Hong Kong – Taiwan EPC / RFID Academia Awards
香港–台灣大專學界 EPC / RFID 大獎
2011

Winning Case Sharing
得獎案例分享

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About GS1 Hong Kong

Founded in 1989 by the Hong Kong General Chamber of Commerce, GS1 Hong Kong is a not-for-profit industry support organization. It is committed to enhancing Hong Kong enterprises' competitiveness through the provision of global supply chain standards, best practices and enabling technologies. As GS1's local chapter, GS1 Hong Kong is authorized to issue and administer GS1 identification numbers in Hong Kong. Standards and solutions offered include bar coding services, B2B e-commerce services, Global Data Synchronization (GDS) and Electronic Product CodeTM / Radio Frequency Identification (EPC/RFID). The organization also hosts a wide range of training courses to facilitate knowledge transfer for SCM principles, e-business strategies, global standards and the implementation of enabling technologies. The GS1 community has over one million corporate members spanning over 150 countries and economies and more than 20 industries around the world. For more information about GS1 Hong Kong, please visit: http://www.gs1hk.org.

香港貨品編碼協會簡介

香港貨品編碼協會由香港總商會於 1989 年成立，是一個非牟利的工商業支援機構，致力透過發展全球供應鏈標準、應用技術及提供最佳實務守則，爲香港企業提高市場競爭力。香港貨品編碼協會爲 GS1 國際組織的本地分會，是獲認可簽發及管理 GS1 國際貨品編碼的機構。協會所提供的標準和解決方案包括貨品編碼及條碼服務、企業對企業電子商貿服務、全球數據同步 (GDS) ，以及產品電子代碼 / 無線射頻識別 (Electronic Product CodeTM / Radio Frequency Identification)。協會亦舉辦一系列促進知識轉移的培訓課程，包括供應鏈管理原理、電子商貿策略、全球標準及如何實施應用技術。GS1 在全世界各地擁有逾一百萬企業會員，遍布全球超過一百五十個國家和經濟體及二十多個行業。如欲獲得更多有關香港貨品編碼協會的資料，請瀏覽：www.gs1hk.org。

About GS1 Taiwan

GS1 Taiwanis established in 1986 and it is a non-governmental organization that forms a bridge between the government and industry sectors. The major job is introducing GS1 Standards to domestic industries. Currently, the organization has over 19,000 barcode members. The major mission of GS1 Taiwan is to enable a harmony to be reached on solutions that meet both the demands of business and the broader needs of society.

Since 1986, GS1 Taiwan has supported many governmental projects to adopt traceability and remain safety in deferent industry segments. In recent years, the organization has nurtured over 4,000 talents via training courses, examinations and activities to fulfill barcodes and EPC/RFID territories.

GS1 Taiwan 簡介

GS1 Taiwan 於 1985 年正式成立並申請加入 EAN International，並於 1986 年通過 EAN 國際組織入會申請核給商品條碼國家代號 471。GS1 Taiwan 為非營利組織，執行長為林暉先生，在商業夥伴中保持中立，結合產、官、學、研等各界資源，使 GS1 Taiwan 真正成為企業夥伴間協同合作的平台。

自 1988 年至今，多次承接經濟部及標準檢驗局之條碼及產業自動化相關專案；近兩年，分別承接"低壓儲氫罐流通履歷認驗證制度研究"，及"台灣用藥安全及藥品控管效率提升之條碼系統應用計畫"等政府專案，推動條碼及 EPC/RFID 技術在工業及醫療產業的發展應用。

GS1 Taiwan 於 2009 年起，於台灣校園及業界推動條碼及 EPC/RFID 人才培育認證教育訓練及考試制度，至今約 4 ,000 人取得 EPC/RFID 基礎認證、數百人取得 GS1 條碼管理師認證，並藉由舉辦多項活動，以培育更多條碼及 EPC/RFID 的人才。

The Hong Kong U-21 RFID Awards

The Hong Kong U-21 RFID Awards was first established in 2009 by GS1 Hong Kong to bring recognition to creative young talents who were committed to developing new EPC/RFID applications or technological products to address business issues and problems of daily lives. The purpose of the Awards is to promote wider adoption of EPC/RFID technology in business and daily lives, and encourage further original EPC/RFID application and technology development in the local academic institutions.

Technology advancement and sustainability requires inputs from both industry and academia. Today's young generations are the industry talents in the future who will undertake the important role of sustaining Hong Kong's competitiveness in the global marketplace. Against this backdrop, the Hong Kong U-21 RFID Awards 2011 was established to:

- Foster collaboration between industry and academia to develop new EPC/RFID applications and technological products with market potential
- Nurture a new generation of technical professionals with creativity and business acumen
- Stimulate market demand for innovative EPC/RFID applications and products
- Inspire new insights in the industry with the innovativeness and enthusiasm of tertiary students

Categories

Best EPC/RFID Concept

The winner of this award will demonstrate a high level of originality and creativity in adopting EPC/RFID technologies attempting to address a well-defined business issue or daily lives' problem, which has foreseeable market potentials.

Most Innovative EPC/RFID Application

The winner of this award will be an EPC/RFID application, integration or product, which is innovative, possesses distinctive features, complies with global RFID standards, and may also address market needs. Heavy weights will be allocated for projects developed through partnership between an enterprise and an academic institution.

香港 U-21 RFID 大獎

香港 U -21 RFID 大獎於 2009 年由香港貨品編碼協會設立，旨在獎勵創意青年人才投入發掘 EPC/ RFID 應用或研發產品，以解決商業以及日常生活的問題。獎項目的是推廣 EPC / RFID 技術更廣泛地在商業和日常生活上採用，並進一步鼓勵本地學術機構發展原創的 EPC/ RFID 應用和技術的。

技術的進步和可持續的發展需要業界和學術界的投入。今天的年輕一代是未來行業的人才，他們將擔任維持香港在全球市場上的競爭力的重要角色。有見及此，香港的 U -21 無線射頻識別大獎成立包含以下目的：

- 促進業界和學術界的合作，開發具有市場潛力的新的 EPC/ RFID 應用和技術產品
- 培養具有創造力和商業頭腦的新一代專業人才
- 激發 EPC / RFID 應用系統和產品的市場創意需求
- 啓發大專學生的創新精神及熱誠

獎項類別

最佳 EPC / RFID 概念

此獎項得主需展示高度的原創性和創造性，以採用 EPC / RFID 技術，解決明確的商業或日常生活中的問題，並能洞察市場潛力。

最具創意 EPC / RFID 應用

此獎項得主需以 EPC / RFID 技術的應用、整合或產品爲其參賽項目，得獎項目需具創新意、有鮮明的特點、符合全球 RFID 標準、並滿足市場需求。評通過企業和學術機構之間的合作開發項目可獲更重評分。

The Taiwan EPC Architecture Award

The Taiwan EPC Architecture Award along with college contest of the EPCglobal Standards and the Internet of Things (IOT) was established by EPCglobal Taiwan in 2010. This award and contest are focus on undergraduate students of domestic institutes and universities.

The main purpose of this contest is to introduce EPCglobal Standards to most college students and cultivate experts. Via this activity, students have chances to learn experiences from industrial professions, and exchange ideas with other students.

The contestants should showcase their projects which follows the standard(s) of EPCglobal Architecture Framework.

The contest has two stages:

The First Stage: Referees will judge the students' paper assignments.

The Second Stage: Nominees will present the live demo of their projects in front of referees. In last ten minutes, referees will have the Q&A session with nominees.

After the contest, EPCglobal Taiwan will provide awards and prizes to winners for encouraging their motivation.

EPC 暨物聯網標準專題競賽

EPCglobal Taiwan 為提升 EPCglobal 標準之應用解決方案及專題研究，舉辦大專院校 EPC 暨物聯網標準專題競賽，活動以大專院校大學部學生為主。EPCglobal Taiwan 舉辦此活動，目的在於與業界經驗交流機會，共同營造 EPCglobal 標準之研究、發展、應用，達到培育優質人才落實於產業的效益，因此將頒發獎金及獎狀，以茲鼓勵。

競賽主題將以 EPCglobal Architecture Framework 為主，參賽學生得依其 EPCglobal Architecture Framework 任一標準製作相關專題，發表相關領域成果。

本競賽將分為初賽及決賽兩階段；初賽為書面審查，由 EPCglobal Taiwan 聘請各會內外之專家擔任評審委員，依創新性、實用性及特色展現等相關項目，進行分類及審查，並依成績高低遴選出決賽作品。決賽則邀請入圍學生或團隊至 EPCglobal Taiwan 總會報告其成果，接受各領域之專家評審委員提問 10 分鐘進行審查，並依展示、簡報內容、台風及問答進行決賽評審。

本競賽依照評審委員決議，決選出首獎、特優獎、優等獎各 1 名，佳作若干名，以鼓勵參加競賽的學生。

Congratulation Message

It is our great pleasure to co-organize the first-ever Hong Kong-Taiwan EPC/RFID Academia Awards with GS1 Taiwan. Through the Awards, we give recognition to those academic elites who are committed to innovating and developing new EPC/RFID applications and technological products.

