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

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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) and Web 2.0 tools in the management of inventory .IoT 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. IoT 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 Radio Frequency Identification (RFID) and IoT, in collaboration with web 2.0 tool, twitter, for loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, etc. The system will focus on South African Enterprises as a developing country in Africa.

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

1. Introduction

Supply chain management is the well-organized management of the end-to-end process. It begins with the design of the product or service and ends with the time when it has been sold, consumed, and in the end, discarded by the end user. The complete process involves product design, procurement, planning and forecasting, production, distribution, fulfilment, after-sales support, and end-of-life disposal (Michael and McCathie, 2005). Inspection and anti-counterfeiting for merchandise are vital contents of supply chain management, enterprises which need to open the market completely, have to offer consumers a real-time information inquiry platforms on commodity, and to let consumers have a clear understanding of the entire life cycle of the goods they consumed and to give them a convenient way to identify the accuracy of the products. Unfortunately, few enterprises have systems in place that can monitor whole cycle of products currently. To resolve this difficulty, this paper recommends a products monitoring information system based on RFID and IoT.

The paper is structured as follows. Section 2 is the literature review on the IoT. Section 3 is the research methodology, Section 4 represent the rationale of the study, while Section 5 looks Web 2.0. Technology in general. Section 6 is the proposed architecture of the inventory management system that fully integrates the technical advantages of RFID and IoT, in collaboration with web 2.0 tools twitter, for loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, etc. The system will focus on South African Enterprises as a developing country in Africa.

2. Background and context of the study

2.1 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, and virtual personalities and use intelligent interface, and are seamlessly integrated into the information network(de Saint- Exupery, 2009).

Figure 1 is 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 for informed decisions.

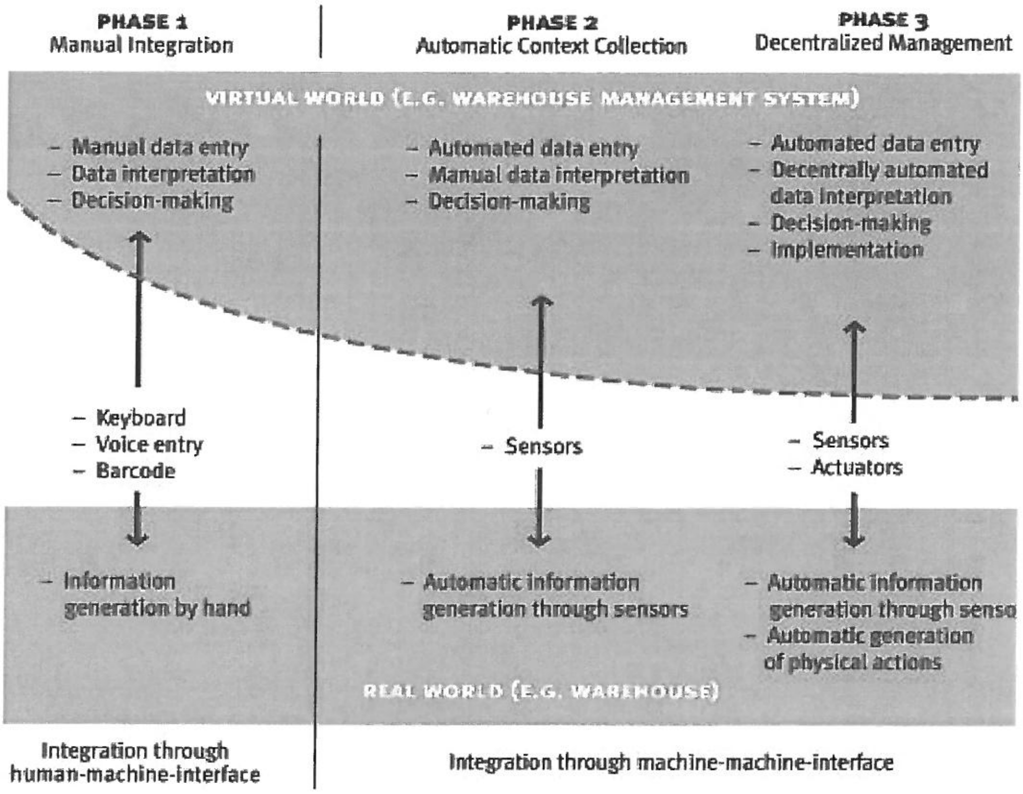

Figure 1: IoT in warehouse management (adapted from Fleisch, 2010).

Figure 2 illustrates how the IoT functions.

