The use of RFID and Web 2.0 Technologies to Improve Inventory Management in South African Enterprises

Sizakele Mathaba[1], Nomusa Dlodlo[2], Andrew Smith[3] and Mathew Adigun[3]
[1] [2] [3]Council for Scientific and Industrial Research, Meraka Institute, South Africa
[1] [3]University of Zululand, South Africa
smathaba@csir.co.za
sizamath@gmail.com
ndlodlo@csir.co.za
asmith@csir.co.za
madigun@pan.uzulu.ac.za
profmatthewo@gmail.com

Abstract: Cost-effective inventory management includes balancing the cost of inventory with its profit. Most business owners fail to recognize the value of the cost of carrying inventory, which include not only the direct cost of storage, insurance and taxes but also the cost of money tied up in inventory. Running inventory using paper-based systems, Excel files and traditional enterprise software is a costly and resource-intensive approach that may not even address the appropriate issues for most businesses. It is with this in mind that this research proposes taking advantage of the Internet of Things (IoT) technology i.e. Radio Frequency Identification (RFID) and Web 2.0 tools in the management of inventory. RFID promotes the communication of things/object through sensors. On the other hand Web 2.0 tools promote the communication of people through their phones or desktop computers. The collaboration of these two technologies could improve inventory management. A comprehensive literature survey is conducted on inventory management functionalities. RFID and Web 2.0 technologies are then mapped to the identified inventory management functionalities. As a result the research proposes inventory management architecture. The paper looks at the architecture of a system that fully integrates the technical advantages of RFID and Web 2.0 tools, such as Twitter for loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, and notifications on stock level on the shelve, amongst other applications. The system focuses on enterprises in developing regions in Africa, and South Africa in particular.

Keywords: Internet of things (IoT), Radio Frequency Identification (RFID), Web 2.0 tools, inventory management, South African Enterprises, Twitter

1. Background

1.1 Introduction

Inventory management is a backbone for almost all enterprises, to define the growth, survival or the success of a business. Poor inventory management can lead to reduced sales which in turn can result in the failure of a business. Unfortunately not all enterprises seem to have proper inventory management in place. Enterprises face problems like product misplacement, counterfeited products, and replenishment of stock on shelves. Stock outs are estimated at 30% which affects retail sales by 5% to 18% (Xin 2009). The use of RFID has shown to be the top available technology in improving inventory management for most enterprises i.e. Wal-Mart stores. This technology enables the reading of products in real time and eliminates problems like counterfeiting, replenishment of stock, and product misplacement without requiring human intervention, and the information is sent directly to the back-end system for later retrieval. However, the stock may be misplaced or running short on shelves and that problem may be identified too late and only when checks are made using the stand-alone database or server in an organisation. This study proposes the use of a Web 2.0 tool such as Twitter which is integrated with RFID technology to keep inventory managers informed at anytime and anywhere on the Internet using cell phones. The cell phones are the most used and affordable communication technology in South Africa, more so than the desktop computer.

1.2 Inventory technologies in South African enterprises

Information Technology (IT) provide value to the firm by increasing internal and external coordinating efficiencies, and firms that do not adopt them may have higher cost structures and thus competitive disadvantage. Large retailers use sophisticated inventory management technologies, including electronic data transfer with suppliers to increase operational efficiencies and improve services. Figure 1 illustrates technologies which are still used today in retail industry including South Africa.

Most retailers still use scanners to log the receipt of goods, at the point of sale (POS) to record purchases for accounting, marketing, and inventory management issues and for taking physical inventories etc. These kind of technologies will slowly fade as new technologies emerge i.e. Wal-Mart announced that all its suppliers must deliver RFID technology enabled products by 2007.