The competitiveness of Hong Kong lies on the creative and pervasive use of innovative technology. The event plays a crucial role in inspiring new insights in the industry with the innovativeness and enthusiasm of tertiary students.

We take this opportunity to congratulate all winners in Hong Kong and Taiwan on their success, and wish that all the young talents can continue their efforts in creating more innovative EPC/ RFID applications and products, realizing the benefits of the technology in optimizing enterprises and improving our daily lives.

Ms. Anna Lin
Chief Executive
GS1 Hong Kong

賀詞

我們很高興能與GS1 Taiwan共同舉辦第一屆香港---台灣大專學界EPC/RFID大獎。透過這個獎項，我們表揚致力創新和發展 EPC/ RFID 的應用和科技產品的學界精英。

香港的競爭力有賴具創意和廣泛使用創新科技。在這方面，是次比賽擔當一個重要的角色，藉著那些大專生的創新和熱誠，為業界啓發靈感，賦予創新活力。在此，我們恭喜所有香港和台灣的得獎者，並希望所有具創意天賦的年青人，能夠繼續致力創造更多創新 EPC/ RFID 的應用和產品，體現科技優化企業和改善我們日常生活的好處。

香港貨品編碼協會
總裁
林潔貽女士

Congratulation Message

Congratulations to the winners of the 2011 Hong Kong – Taiwan EPC/RFID Academia Awards

On behalf of GS1 Taiwan, we are pleased to announce that The University of Hong Kong, The Hong Kong Polytechnic University and Hong Kong Institute of Vocational Education (Tsing Yi) have been awarded the 2011 Hong Kong – Taiwan EPC/RFID Academia Awards.

To choose recipients of this award, winning teams tracked all new innovation projects, products in maturity, and marvelous features. I believe with its unique presence in the EPC/RFID domain, especially for Greater China region, and with the capability of these incredible projects by award winners will have an impact on the industry in the near future.

The greatest growth of RFID market will be found in the territory of the Internet of Things, storage management systems and Real Time Location Systems in the next decade. Throughout the competition, we could see more excellent projects have met these market segments.

In recognition of the novel technical capabilities, GS1 Taiwan presents the 2011 Hong Kong – Taiwan EPC/RFID Academia Awards to all three terrific teams. I am wishing you every success in 2011.

Thank you.

Sincerely,

GS1 Taiwan
CEO Lin Hui / Ph.D

賀詞

GS1 Taiwan 首先恭賀香港大學、香港理工大學及香港專業教育學院(青衣分校)奪得 2011 年香港-台灣大專學界 EPC/RFID 大獎，由於三所學校得獎作品具有創新性及實用性，並帶給各界耳目一新的感覺，因此特頒發此獎，以示鼓勵。

我們相信這些得獎者優秀的作品，除了本身有具有獨特性外，對未來在 EPC/RFID 產業中，亦會發揮影響力。在未來十年裡，物聯網、倉儲管理系統及即時定位系統爲 RFID 成長最快速的三大領域，在這些得獎作品裡，皆可見到以這些領域爲主的創作，足見得獎團隊相當具有前瞻性。

由於得獎團隊的優異表現，因此謹代表 GS1 Taiwan 頒發 2011 年香港-台灣大專學界 EPC/RFID 大獎給三位團隊成員。希望得獎團隊能夠持續在 EPC/RFID 產業大放異采。

財團法人中華民國商品條碼策進會
執行長林暉/企管博士

Hong Kong U-21 RFID Awards 2011 香港 U-21 無線射頻識別大獎 2011
Gold Award 金獎
Most Innovative EPC/RFID Application
最佳 EPC/RFID 概念

Project title 項目名稱: RFID-based Carbon Leveling Information Platform (RF-CLIP)
Students 學生:Cheng Cheung Tong Thomas, Yeung Chui Ling Charlie 鄭章湯、楊翠玲
Supervisors 指導: Dr. Andrew W.H. IP, Dr. Sandy S. To, Dr. Benny C.F. Cheung
葉偉雄博士、杜雪博士、張志輝博士

Abstract:

An RFID-based Carbon Leveling Information Platform (RF-CLIP) is proposed to collect, analyze and share the information of product in the carbon footprint society which consists of two main engines (a) Product Carbon Footprint Engine and (b) Dynamic Pedigree of Carbon (PoC) Engine. Product Carbon Footprint Engine is responsible to collect information provider’s (i.e. supply chain partners) data related to the product carbon footprint using API and web-based GUI, respectively. With respect to the information provider’s input, the result of product carbon footprint in item level is generated. Dynamic PoC Engine is responsible to provide dynamic information of product carbon footprint with respect to the dynamic PoC to facilitate information consumers (i.e. end consumer and corporate consumer) in choosing the product, subjected to the principles of Ethical Consumerism and Corporate Social Responsibility (CSR).The information consumers retrieve the information of product carbon footprint via RF-CLIP using Radio Frequency Identification (RFID) technology (i.e. kiosk with RFID module)and Near Field Communication (NFC) technology (i.e. smart phone with NFC module), respectively. By leveraging EPC/RFID technologies, EPC standard is adopted for representing the product data and RFID data are identified, captured and exchanged by EPCglobal Network Architecture in the carbon footprint society.

Chapter 1 Introduction

A great majority of daily and business activities generate excessive Green House Gases (GHG) to the atmosphere; so that causes climate change and global warming. The frequent natural disasters (i.e. hail and drought) and melted ice in Arctic showed the climate changes over the decades. It becomes a critical environmental problem and concerned over the world. Different international treats and conferences (i.e. Kyoto Protocol and Copenhagen Conference) are held and aimed at reducing Green House Gas (GHG) emission in corporate and impacts of global warming. For example, Kyoto protocol aimed to minimize the most important GHG contributions, included Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (*HFCs*), Perfluorocarbons (*PFCs*) and Sulphur hexafluoride (SF_6). According to the statistics of IPCC Assessment Report (Figure 1), CO_2 is the major greenhouse gas (GHG) emissions in the world and occupied about 76.7% of major global GHG. Therefore, lots of GHG measurement and standards use CO_2 as a measurement unit. However, how many companies follow the rules and implement "green" policy? How the public can get the "green" information?

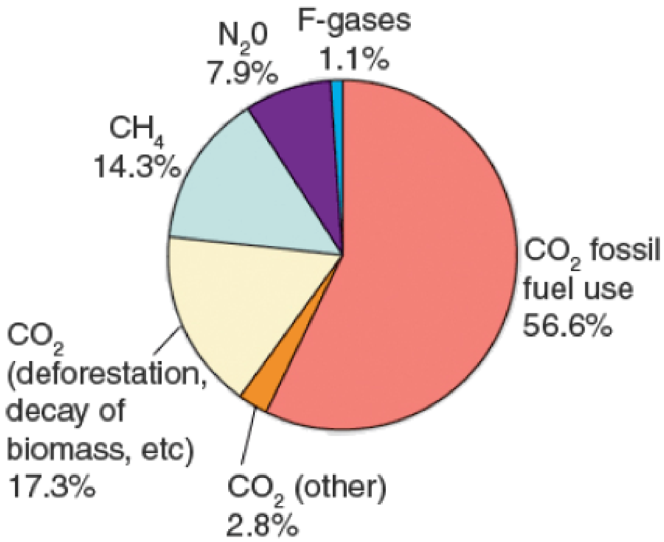

Figure 1 Major Global Greenhouse Gases

(Source: IPCC 4th Assessment Report - Climate Change 2007: Synthesis Report)

The eco awareness of public is rising as the climate changes are affecting our daily life. Eco-friendly becomes one of product purchasing consideration, so called "Ethical Consumerism". According to Ethical Consumerism Report 2010, consumer spending on ethical food and drink has increased by 27% and ethical personal products have increased by 29% over two years. This showed that consumers are more willing to buy more environmental friendly products when they have choices. In order to fit in the requirements of consumers, corporate should show their "Corporate Social Responsibility" (CSR) through implementing "green" policy and publish "green" information. Therefore, corporate can integrate social and environmental concerns in their business operations and fulfill the requirements of consumers, and even international regulation.

