of uniquely identifying personal belonging (things) and things (personal belongings) identifying people (interaction and collaboration).As envisioned, more things will be identified, a fast growing technology known as internet of things is also set to engage RFID of things. Hence paving way for lots more things that were not envisaged in the

internet of things arena to become connected. When RFID of things becomes fully implemented, we anticipate more things be connected as well over the internet leading to another paradigm known as internet of domestic things as well.

8.0 CONCLUSSION

In the near future, we believe that every personal belongings will identify people and people will be able to identify their personal belonging. In other words, things owned by any person (organization, groups or individual) will identify its legitimate owner and the legitimate owners of these things will identify their things. Hence, one suitable identification technology which has the prospect of fulfilling this demand is radio frequency identification technology, which has been used in variety of application across industries, such as commercial, industrial, security and automation industry, due to its cost effectiveness and automatic identification. Finally when rfid os things becomes fully implemented, we anticipate more things to be connected as well over the internet.

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