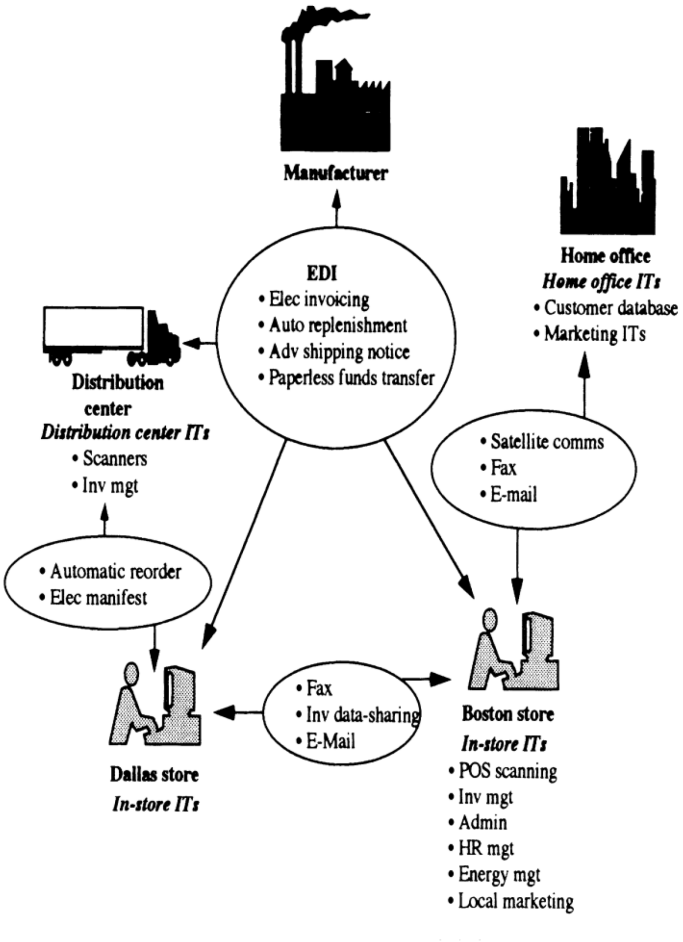

Figure 1: Technologies which are still used today in retail industry

IT linkages in a retail industry (adapted from Powell T. 1997)

Most technological changes are not always strategically beneficial, or guarantee profitability, in fact, it may lower the competitive advantage. IT alone has not produced sustainable performance advantages in the retail industry. However, some firms have gained advantages by using IT to leverage intangible, complementary human and business resources such as flexible culture, strategic planning, IT integration, and supplier relationships (Powell 1997).

1.3 Web 2.0 in the enterprise (Enterprise 2.0)

The term 'Web 2.0' was first coined by (MacAfee 2007) to portray the use of Web 2.0 techniques within organization/enterprises to enhance productivity and effectiveness.

Most organizations of all types and sizes, and from all industry verticals, have noticed the explosive growth on the web of social and community sites in the consumer space such as MySpace, YouTube, and the deluge of Web 2.0 sites. Enterprises have observed the move of major web players such as Amazon, eBay, Live, Google, and Yahoo to include social and community elements, and the interest and demand that this has created. Now they are enthusiastically considering, and in several cases constructing portals in communities and businesses for their own organizations. Web 2.0 is moving to enterprises (Kittowski et.al 2009).

Organizations are interested in using Web 2.0 practices mainly in two places. These are 1) within the business to advance competency and production, and 2) from the organization to the customers to improve revenue and customer satisfaction. The use of Web 2.0 within organizations is called

Enterprise 2.0 and is likely to be the first area where Web 2.0 will be used by organizations. Enterprises are using Web 2.0 technology mainly to communicate with customers (advertising), business partners and potential employees, allowing them to achieve the goal of true real-time collaboration among these parties. This can increase output and also provides enterprises with a mechanism to easily promote their products. The creation of online communities, blogs, and wikis that initiate conversations and promote the sharing of knowledge is proving to be particularly interesting to enterprises. Enterprises are already using the Web 2.0 technologies inside the organization for communication with employees and customers and marketing. It enables analysts, decision makers, and consumers to control their own user experiences with less guidance from IT and thus make for them more insightful and competent work environment. The benefits of this include improved worker productivity, morale, and user satisfaction. Web 2.0 tools can also play a major role in inventory management in enterprises.

1.4 RFID in the enterprise

RFID technology has been around for years and it has been used in many industries including the retail industry, food industry, livestock management, and supply chain management. RFID has become a new and exciting area and is receiving much attention. The major push started when the giant retailer Wal-Mart announced that all its suppliers must supply RFID enabled shipments in 2005. RFID technology in a retail industry provides real-time replenishment of products, and it does not require human intervention or line of sight to function (Chen et.al 2010). RFID technology is able to keep track of, and trace the location of products more precisely than other methods in current use, thereby potentially reducing losses. Wal-Mart stores which are RFID enabled were 63 % more efficient in replenishing out-of-stock and thus leading to a 16% drop in out-of-stock problems (Dane et.al 2010).

2. Motivation

South Africa is not only becoming more aware of RFID, but is also progressively rising in the uptake of this technology. RFID vendors are becoming specialised in providing specific applications and catering their offerings to particular industries. A diversity of factors currently influences South Africa's demand for RFID applications, namely:

- The need to reduce theft,
- Fraud and counterfeit products.

The RFID technology has the potential to keep track of, and trace the location of products precisely, more so than other current technologies in widespread use. The result is a reduction in losses. This technology also holds the promise of increased efficiency. The South African government's support for RFID projects plus international policies that require RFID applications on specific goods for import, such as beef products, are influencing the adoption of RFID in South Africa. (Online, URL: http://dataweek.co.za/article.aspx?pklArticleId=5027&pklCategoryId=31).

The slow adoption of RFID in South Africa presents diverse opportunities for retailers. The most vital is the availability of abundant opportunities that have not yet been exploited but are perfect for early mover advantage. Missions to roll out RFID applications in different countries are also on the rise. Supply chain, asset management and mining are amongst the areas expected to increase the demand for RFID applications, and actions in these areas are on the rise in many other African countries. Despite the numerous opportunities for RFID applications, there are hindering factors to its expansion. The most remarkable is the high cost of installing the application, particularly for low value volume products. Most enterprises in South Africa are small to medium enterprises with low quantity of manufacturing. RFID is costly for such businesses to implement. Consequently, many sectors continue to use alternative solutions such as bar codes.