Carbon Footprint measurement is one of "green" information that can provided by corporate and let the consumer to choose more environmental friendly products. Carbon Footprint measures the amount of GHG produced in daily activities through burning fossil fuels for electricity and transportation. Carbon Footprint can be measured in product, corporate and country base. In Hong Kong, Country Carbon Footprint is measured by international authority such as Intergovernmental Panel on Climate Change (IPCC) and published yearly indicator. Corporate Carbon Footprint is being promoted in recent years. Product Carbon Footprint is always ignored but is the information that consumers want to know. As Product Carbon Footprint need to collect the GHG emission in the entire life of product, it is difficult to collect data in each point and calculate the total carbon footprint. Corporate and government lack of incentive to promote the product carbon footprint measurement.

Therefore, RFID-based Carbon Leveling Information Platform (RF-CLIP) is designed to facilitate corporate to measure product carbon footprint (PCF) from raw material production to the selling point. It is a "cradle to gate" supply chain assessment (see Figure 2) that calculates the major GHG emission (CO_2) from raw material production, manufacturing, upstream and downstream transportation to before end consumers purchasing. Therefore, conducting a "cradle to gate" product carbon footprint allowing consumers and also supply chain parties recognize the CO_2 emission level in the entire life of each product.

Figure 2 Measurement Score of Supply Chain

Radio Frequency Identification (RFID) technology and Electronic Product Code (EPC) standard are employed in RF-CLIP. Each item and goods are placed RFID tags to identify unique product supply chain flow and process dynamic carbon footprint information. "Pedigree of Carbon" (PoC) concept is applied to measure partial carbon footprint with one node and path. Automatic carbon footprint calculation is done through processing the data provided by supply chain parties. Consumers can know what they want to know about green product information. With the effort of consumer, corporate and government, Carbon footprint society is form to measure and share product carbon footprint information. Hence, RF-CLIP aimed to raise the environmental consciousness of consumers and corporate. GHG emission can be reduced through visualize carbon information. As a result, it can benefit society as a whole as well as bringing positive impact on corporate reputation.

1.1 Problem Statement

RFID based Carbon Leveling Information Platform (RF-CLIP) attempted to address the current social issues and challenging when measuring product carbon footprint as following mentions.

(a) High Environmental Consciousness on Product Purchasing

As the impacts of serious climate change and greenhouse gas emission, the public environmental consciousness is rose. A high environmental consciousness influences human behaviour in purchasing consumption and preference. Therefore, the term of "Ethical Consumption" has been rose. According to a governmental survey (2009), about one fourth Hong Kong interviewees willing to buy recycled (green) product as environmental consciousness. Recycled products, organic foods and fair-traded products are the trend of product market nowadays. Ethical consumers are more willing to buy green products that allow them to enjoy a healthier lifestyle. Hence, the demand for green products will be increasing. For a customer oriented product market, the desire of consumers becomes more important for product designing and development. Corporate should take "green" action to response the requests of ethical consumers.

(b) *Low Information Visibility of Product Carbon Footprint*

In Hong Kong, corporate usually only provide some specification and characteristics of products, but few or even no "green" production information or standards such as material sources and greenhouse gas emission is showed to consumers. Even some international corporate such as Apple Computer has showed the carbon footprint level, but they only provide the total amount, rather than the whole product supply chain. It cannot show the greenhouse gas emission of each stages and start from suppliers. It lacks of transparency of each stages and transportations. Besides, the product information is same for the same type or same lot of products. Therefore, the accuracy of green product information is not high. Therefore, public aware the environmental problem and want to buy a greener product, but they don't know the information they want to know. Hence, the product information visibility is low in Hong Kong.

(c) *Lack of Governmental Control on Measuring Carbon Footprint*

Besides public consciousness towards corporate environmentalism, government also acts as an importance role on monitoring and setting legal provisions on green policy. Globally, there are different scale carbon footprint projects and policies (see Table 1) formed to measure product footprint in mandatory and voluntary way. However, in Hong Kong or China, there is no environmental policy to enforce corporate to measure carbon footprint. Less governmental authorized organizations or cooperated programs are formed to promote green product information publishing. The Public also cannot get the related and detailed information from a centralize database, as all related information is for internal reference and will not be published. Hence, the role of Hong Kong government is not enough to support the on carbon footprint measuring. Therefore, a comprehensive carbon footprint measurement system needs to combine the effort of consumer (Ethical

Consumption), corporate (Corporate Social Responsibility) and government (Legal Provisions). The idea of "carbon footprint society" needs to propose to achieve a comprehensive carbon footprint measurement system and bring positive benefit to society.

Table 1 List of World Carbon Footprint Projects and Policy

	Project of Carbon Footprint	Type	Legal Provisions	Industrial Incentive	Public Information
Australia	carbon tax	Mandatory taxing system	✓ (2012)	×	×
France	Grenelle 2 law	Environmental labeling mandatory	✓ (2012)	×	×
US	Carbon Trust	carbon-footprint labeling	✓ (all Tesco's goods)	Tesco	×
Japan	National LCA Project	Official database	×	Corporate voluntarily committing	× (Private only)
Taiwan	ITRI Database	Official database	×	Association leading	✓

1.2 Objectives

The aim of the project is to propose an RFID based Carbon Leveling Information Platform for measuring carbon footprint of products as well as providing relevant carbon footprint information to the consumers focused on ethic-based decisions in the mass market. To achieve this aim, several objectives are needed to be accomplished:

(i) To measure total carbon footprint through visualize carbon footprint of the entire products supply chain

(ii) To compare carbon footprint of similar products and reference for ethical consumer and corporate purchasing

(iii) To promote ethical consumption and sustainable purchasing by centralize product carbon footprint on a public cloud platform

(iv) To promote the concept of Corporate Social Responsibility (CSR) to corporate on providing greenhouse gas emission amount

(v) To level the greenhouse gas emission and as a standard on green product design and corporate performance

(vi) To encourage corporate to reduce green house gas emission and bring positive impact on social environment

Chapter 2 Carbon Footprint Society

The conceptual architecture of the carbon footprint society is shown in Figure 3. Carbon footprint society is proposed to be a large social group (i.e. the whole supply chain) that shares the information of product carbon footprint to each other, subject to the political authority, principles of Ethical Consumerism and Corporate Social Responsibility (CSR).

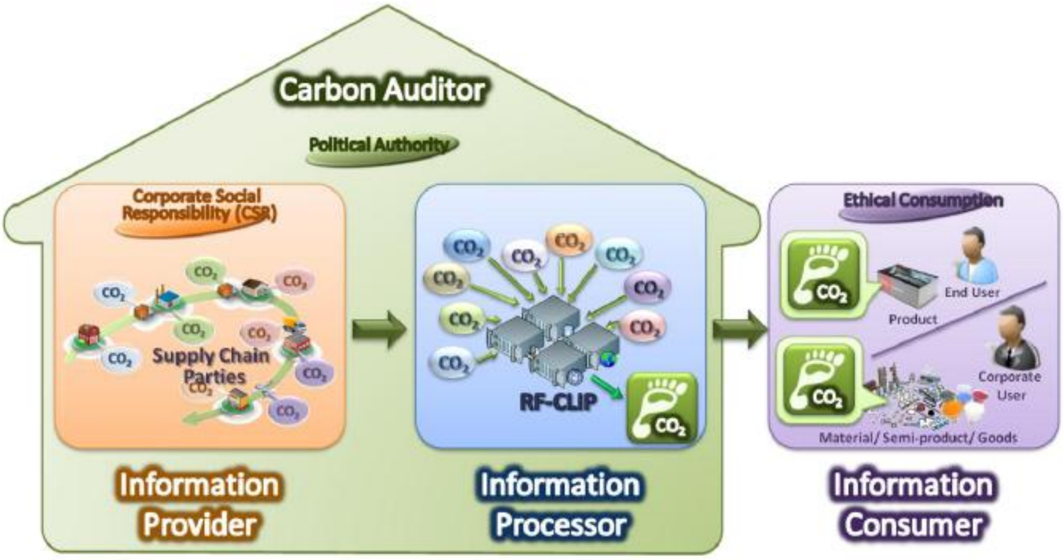

Figure 3 Carbon Footprint Society

Moreover, Radio Frequency Identification (RFID) technology is proposed to apply for measurement of product carbon footprint in the whole supply chain. An RFID tag is attached to each product (see Figure 4) and it is used to identify each product in item-level. By leveraging EPC/RFID technologies, two types of identification keys (i.e. Serialised Global Trade Item Number (SGTIN) and Global Location Number (GLN)) are proposed to use in the whole supply chain of the carbon footprint society.