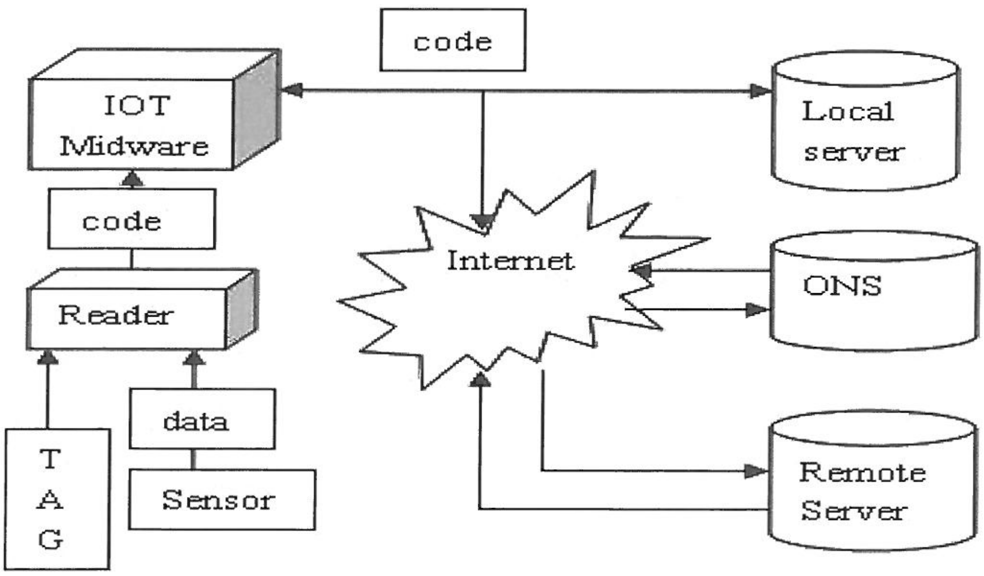

Figure 2: Illustration of Internet of Things (adapted from Shen, 2010)

It consist of tags which are programmed into an object, each tag contains product information such as the expiry date, object pressure, temperature, prices etc. Sensors are embedded into these tags and readers, and they enable data transfer from the tags to the readers. 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).
Typical Applications of IoT:

- "Toyota (South Africa), Carrier tagged to streamline manufacturing and vehicle tracking. The tags are intended to remain with the vehicle throughout its life cycle" (Baudin, 2005).
- A car which notifies you when it must have a service.
- A smoke detector which is directly connected to local fire station.
- Washing machine twittering when it finishes washing etc. There are quite many areas where IoT can be applied.

2.2 Radio Frequency Identifiers

RFID tags are divided into two general types, active and passive, depending on their supply of electrical power. Active RFID tags consist 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 selections, depending on the kind of tag they read (Intermec Technologies, 2007).

2.2.1 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).

2.2.2 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 3 represents the RFID components and illustrates how these components works in any given environment. Tags which usually very small in size, are attached to any given object and they send out signals which are received by the reader through antenna, which is an enabler for tags and readers to transmit information. The information is sent to a back-end computer system for processing.

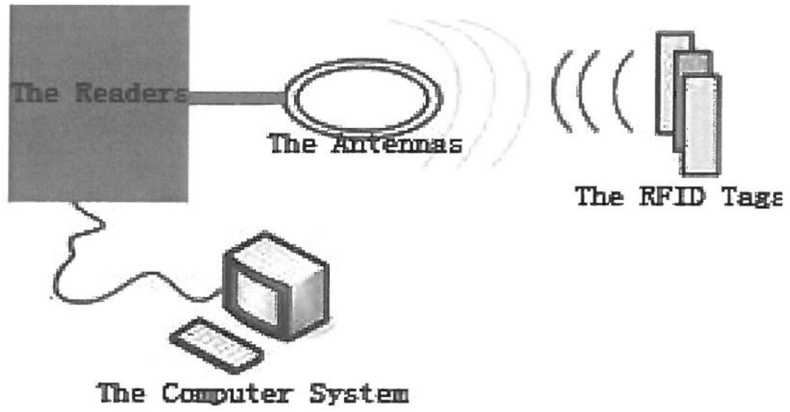

Figure 3: RFID system components (adapted from Yan et.al, 2008)

3. Methodology

A comprehensive literature survey was conducted on inventory management functionalities, and to identify research work that has been covered in the IoT and web 2.0 in enhancing the management of inventory in South African Enterprises. IoT and Web 2.0 are then mapped to the identified inventory management functionalities.

The research question is:

How can IoT and web 2.0 technologies be utilized to improve inventory management systems in South African enterprises?

Objectives of the study

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

4. Rationale of the study

Stock outs result in much loss for enterprises. It is estimated at 30%, which affects retail sales by between 5 and 18%. In most cases, the stock maybe available but misplaced (Xin, 2009). This is a huge loss for enterprises. 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. 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 is able to keep track and trace the location of products precisely than current technologies in use, which leads to a reduction in losses. The ability of technology to increase efficiency, government support for RFID projects and international policies that require RFID applications on specific goods for import, such as beef products, are also influencing the adoption (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. Mission 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 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 function under 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 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 things, where the market for RFID is currently small. This will offer solution for a variety of enterprises of all sizes. Participants in market have need of working together to resolve interoperability and other concerns that have an effect on the use of RFID applications, such as discovery of 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 they 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, says Max Stone, distribution and partner manager at Motorola Southern Africa's Enterprise Mobility business(online, url: http://www.autoidlabs.ch/).