The RFID technology is ineffective if used in certain conditions i.e. Transponders do not function well when tagged on iron objects or wet surfaces. This creates complications for manufacturing and other industries that use a variety of metallic objects (Dane et. al, 2010). The low level of alliance among industry participants is also slowing the market's development. Having agreed that RFID requires a standard of infrastructure, mostly in power and telecommunications, the demand is affected in many countries and regions facing infrastructural complications. Regardless of the various technological challenges, the cost of RFID tags has started to drop. This movement is expected to carry on as more advances in the manufacturing of low cost RFID continue. The continued drop in prices will be a key

issue in growing the demand for RFID in South Africa. Low cost tags will be particularly engaging to low value volume items where the market for RFID is currently small. This will offer solutions for a variety of enterprises of all sizes. Participants in the market need to collaborate in order to resolve interoperability and other concerns that have an effect on the use of RFID applications, such as agreeing to a general approach to the industry principles (online, url: http:// dataweek.co.za) .

The forecast for RFID technology in South Africa are not as rosy as those for biometrics. It is doubtful that RFID in SA will see the same adoption rate as seen in the US, as local retailers are unlikely to set up RFID go-ahead like others did in the US. On top of that, the charge of importing tags and the difficulty of deployment are likely to put off many potential RFID customers (online, URL: http://www.autoidlabs.ch/).

RFID in South Africa is well established in some niche environments though, such as access control i.e. biometrics and tollgates. South African regulator ICASA only permitted suitable EPC (Electronic Product Code) RFID frequencies in 2010, so major deployments are yet to take place. RFID has been deployed very selectively in South Africa; the cost of the tags has been too high for retail organisations to see advantage from using this type of real-time tracking. However, this may eventually change (online, URL: http://www.iweek.co.za/ViewStory.asp?StoryID=201372).

3. Literature review

3.1 Internet of Things

The IoT is an incorporated part of the Future Internet and could be defined as a dynamic worldwide network infrastructure a with self-configuring ability based on criterion and interoperable communication protocols where physical and virtual things have distinctiveness, physical characteristics, virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network (de Saint- Exupery, 2009).

3.2 The Internet of Things technologies

IoT technologies i.e. RFID, promote the communication among objects without any human intervention.

Figure 2 represents an example illustrating how IoT works in warehouse management. Traditionally, operations in warehouse management are processed manually, with information gathered by hands and captured through keyboards, voice entry or barcodes and integration through human-machine-interface. The introduction of IoT, involving RFID sensors & actuators, changed the laborious processing of warehouse operations. Data entry is now automated, which results in accurate information gathering and thus informed decisions can be made.

Figure 3 illustrates how the IoT functions. It consist of tags which are attached to an object with each tag can containing product information such as the expiry date, object pressure, temperature, prices etc. Sensors may optionally also be embedded within the tagged object Readers access data from the tags in a code form. IoT middleware filters repeating and irrelevant data and sends the code to the local server. The object information will be available to the internet through the remote server. Object Naming Service (ONS) works similar to the Domain Name Service (DNS): it points out the servers storing object information.

In the IoT, objects are autonomous entities in companies, information and social processes where they will be enabled to interact among themselves. They also interact with the environment by exchanging data and information sensed on the environment, while reacting autonomously to the real physical world events and influencing it by running processes that trigger actions and create services with or without direct human intervention. The interfaces in the structure of services facilitate communications with these smart things over the Internet, query and change their state and any information related with them, taking into account security and privacy matters(de Saint- Exupery, 2009).