(a) Global Location Number (GLN)

Global Location Number (GLN) is used to identify physical location of each information provider which is the GS1 Identification Key for Locations.

(b) Serialised Global Trade Item Number (SGTIN)

Serialised Global Trade Item Number (SGTIN) is used to identify unique target item at item-level which is the GS1 Identification Key for Items.

Figure 4 Product with RFID Tag

In the carbon footprint society, various parties in the whole supply chain are proposed to play different roles for sharing the information of product carbon footprint. The society consists of four significant parties including Information Provider, Information Processor, Information Consumer and Carbon Auditor.

(d) Information Provider

As shown in Figure 5, information provider is responsible to provide the data of product carbon footprint during production and transportation subject to Corporate Social Responsibility (CSR) in the society. Various supply chain parties are proposed to be information providers including manufacturers, suppliers, vendors, wholesalers, retailers, etc. Each supply chain partner only provides data of CO_2 emission during production and transportation of their own products that is called "partial" carbon footprint of product (see Figure 6).

Figure 7 RFID-based Carbon Leveling Information Platform (RF-CLIP) as Information Processor

(f) Information Consumer

As shown in Figure 8, two types of the information consumers in the society are proposed that include end consumer (i.e. end user) and corporate consumer (i.e. merchandiser). Product carbon footprint will be shared to the information consumers by the information processor during consuming the products. According to the product carbon footprint, all the information consumers (i.e. end consumers and corporate consumers) make ethic-based decisions during selecting products and / or before consuming products based on Ethical Consumerism and CSR, respectively.

Figure 8 Types of Information Consumers

(g) Carbon Auditor

Carbon auditor (i.e. Government or authority organization) is responsible to audit the data of product carbon footprint provided by the information provider, subject to the political authority (see Figure 9).

Figure 9 Carbon Auditor subjected to Political Authority

2.1 Product Carbon Footprint

Carbon footprint is defined as systematic quantification, tracing, classification and reporting the greenhouse gas (GHG) emissions. In accordance with the Kyoto Protocol, the relative composition of carbon dioxide (CO_2) is the highest one (i.e. approximately 85%) as compared with other five GHG (e.g. methane (CH_4) of approximately 12%) and the emissions of CO_2 are directly proportional to fossil-fuel based energy consumption (i.e. fuel and electricity) regarding their energy consuming system (i.e. machine and delivery truck) and carbon emission activities (i.e. production and transportation).

In the carbon footprint society, the product carbon footprint is proposed to measure the CO_2 emissions as caused directly (i.e. during production) and indirectly (i.e. during transportation) in item-level. Moreover, the product carbon footprint is also measured in the whole supply chain. In the other words, product carbon footprint is also measured from the raw material production, manufacturing, upstream and downstream transportation to before end consumers purchasing (see Figure 10). In the carbon footprint society, each supply chain partner provides partial carbon footprint of product (see Figure 11) to the information processor. By gathering the entire partial carbon footprint provided by the supply chain partners, a total carbon footprint is generated by the information processor for a product.

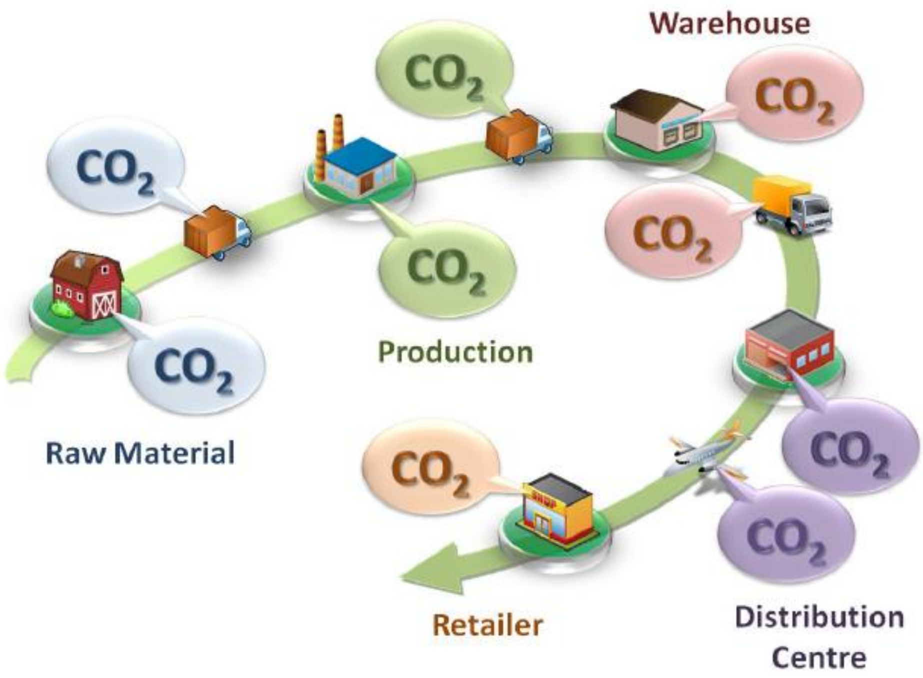

Figure 10 Conceptual Diagram of CO_2 Emission in various Supply Chain Partners

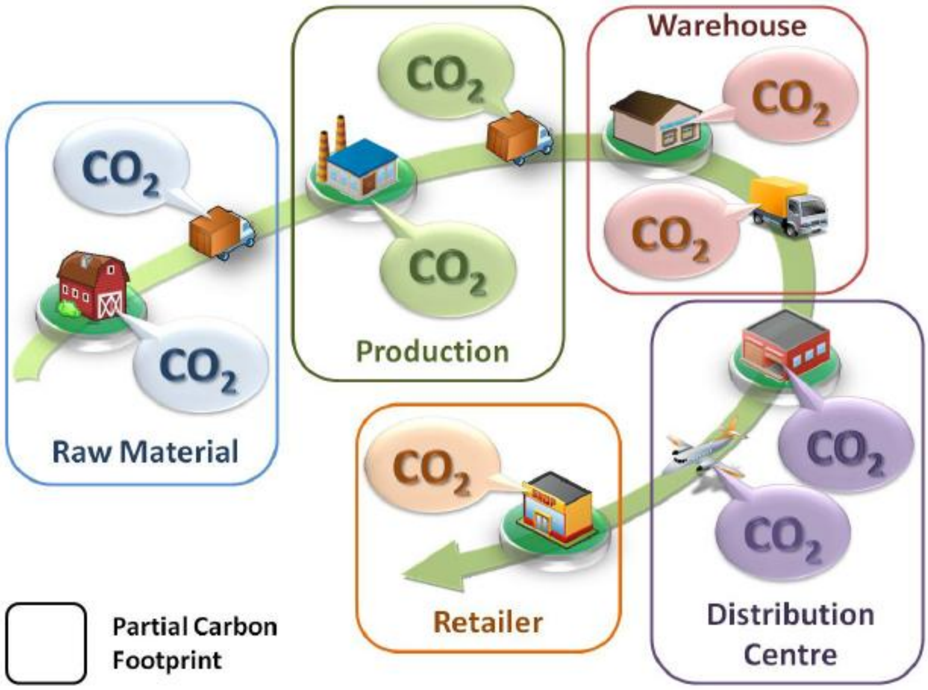

Figure 11 Conceptual Diagram of Partial Carbon Footprint

2.2 Dynamic Pedigree of Carbon (PoC)

By gathering all the data of the partial carbon footprint provided by the supply chain partners, a dynamic Pedigree of Carbon (PoC) is generated by the information processor for a product at the same time. A schematic diagram of PoC in item level is shown in Figure 12.