RFID in South Africa is well established in some niche environments, such as access control i.e. Biometrics, tollgates. South African regulator ICASA only permitted suitable EPC (Electronic Product Code) RFID frequencies for SA last year, so major deployments are yet to happen. 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 change as time elapses (online, url: http://www.iweek.co.za/ViewStory.asp?StoryID=201372).

5. Web 2.0

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.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, which is within the business to advance competency and production, and 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 technologies to mainly 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 provides enterprises with a way to easily promote their products. The creation of online communities and blogs or wikis to initiate conversations and share 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, etc. IoT technologies, on the other hand promote the communication among objects without any human intervention leading to a reduction of labor costs. This study proposes that IoT can be collaborated with web 2.0 technologies for communication purposes with humans. The objects will communicate with humans for updates through web 2.0 technology Twitter, to bridge the communication divide between objects and humans.

6. Proposed architecture for inventory management

Enterprise architecture (EA) presents a bright approach to support business strategy execution. EA is an outline that can direct organizational activities in the technological sense, and supports the business strategy from the lowest level of process. This outline helps to facilitate an organization's business vision by encapsulating multiple views of an enterprise and provides a general understanding of what the organization aims to achieve. In addition, EA view the enterprise from a holistic and more complete architectural point of view (Chuang and Loggerrenberg 2010). Figure 4 shows the proposed architecture for inventory management. It is architecture of a system that fully integrates the technical advantages of RFID and IoT, in collaboration with the web 2.0 tools twitter, for loss prevention and as an enabler for locating misplaced stock, anti-counterfeiting of stock, availability of stock on shelves etc.

In this architecture, RFID basically 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 end user. Since the application of FRID require no human intervention, it is essential that the end user is updated in the whole process.

The 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 information, 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 to the relevant user.

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 twitter the information to the user i.e. reports on inventory, aggregate counts, errors occurred, misplaced stock etc. through the use of web 2.0 technology. 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.

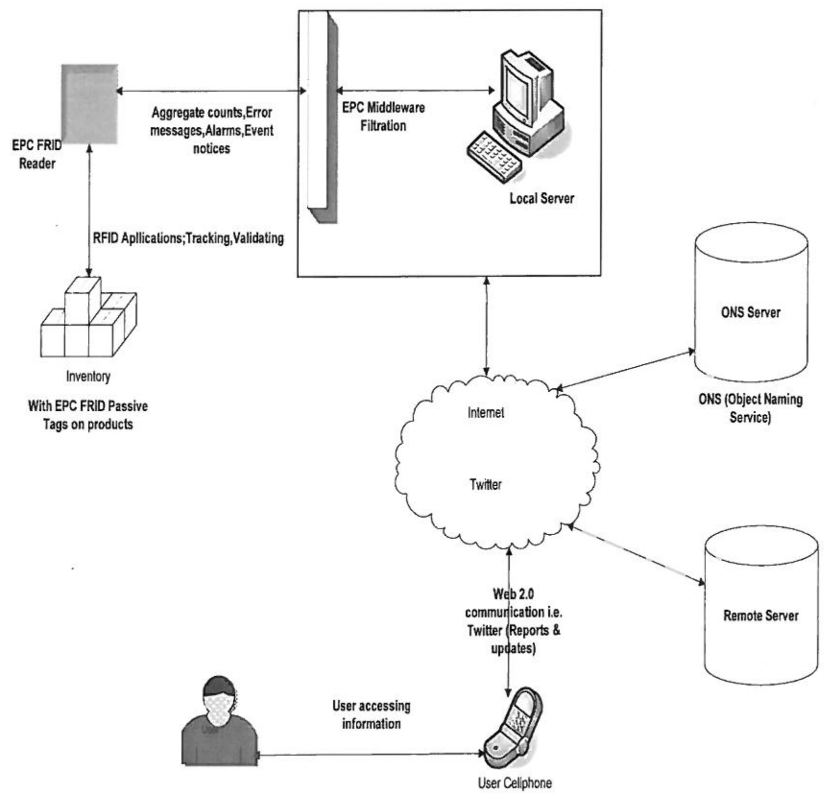

Figure 4 The Proposed Architecture for Inventory Management

Figure 4: The proposed architecture for inventory management

7. 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. The IoT have the drawbacks though i.e. the cost of the technology is a major concern for developing countries like South Africa, but that can addressed by major investments and collaboration with developed countries if possible.

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