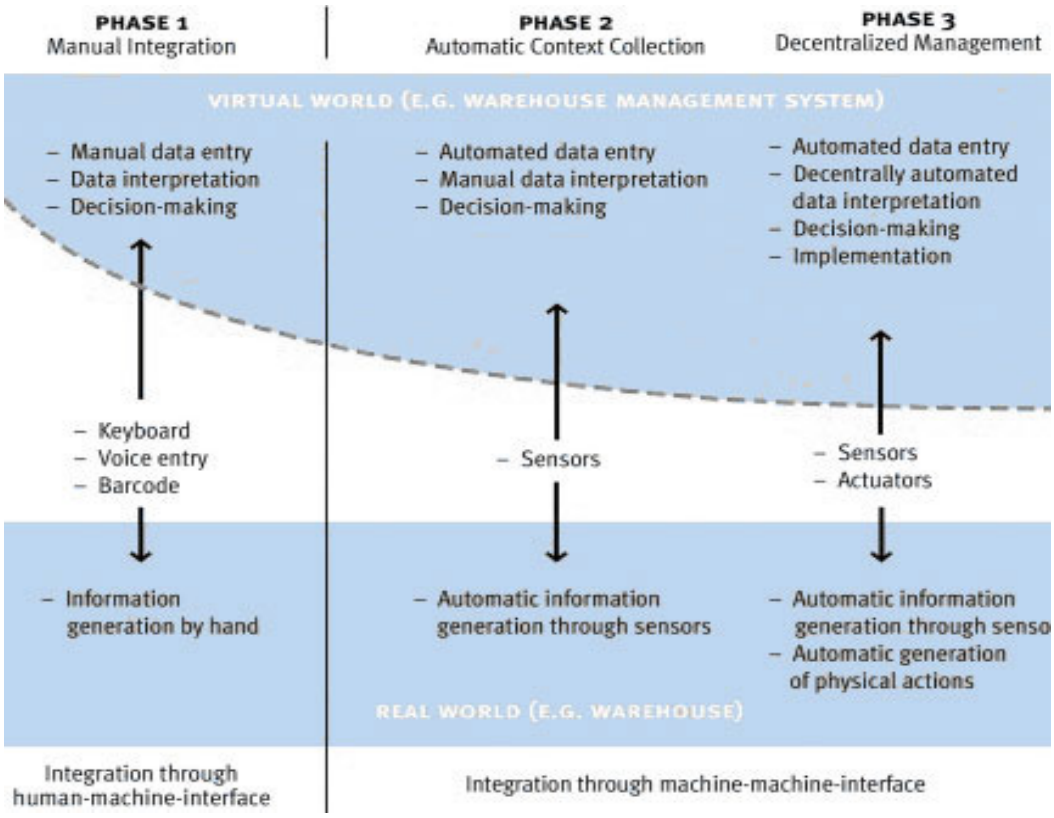

Figure 2: IoT in warehouse management (adapted from Fleisch, 2010)

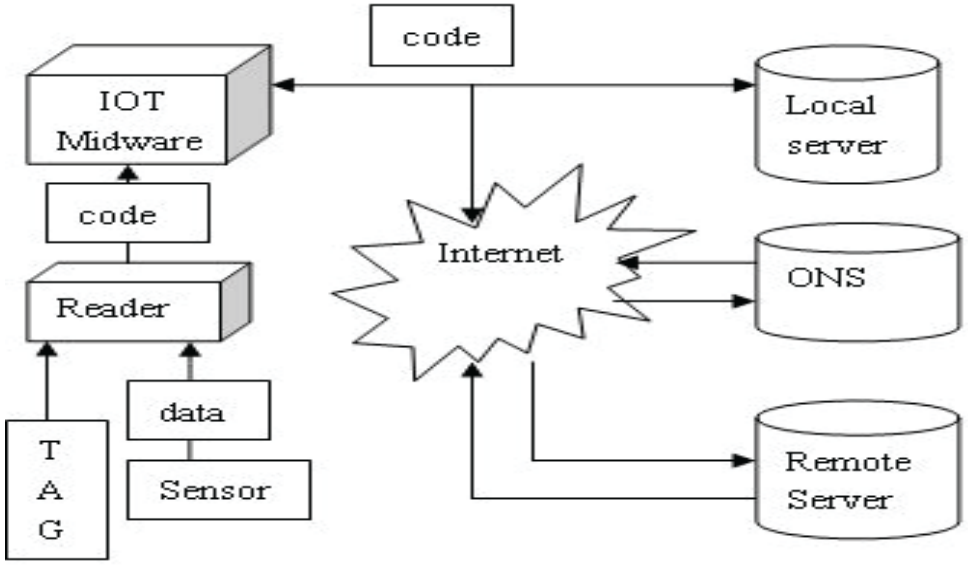

Figure 3: Illustration of Internet of Things (adapted from Shen, 2010)

3.3 Radio Frequency Identifiers

The RFID technology was developed during World War II as a method to assist aircraft to identify fellow aircraft and commanders on the ground (Niederman et. al). RFID tags are divided into two general types: active and passive, depending on their supply of electrical power. Active RFID tags contain of their own power source, normally an on-board battery. Passive RFID tags get power from the signal of an external reader. RFID readers also come in active and passive varieties, depending on the kind of tag they read (Intermec Technologies, 2007).

3.3.1 Active tags

Active tags contain their own power source. They send out a stronger signal, and readers can access them from further away. The on-board power source makes them big and costly, and thus active RFID systems normally work well on big objects tracked over lengthy distances. Low-power active tags are generally a little larger than a deck of playing cards. Active tags can stay inactive until they come in range of a receiver or can continuously transmit a signal. As a result of their on-board power source, they can function at higher frequencies, normally 455 MHz, 2.45 GHz, or 5.8 GHz, relying on the application's read reach and memory needs. Readers can converse with active RFID tags across 20 to 100 meters (Intermec Technologies, 2007).