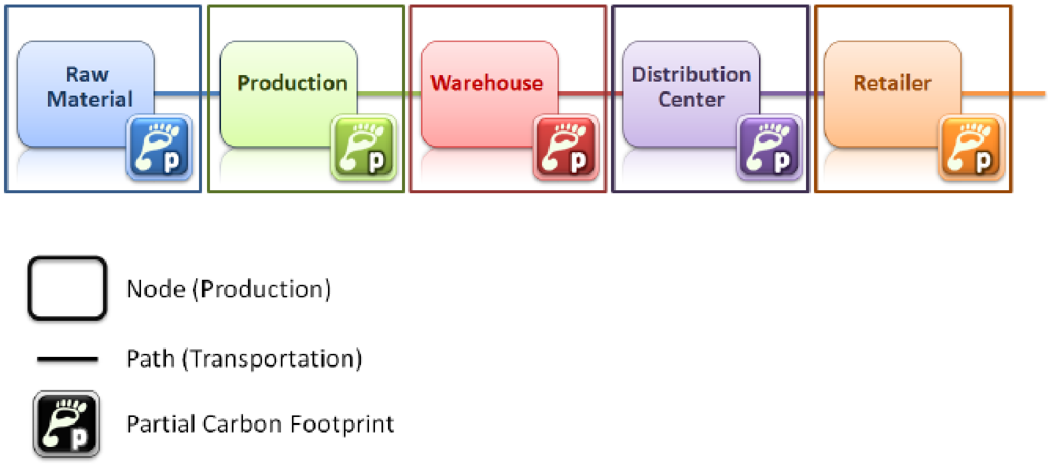

Figure 12 Schematic Diagram of Pedigree of Carbon (PoC) in Item-level

As shown in Figure 12, node represents product carbon footprint in production and path represents product carbon footprint in transportation, respectively. In item-level, one node with one path represents the partial carbon footprint of a product in each supply chain partner which also represents partial PoC of a product. Thus, all the nodes with paths represent total carbon footprint of the product which also represent PoC of the product. In the other words, the generation of each Pedigree of Carbon (PoC) depends on the number of nodes with paths that is also called "Dynamic Pedigree of Carbon".

Chapter 3 RFID-based Carbon Leveling Information Platform (RF-CLIP)

An RFID-based Carbon Leveling Information Platform (RF-CLIP) is proposed to be information processor to collect, analyze and share the information of product carbon footprint as a middleman in the carbon footprint society. System architecture of RF-CLIP is shown in Figure 13.

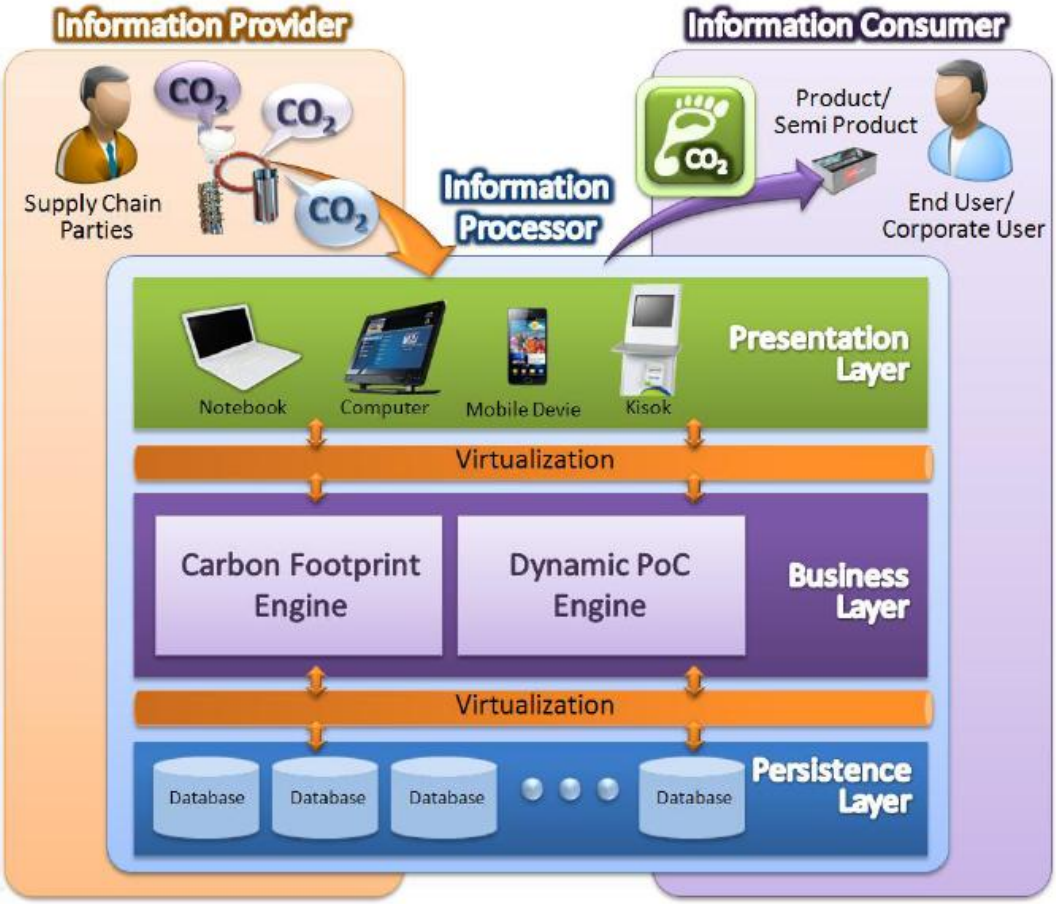

Figure 13 System Architecture of RFID-based Carbon Leveling Information Platform (RF-CLIP)

As shown in Figure 13, RF-CLIP is information processor as a core module in the whole supply chain of the carbon footprint society which consists of three main tiers including (a) persistence tier, (b) business logic tier and (c) presentation tier for measurement of product carbon footprint.

3.1 Persistence Tier

Basically, persistence tier maintains all the information of the of the business logic tier in the system database. Persistence tier (i.e. database) is an architectural layer which is used to

- Store data provided by the information provider
- Retrieve specific data (i.e. CO_2 emission) from the system database and turn it into useful information (i.e. product carbon footprint, pedigree of carbon (PoC))

3.2 Business Logic Tier

Business logic tier is a core module as a human brain which has two core engines including: -

(i) Product Carbon Footprint Engine
(ii) Dynamic Pedigree of Carbon (PoC) Engine

3.2.1 Product Carbon Footprint Engine

As shown in Figure 14, product carbon footprint engine of RF-CLIP is proposed to collect information provider's data related to the product carbon footprint. With respect to the information provider's input, the result of product carbon footprint in item level is generated and stored in the persistence tier.

Two modes for collecting information provider's carbon emission data and energy consuming information are proposed that include: -

(i) Provide the product carbon footprint by the information provider
(ii) Calculate the product carbon footprint by the engine with respect to information provider's carbon emission data and energy consuming information

Product carbon footprint engine provides a self-explanatory and step-by-step guidance to the information provider. According to the guidance, the information provider only inputs the specific information regarding their energy consuming system (i.e.

production machine and truck, etc.) and carbon emission activities (i.e. production and transportation) relating to their operational and energy consumption needs (i.e. electricity and fuel), so as to calculate the product carbon footprint using tailor-made algorithm instantly. For calculation of product carbon footprint, a tailor-made algorithm is proposed and shown in Section 3.2.1.1.