3.3.2 Passive tags

On the other hand, passive tags are very economical, they can cost as little as 20 cents a piece, and new technologies are continuously manufacturing them on a low-price for integration into general materials and products. Since passive tags are inexpensive, they are expected to be the starting point in the expansion of RFID implementations especially in South Africa as a developing country. Besides to their low cost, passive tags can also be reasonably small. Recent antenna technology confines the smallest functional passive tag simply to the size of a quarter. The larger the tag, the larger the read range. At present, passive RFID tags contain about 2 Kbits of memory which is quite small to hold much more complex information than identification and history information. Technology in the nurture of RFID is continuously improving. Consequently, the amount of information and capabilities of RFID tags will increase over time, thereby allowing RFID tags to ultimately hold and transmit enough information (Weinstein, 2005).

Passive-tag readers can continuously transmit its signal or transmit it when required. Once a tag moves across the reader's range, it accepts an electromagnetic signal from the reader through the tag's antenna. The tag then keeps the energy from the signal in an on-board capacitor. This process is called inductive coupling. Once the capacitor has made sufficient charge, it can be able to power the RFID tag's circuitry, which transmits a modulated signal to the reader. The return signal consists of information stored in the tag. Low-frequency tags (less than 100 MHz) send information by releasing energy from the capacitor to the tag coils in altering strengths over time, which affects the radio frequency produced by the tag. The reader perceives these varying waves and can use these variances to demodulate the code (Weinstein, 2005).

In higher-frequency tags (greater than 100 MHz), the tag transmits the signal by means of backscatter, in which the tag's circuit adjust the resistance of the tag's antenna. This change in resistance makes a transmission of Radio Frequency (RF) waves, which the reader can accept and demodulate. Passive tags usually work at frequencies of 128 KHz, 13.6 MHz, 915 MHz, or 2.45 GHz, and have read ranges of only few inches to 30 feet. Frequency selection depends on the system's environment, kind of material the signal have to pass through , and the system's essential read range. RFID tags can be enclosed in numerous materials. Plastics are the most familiar material for RFID, making identification cards for building entrance, credit cards, or bus fares (Weinstein, 2005 and Intermec Technologies, 2007).

Figure 4 represents the RFID components and illustrates how these components work in any given environment. Tags which are usually very small in size are attached to almost any given object and they send out signals which are received by the reader through an antenna, which is an enabler for tags and readers to transmit information. The information is sent to a back-end computer system for processing.

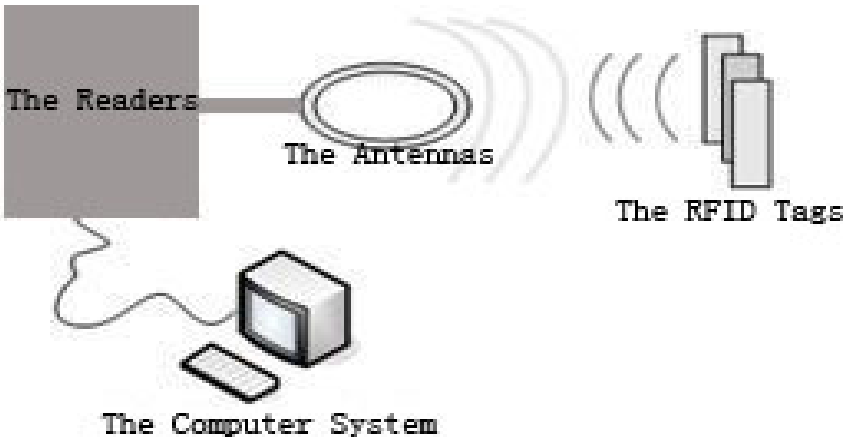

Figure 4: RFID system components (adapted from Yan et.al, 2008)

3.4 Web 2.0

The web 2.0 idea came out in the brainstorming session conference between O'Really and Dale Doughety. It was defined as "visualization of web 2.0 as a set of principles and practices that tie together a veritable solar system of sites that demonstrate some or all of those principles at varying distance from that core". Web 2.0 promotes people to meet virtually, share opinions, interests or simply listen and observe (O'Really 2005)

Web 2.0 technologies outline the beginning of the subsequent creation of web-based applications. It allows web applications to be created, that are more operationally rich and quick to respond than the usual static pages of traditional web technologies. It's also enabling content to be produced and shared in real time, with end-users commonly able to add content to applications themselves (O'Reilly 2007). This implies that Web 2.0 technologies support open communications and provide users the freedom to share their suggestions and opinions.

Characteristics of Web 2.0:"

- The Web as a platform,
- Harnessing collective intelligence
- Data as the next Intel inside
- End of the software release cycle
- Lightweight programming models
- Software above the level of a single device
- Rich user experience" (Oreally T, 2007).

3.4.1 The Web as a platform

Web 2.0 tools use Web as a platform, in which a massive collection of interconnected devices offer dynamic level of rich and explorative experience for the users, and it uses lightweight programming models for the developer and a quick, flexible deployment method for the supplier. Web 2.0 foresees the Internet from the user, the developer, and the supplier's perception, for each allows new and creative utilization of the Internet.