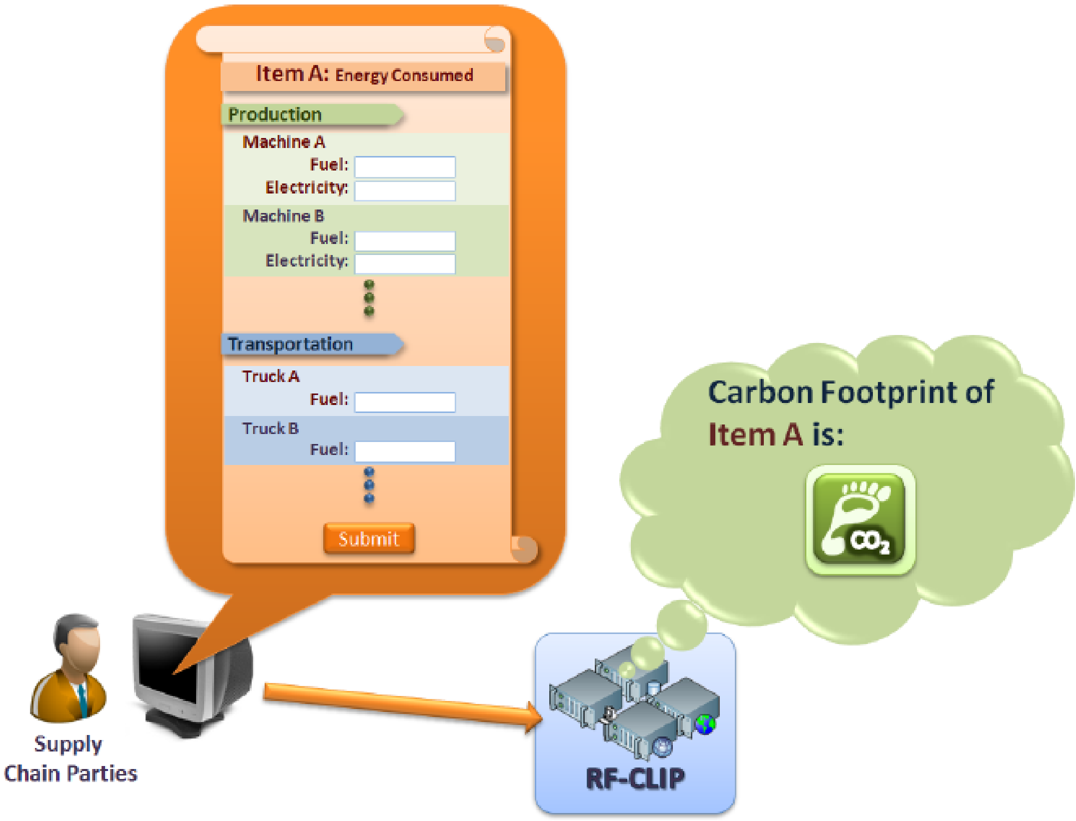

Figure 14 Conceptual Diagram of Product Carbon Footprint Engine

3.2.1.1 Algorithm for Calculation of Product Carbon Footprint

Basically, the emission of CO_2 during the production and transportation carbon footprint of each product is proposed to measure in the whole supply chain. The carbon footprint results are expressed in kilograms of carbon dioxide equivalent ($kg\ CO_2$) emissions. The total CO_2 emission per target item ($E_{CO_2,i}$) is mainly determined by the CO_2 emission per target item i in production ($E_{CO_2,i,P}$) and CO_2 emission per target item i in transportation ($E_{CO_2,i,T}$) in $kg\ CO_2$.

The equation of product carbon footprint per item in production can be expressed as: -

$$E_{CO_2,i,P} = \sum[(EI_{CO_2,f} \times EC_{P,f})/Q_{i,P}] + \sum[(EI_{CO_2,e} \times EC_{P,e})/Q_{i,P}] \qquad (1)$$

where

i = 1, 2, 3, … , n

$EI_{CO_2,f}$ = CO_2 emission index for fuel types, $kg\ CO_2/l$ in unit

$EC_{P,f}$ = Energy consumed in production for fuel types, l in unit

$Q_{i,P}$ = Quantity of target items i in production

$EI_{CO_2,e}$ = CO_2 emission index for electricity, $kg\ CO_2/kWh$ in unit

$EC_{P,e}$ = Energy consumed in production for electricity, kWh in unit

The equation of product carbon footprint per item in transportation can be expressed as: -

$$E_{CO_2,i,T} = \sum\{EI_{CO_2,f} \times [(EC_{T,f}/W_T) \times W_{i,T}]\} + \sum\{EI_{CO_2,e} \times [(EC_{T,e}/W_T) \times W_{i,T}]\} \qquad (2)$$

where

i = 1, 2, 3, … , n

$EI_{CO_2,f}$ = CO_2 emission index for fuel types, $kg\ CO_2/l$ in unit

$EC_{T,f}$ = Energy consumed in transportation for fuel types, l in unit

W_T = Total weight of all items in transportation, kg in unit

$W_{i,T}$ = Weight per target item i in transportation, kg in unit

$EI_{CO_2,e}$ = CO_2 emission index for electricity, $kg\ CO_2/kWh$ in unit

$EC_{T,e}$ = Energy consumed in transportation for electricity, kWh in unit

The equation of total product carbon footprint per item can be expressed as: -

$$E_{CO_2,i} = \sum (E_{CO_2,i,P} + E_{CO_2,i,T}) \quad (3)$$

where

i = 1, 2, 3, … , n

$E_{CO_2,i,P}$ = CO_2 emission per target item i in production, $kg\ CO_2$ in unit

$E_{CO_2,i,T}$ = CO_2 emission per target item i in transportation, $kg\ CO_2$ in unit

3.2.2 Dynamic Pedigree of Carbon (PoC) Engine

As shown in Figures 15 and 16, Dynamic Pedigree of Carbon (PoC) Engine provides dynamic information of product carbon footprint with respect to the dynamic PoC to facilitate information consumers (i.e. end consumer and corporate consumer) in choosing the product, subjected to the principles of Ethical Consumerism and Corporate Social Responsibility (CSR).

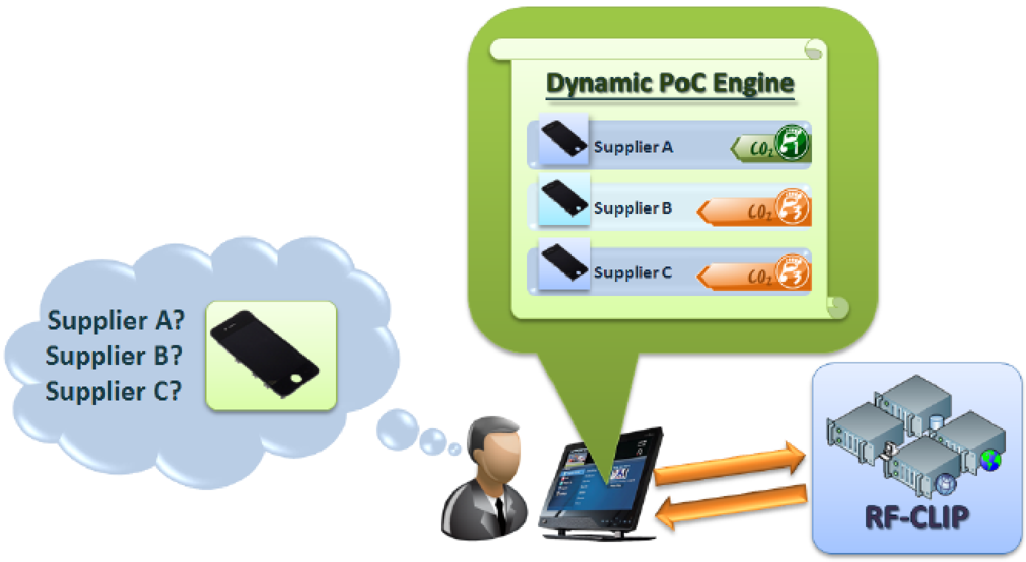

Figure 15 Conceptual Diagram of Conceptual Diagram of Dynamic Pedigree of Carbon (PoC) Engine for Information Consumer (i.e. Corporate Consumers)

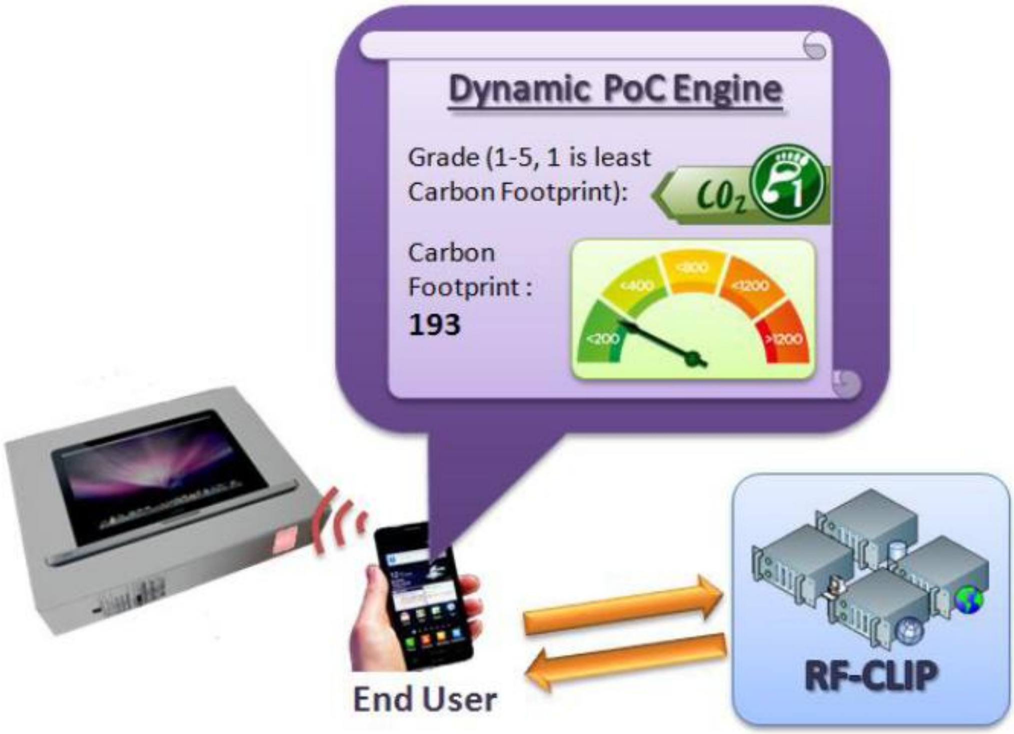

Figure 16 Conceptual Diagram of Dynamic Pedigree of Carbon (PoC) Engine for Information Consumer (i.e. End Consumers)

As shown in Figure 17, PoC engine provides an easy to use and easy to understand method (i.e. Dynamic Product Carbon Footprint Grade) by which information consumers (i.e. end consumer and corporate consumer) can retrieve the PoC of the product. Dynamic Product Carbon Footprint Grade is proposed to be standardized measurements of varying levels of product carbon footprint with respect to the dynamic PoC that the grading level is assigned in number (i.e., 1, 2, 3, 4, or 5). In the grading level, Grade 1 is the least carbon footprint (or CO_2 emission) and follows with Grade 2. Grade 5 is the most carbon footprint (or CO_2 emission). Besides, the actual value of product carbon footprint is also provided and indicated in gauge indicator.

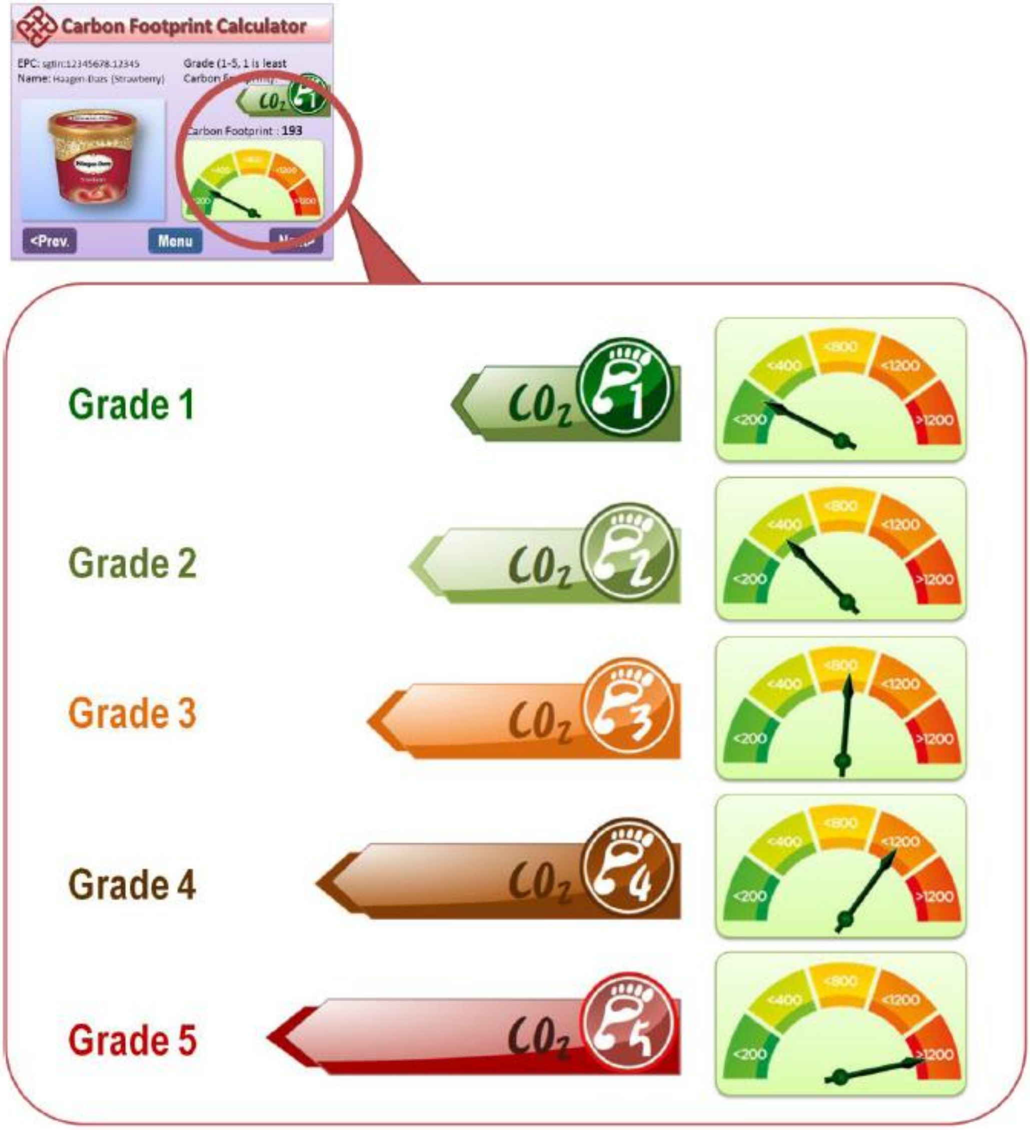

Figure 17 Dynamic Product Carbon Footprint Grade

3.2.2.1 Algorithm of Pedigree of Carbon (PoC)

By aggregating the Pedigree of Carbon (PoC) of the product, a tailor-made computational algorithm is proposed and used in the Dynamic Pedigree of Carbon (PoC) Engine (see Algorithm 1).

```
void aggregate(CheckPoint pt, CarbonFootprint cfp)
{
        cfp.sum(pt.calculate());

        if(pt.hasChild())
        {
                List<CheckPoint> ptList = pt.getChild();

                for(CheckPoint ptChild : ptList)
                {
                        aggregate(ptChild, cfp);
                }
        }
}
```

Algorithm 1 Aggregate of Pedigree of Carbon (PoC)

3.3 Presentation Tier

Presentation tier is designed in such a way that users (i.e. information consumer and information provider) can easily interact with the information processor (i.e. RF-CLIP) via the software layer and hardware layer.

In the software layer, the information provider (i.e. supply chain partners) provides the data of product carbon footprint to RF-CLIP using Application Programming Interface (API) and web-based Graphical User Interface (GUI), respectively. The information consumer (i.e. corporate consumer) retrieves the information of product carbon footprint via RF-CLIP using web-based Graphical User Interface (GUI).

In the hardware layer, the information consumers (i.e. end consumer) retrieve the information of product carbon footprint via RF-CLIP using Radio Frequency Identification (RFID) technology (i.e. kiosk with RFID module) and Near Field Communication (NFC) technology (i.e. smart phone with NFC module), respectively (see Figures 19 and 20).

Figure 18 Retrieve the information of product carbon footprint via RF-CLIP using Radio Frequency Identification (RFID) technology (i.e. kiosk with RFID module)

Figure 19 Retrieve the information of product carbon footprint via RF-CLIP using Near Field Communication (NFC) technology (i.e. smart phone with NFC module)

Chapter 4 Benefits and Impacts of RFID-based Carbon Leveling Information Platform (RF-CLIP)

RFID-based Carbon Leveling Information Platform (RF-CLIP) not only aims to measure the total greenhouse emission of product supply chain; but also to bring positive impact on social environment through cooperation with customers, corporate and government. Hence, users can enjoy the following benefits and impacts brought by the outstanding points of RF-CLIP.

4.1 Originality, Uniqueness and Innovativeness

(a) Total Product Supply Chain Concept

Usually, the product carbon footprint is measure the total greenhouse gas emission on last stages of supply chain. It is not the “real” carbon footprint level for a product. RF-CLIP applies “cradle to gate” product supply chain concept, which measure the carbon emission from raw material extraction ('cradle') through materials processing, manufacture, distribution to retail gate (i.e., before it is transported to the consumer). Therefore, RF-CLIP can let users know the “real” product carbon footprint throughout entire supply chain before the product transported to them.

Besides, “Pedigree of Carbon” (PoC) concept applies in RF-CLIP to measure carbon footprint of each stages and transportations (partial carbon footprint of product). Users not only can recognize the total greenhouse gas (GHG) emission and product carbon footprint, but also sub-total and carbon footprint of each stages and transportations. Hence, it facilitates users (especially corporate consumers) to choose green products with greener material, suppliers and producers.

data needed. For the supply chain parties who have low recognize about GHG emission, straightforward questions are used to guiding them rather than ask them the total amount of GHG emission. For example, inputting the fuel types, energy consumed and quantity of target item can find the CO_2 emission index. After sum up all transportation and production can be calculated its partial carbon footprint. Besides, EPC can be used to represent specific items, so to reduce the typing errors or misunderstanding on the product name and types.