The web service system supports all connected systems, which includes Web 2.0. Service-based system is based on the approach of separation of concerns through the employment of loose coupling or message passing. Loose coupling enable functionality to be produced as a service and delivered over the network, i.e. in the Web 2.0 world, updates on inventory can be provided by a blog engine and be sent as a service to the end user (management team) or blogger over the Internet. This delivery of software utilization over the Internet is generally called Software as a Service (SaaS) and it is an enabler for the majority of Web 2.0 systems at present (Oreally T, 2007).

Software as a Service (SaaS) is a software distribution model where applications delivered by a vendor or service provider are made available to consumers over a network, normally over the Internet. Software-as-Service is progressively becoming a more prevalent delivery model as fundamental technologies that sustain web services and service-oriented architecture (SOA) are getting more established and innovative developments approaches i.e. recently, the broadband service has become more accessible to enable more user access countrywide. (Online URL: http://searchtelecom.techtarget.com/sDefinition/0,,sid103_gci211706,00.html)

SaaS model enables the following:

- Easier management
- Automatic updates and patch management
- Consistency, i.e. same version of software to all users.
- Easier alliance
- Worldwide openness.

Simple Object Access Protocol (SOAP)-based Web services are normally implementation of SOA though there are non-Web services implementations of SOA that offer related benefits. The protocol autonomy of SOA implies that diverse users can correspond with the service in different ways. (Online URL: http://searchcloudcomputing.techtarget.com)

As far as Internet as a platform is concerned, it has to offer significant platform fundamentals such as device autonomy, friendly user interface, familiar programming interface, and a software or service deployment and administration method.

3.4.2 Rich user experience

The significance of rich and immersive user experience has been noted in the PC world long ago in the introduction of Windows and has been a centre of browser-based applications for years. JavaScript and DHTML were introduced as lightweight programming models for providing client-side programmability and enriching user experience in what is called Rich Internet Applications (RIA).

The compilation of technologies used to offer these rich and dynamic browser-based systems is Ajax (Asynchronous JavaScript and XML). It is has several technologies collaborated in powerful new ways to provide RIA functionality. It entails

- Standards-based presentation by means of XHTML and CSS.
- Dynamic demonstrations and interaction using the Document Object Model.
- Data interchange and manipulation using XML and XSLT.
- Asynchronous data retrieval using XMLHttpRequest.
- JavaScript as the programming metaphor.

Ajax is a key module generally for Web 2.0 applications, it enables the creation of rich and dynamic web applications as Windows-based applications, now Ajax-based applications can work while disconnected from the Internet and consequently provide offline operations similar to Windows-based clients such as Outlook.(O'Really T,2007)

There are technologies other than Ajax which are increasing the value of the user experience in areas of communications, i.e. voice, and video ,instant messaging (IM) which are profoundly used in Web 2.0 applications to provide instantaneous communications, and there are a broad series of agents and delivery options available for IM systems, the voice over IP (VOIP) systems enables voice and teleconference communication over the Internet as part of the user experience.

The elasticity delivered by these technologies alter the user interface(UI) beyond a dynamic UI to a complete interactive audio visual experience, with new, powerful ways for people to interact with systems and one another.
The provision of users with a solitary user experience for the majority of their requirements increases efficiency, reduces training expenses, and motivates deeper implementation and usage. That encompass access to information and applications irrespective of being connected or disconnected,

or whether they are using a mobile, laptop, thin client or a smart client. Ajax and graphics subsystems such as Silverlight provide the rich user experience people anticipate in recent systems. Web 2.0 supports Lightweight Programming Models which provides necessary change from the bottlenecks and constrains related with IT based systems.

3.4.3 Lightweight programming models

In Web 2.0, the programming models and concepts differ from those used in the enterprise, though they are services-based and underpinned with the concept of messaging passing; they use Representational State Transfer (REST) protocols, and focus on simplicity and ease of use.

"Web 2.0 programming is based on separation of concerns using a loosely coupled, message-passing-based model on top of an Internet-based, standard set of communications protocols (HTTP) which is often called RESTful programming. It entails the acts of syndication and composition where services are delivered exclusively to knowledge of their use. This is different from a usual tightly coupled, transactional and object-oriented system. It has a different set of benefits, such as flexibility and speed of implementation, and challenges, such as integrity and management" (O'Really T, 2007). The languages used in Web 2.0 like Perl, Python, and Ruby frameworks are simple and dynamic and thus providing a low blockade to entry, reuse and high productivity.

3.4.4 End of software release cycles and deployment

The perception following Web 2.0 went to a new balance between the controls, managerial ease of centralized systems, elasticity and user empowerment of distributed systems. Web applications are by nature centrally deployed, Software-as-a- Service (SaaS) builds on this concept to provide the idea of software and services delivery over the Internet. Web 2.0 builds on top of SaaS to offer social and content services over a SaaS system. This usage of SaaS by Web 2.0 as a deployment provides all the eminent SaaS advantages of simple deployment, minimized management and administration and, continual update. The underlying usage of Internet as a platform in Web 2.0 enables simplicity, quick, and flexible delivery of applications and data throughout the enterprise and eradicating the user from predetermined and inflexible IT upgrading cycles and enabling new height of organizational support and responsiveness for the user.

3.5 Web 2.0 in the enterprise

Enterprise 2.0 refers to the use of web 2.0 technologies in the enterprise, below are some characteristics of enterprise 2.0.

3.5.1 Read/write web

Information documents and data are essential to any business and Web 2.0 is a service-based system, it allow data and document establishment, alteration and substitutions with reduced complexity and improved simplicity of use. The provision of facts, content regulation, and alliance systems which can support the rich content format and social techniques of Web 2.0 is vital for the use of the read/write Web in the Enterprise.

3.5.2 Collaborative web

Large enterprises with many employees, partner, suppliers and customer relations can witness the significance of the knowledge living in employees' minds and in the databases and vague documents found across the organization. Efforts to gather information into knowledge management systems have been made long-ago with varying levels of accomplishment but the use of Web 2.0 technologies such as blogs, wikis, and enterprise search for individuals and data may reduce the bar to knowledge management and offer a new platform to collaborate on amalgamated and innovative tasks. In conclusion, one can motivate that Web 2.0 tool like twitter which is an online social bogging service which allows people to share short textual messages with others (Boyd et. al 2010), can be an enabler for immediate knowledge notification and knowledge management on the inventory management processes.

4. Statement of the research problem

It is vital that inventory management systems allow managers to receive real time information on inventory. The RFID technology provides the resolution on inventory concerning the products

available on shelves, when some products are misplaced, expired, damaged etc. but the RFID technology alone is not complete since it does not have the feature that will update the inventory managers on what is happening on their inventories using their cell phones and receive notifications (i.e. tweets) on inventory processes noting the fact that RFID requires no human intervention. Twitter is an enabler to help bridge the information gap between the RFID technology and managers. This will assist management to accurately make informed decisions, anywhere anytime and save time and cost used for labour and thus working on inventory management properly, enterprises can make accurate analysis on which product are top sellers and which are slow movers. As a result this study proposes to take advantage of the RFID and Web 2.0 tools in the management of inventory. The collaboration of these two technologies can bridge the digital divide between inventory managers and inventory processes in the enterprise and improve inventory management.

4.1 Proposed solution

4.2 Proposed architecture for inventory management

Below is architecture for inventory management. It is architecture of a system that fully integrates the technical advantages of RFID in collaboration with the web 2.0 tool twitter, for loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, and availability of stock on shelves.

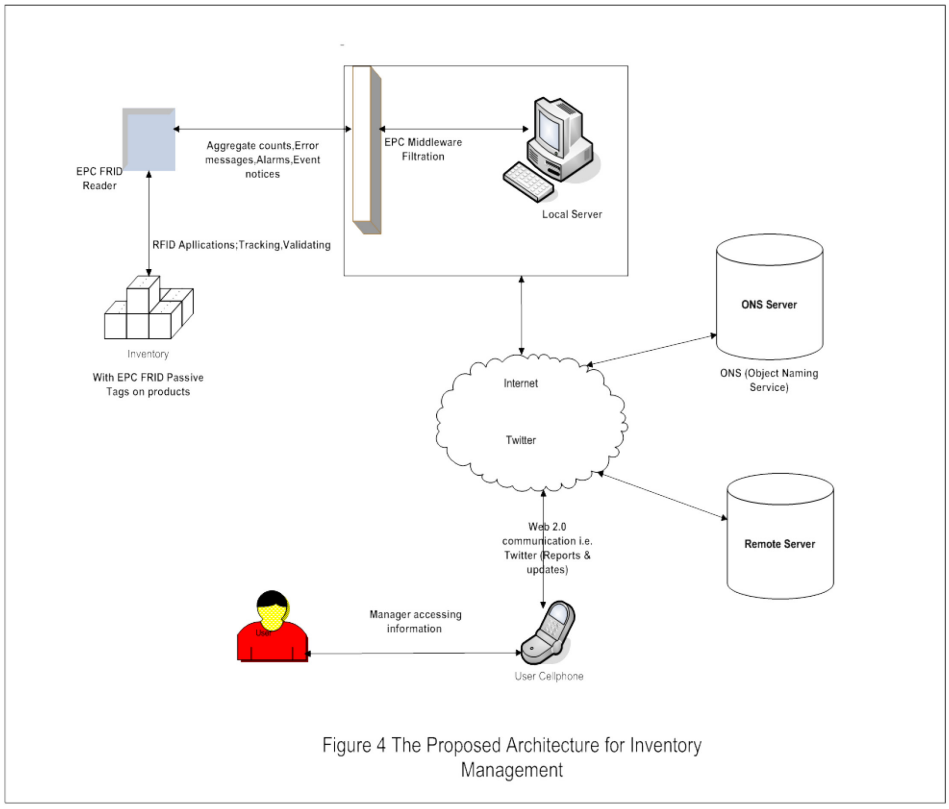

Figure 4 The Proposed Architecture for Inventory Management

Figure 5: The proposed architecture for inventory management

In this architecture, RFID serves as a replacement for the bar code scanners which are normally used to track products and shipments in similar ways. This architecture fully integrates the technical advantages of RFID and web 2.0 to provide feedback on the process to the inventory manager. RFID system consists of three fundamental components. Initially, the RFID tag is attached to an asset or product in the inventory. The tag contains information about the particular asset or product and also may include sensors. The next component is the RFID reader, which communicates with the RFID tags. The last component is the backend system, which links the RFID readers to a centralized

database/server. The centralized database will store all the information of the products, such as price, for each RFID tagged item. In this proposed architecture for inventory management, the passive tags will be used due to their low cost. Among the functionalities expected to be performed by this system includes:

Checking the availability of stock on shelves:

- Identifying misplaced stock on shelves.
- Identifying expired/ ruined stock.
- Identifying counterfeit products.
- Sending updates (tweets) to the inventory manager.

The Electronic Product Code (EPC) is a unique global identifier of each product in IoT technologies which is used to track and trace products (Yan 2008). The EPC RFID readers will be placed among the shelves and the products will be programmed with EPC RFID enabled tags. EPC RFID tags will send out the signal which will be received by the EPC RFID readers in the radio frequency field. The readers will receive the signal through their antennas and transmit the stored information, i.e. Validation, tracking, counts, and error messages to the EPC middleware. The EPC middleware will filter out the repeating and irrelevant information. Thereafter, information will be sent to the local server. The local server computer system will tweets the information to the inventory manager i.e. reports on inventory, aggregate counts, errors occurred, misplaced stock etc. through the use of web 2.0 technology Twitter. The end user/owner will receive the notification on inventory through his/her phone. This system gives effective technical reference for enterprise managers to monitor whole process of inventory without them being physically involved in the process. The consumers of the products will benefit also in this proposed architecture. They can query information about the product on the remote server using the EPC (Electronic Product Code); the ONS (Object Naming Service) is network system which works similar to the DNS (Domain Name Service).It spots out servers storing information in the internet.

5. Research methodology

5.1 Literature survey

The study followed qualitative research method, a comprehensive literature survey was conducted on inventory management functionalities, through conference papers, white papers and online sources to identify research work that has been covered in the RFID and web 2.0 in enhancing the management of inventory in Retail Enterprises.

5.2 Model design

After identifying the existing works on RFID and Web 2.0, inventory management architecture will be formulated. RFID and Web 2.0 Technologies will then mapped to the identified inventory management functionalities.

6. The research question

How can RFID and web 2.0 technologies be utilized to improve inventory management systems in Retail Enterprises?

7. The research goal and objectives of the study

7.1 Research objectives

- Review literature on inventory management
- Identify systems that have adopted RFID technologies that can be utilised in inventory management.
- Come up with inventory management architecture.

7.2 Research goal

The goal of this research is to come up with the enhanced inventory management system for enterprises that will improve the traditional systems used currently. RFID and Web 2.0 technologies

will be mapped to the identified inventory management functionalities. The study will look at the architecture of a system that fully integrates the technical advantages of Radio Frequency Identification (RFID), in collaboration with web 2.0 tool, twitter, for identifying stock levels on shelves, loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, etc.

8. Conclusion

Internet of Things integrated with the RFID technology and web 2.0 technologies can assist enterprise owners in managing their inventory, i.e. using them in monitoring the stock validity, stock on shelves, misplaced stock etc. The use of web 2.0 tools could play a major role in keeping enterprise owners posted about what is happening on the inventory without them being physically there and helping them to make informed decisions, and to know urgent matters which may need their attention immediately. Web 2.0 tools bridge that divide of objects and humans. As a result, this study encourages South African enterprises to actively promote the development procedures of the RFID technology with web 2.0 tools and the Internet of Things to improve the inventory management in their enterprises.

8.1 Limitations

The IoT technologies have the drawbacks though i.e. the cost of the technology is a major concern for developing countries like South Africa, and the uncertainty for big retailers to adopt the technology.

8.2 Contribution

Our research demonstrates the potential that the combination of existing technology such as RFID and Web 2.0 has in supporting small enterprises in developing regions.

8.3 Future work

Although RFID is a suitable technology for many applications, such as described in this article, it does have limitations in certain areas. RFID is not the ideal identification technology where ferrous materials need to be tracked. This is because of the electro-magnetic shielding properties of such metals as well as the de-tuning of the antenna circuits imbedded in the tags. When used on such materials, the reader will not be able to receive data from the tag. When a passive tag is used in such circumstances, it would probably not be able to harvest sufficient energy from the reader to activate in any case, making the use of RFID tags on ferrous materials a tough problem. Volatile liquids are another application area not well suited for RFID because of the risk of explosion.

It is for these reasons that we are planning to extend the system discussed in this paper to incorporate optical markers as replacements for RFID in certain applications. Optical markers include QR codes(18004 - Information technology — Automatic identification and data capture techniques — Bar code symbology — QR Code) and fiducials (Bencina2005, Bencina2005a) such as those used in the reacTIVision system.

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