4.3 Public and Automatic Identifying, Capturing and Exchanging Technology

RF-CLIP provided an all-in-one platform to identify GHG emission data, capture and exchange product carbon footprint information through RFID technology and EPC standards. They are used to track and identify unique item's location of product supply, so that to record the GHG emission of each stages. RF-CLIP acts as a public cloud services to let consumers capture the product carbon footprint information and let supply chain parties to exchange information. All the information is automatically calculating, analyzing and processing through information processor of RF-CLIP or EPCglobal architecture framework.

(a) Social Responsibility

RF-CLIP aims to provide product carbon footprint information for ethical purchasing and encourage corporate to build up social responsibility on green product producing. Therefore, RF-CLIP can help consumers and corporate to address social and environmental concerns in daily life and business operations through product carbon footprint measurement.

(b) Ethical Consumerism

Ethical consumers concern the social and environmental problem when purchasing. RF-CLIP provides product carbon footprint information with dynamic and unique product and item. Therefore, they can know more green information for them to take a greener or ethic action. On the other hand, RF-CLIP can aware others consumers on green product if product carbon footprint is widely used in

Hong Kong and it can improve their livelihood, just like the energy label in Hong Kong. As a result, the demand of green information and green products will be increasing. It also becomes a way to push corporate to provide GHG emission information, and even more.

(c) *Corporate Social Responsibilities (CSR) and Green Company Image*

RF-CLIP provides a channel to corporate on behaving and contributing ethically and with sensitivity toward social and environmental issues. Green company image can be built up through provide company greenhouse gas emission to public. Sometimes, corporate don't know its and upstream suppliers' performance of green product, so they don't have concern and recognize the problem. However, if the company can measure and recognize its and also competitors' green product performance, it can encourage them to promote greener product design and development, in order to fulfill the requests of consumer and gain more green market share.

4.4 Extensibility and Scalability

A practical project should be carried out progressively. The pressure of greenhouse gases reduction pressure will increase in scope and in intensity in the coming years. Therefore, after the success and acceptance, the greenhouse gas monitoring scope can be enhanced and regulation scale can be expended. This project (RF-CLIP) purposes to calculate CO_2 as it is the major greenhouse gas globally and a usual greenhouse gas (GHG) for general product supply chain. After the successful of CO_2 calculation, further platform enhancement can include the calculating of other GHG emission (Methane, Nitrous Oxidea and F-gases), in order to calculate product carbon footprint in higher level and assess more type of industries and electricity carbon.

This project purposes to the carbon footprint society concept to integrate consumers, corporate and government in Hong Kong and China. After the successful of implementation in Hong Kong and China, the carbon footprint society can be expended to international standard and regulation. RF-CLIP can act as a channel for Hong Kong corporate to compliance with global standard and regulation; so that the green product market can be expanded to the world.

Chapter 5 Conclusion

Climate change is now widely recognized as the major environmental problem, so we need to take action to reduce greenhouse effect and start from daily life. The most significant motivations are Ethical Consumerism, Corporate Social Responsible and regulatory pressures to measure the product carbon footprint. In this project (RF-CLIP), employing RFID technology on product carbon footprint is an ideal combination to identify and track unique products and items on carbon emission. Therefore, the concept of "Pedigree of Carbon" (PoC) can be applied to calculate partial carbon footprint in each transportations and production. On the premise that "measure it so can manage it", this project can push supply chain parties to measure and thus manage their green products through regulation. Ethical Consumerism can be promoted in Hong Kong also. It is believed that RF-CLIP can bring positive impacts to society and implement to more aspects of global green management.

Hong Kong U-21 RFID Awards 2011 香港 U-21 無線射頻識別大獎 2011

Gold Award 金獎

Most Innovative EPC/RFID Application

最佳 EPC/RFID 概念

Project title 項目名稱: Simultaneous Score-counting System in Bun Scrambling Competition

Students 學生:Man Hon Fung Rock, Yee Hoi Ting Isaac, Chau Yee Lei Crystal, Wong Chun Ho Francis 文瀚鋒、余鎧廷、周以莉、黃駿灝

Supervisor 指導: Dr. Wilson W.S. Lu 呂偉生博士

Abstract:

RFID, the radio frequency identification technology is becoming more and more common in the past few decades. Way back in history, the first rewritable RFID tag was invented and patented in the 1970s. Ever since, the technology has started to infiltrate into our daily life. Now, it has become one of the major technologies in shaping our convenient and enjoyable environment and living style.

The broad use of the RFID technology has expanded its powerful influence to many industries, improving the efficiency in documenting, tracking, managing resource and in many other ways. How about our long lasting tradition and culture?

Some would say the implementation of new technology would destroy our valuable tradition and culture. Indeed, new technology can even improve the old practice and enhance its value in this technology-leading community. Not only keeping the tradition and culture, at the same time they can be promoted and arise people's interest and attention.

In the project, our team aims to implement the RFID technology into the Hong Kong long lasting tradition - Bun Scrambling Competition in Cheung Chau Da Jiu Festival, which recently has been selected as the Intangible Cultural Heritage.

1. Abstract

RFID, the radio frequency identification technology is becoming more and more common in the past few decades. Way back in history, the first rewritable RFID tag was invented and patented in the 1970s. Ever since, the technology has started to infiltrate into our daily life. Now, it has become one of the major technologies in shaping our convenient and enjoyable environment and living style.

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In the project, our team aims to implement the RFID technology into the Hong Kong long lasting tradition - Bun Scrambling Competition in Cheung Chau Da Jiu Festival, which recently has been selected as the Intangible Cultural Heritage.

2. Objectives

- To promote the traditional culture of Cheung Chau Da Jiu Festival of Hong Kong
- To increase the reliability and efficiency of the Bun Scrambling Competition
- To enhance the excitement of the Bun Scrambling Competition

3. Background Information

3.1 History

Cheung Chau Da Jiu Festival (長洲太平清醮), celebrated on April or May (the Fourth Lunar Month), is one of the most unique festivals in Cheung Chau, which was the home of pirates from the South China Sea.

Fig 1 Cheung Chau Da Jiu Festival (Picture from Wikipedia)

The origin of this festival could be traced back to 100 years ago, when Cheung Chau was devastated by a virus in the late Qing dynasty. At that time, the locals believed that the spread of virus was caused by the evil spirit. They hence built a sacrificial altar in front of the Pak Tai Temple to pray to “Pak Tai” to drive out the evil spirit. Deity parade was performed around the village in Cheung Chau.

Soon after the parade, the spread of sickness terminated. Since then, to express the gratitude to Pak Tai for driving the evil spirit away, the Cheung Chau locals celebrated annually with deity parade. The celebration was later known as the Bun Festival.

As the festival symbolizes the residents’ gratitude, they are still organizing and participating into this annual event. Due to its great specialty and culture value, it attracts local and foreign tourists to participate in this big event in Cheung Chau, the tradition passes on.

3.2 Activities

Bun Scrambling

One of the most highlighted activities of the Cheung Chau Da Jiu Festival is the Bun Scrambling, held on the last day of eating vegetarian meals during the festival.

Fig 2 “Ping-on” (scatheless) Buns (Picture from discoverhongkong.com)

Every year three giant 60-feet Bun Towers are set up near Pak Tai Temple in Cheung Chau. The towers are built in bamboo scaffolding, covered with buns. Due to those bun-covered towers, Cheung Chau Da Jiu Festival is also called “Cheung Chau Bun Festival”. As described by the villagers, young men would climb up the Bun Towers to grab the buns at the midnight. The higher the bun grabbed was located, the better fortune the holder and his family would have. This traditional race is known as "Bun Scrambling". Unfortunately, one of the Bun Towers collapsed during the competition in 1978, injuring more than 100 participants. In the next years, only three climbers (one for each tower) are allowed to race up the respective towers.

Bun Scrambling Competition returned in 2005 but with serious safety requirements by various government departments and extra safety precaution, including proper tools for mountain climbing and tutorial for participants. The competition includes both individual and team scrambling. Since 2007, after the raised concern of food wastage, the real edible buns on the towers are replaced by plastic buns.

Fig 3 Bun Scrambling Competition (Picture from news.cn)

Other than Bun Scrambling

The large carnival-like street procession, with costumed children on stilts held above the crowd, lion dances and other colorful participants, is another highlighted activity. The parade processes through the narrow streets of Cheung Chau to the grounds near the Pak Tai Temple. Nowadays, the street procession is strictly stuck on the hot news in Hong Kong and the world and also with different professions. You may see children pretending firemen, policemen, even Donald Tsang, the Chief Executive of Hong Kong SAR.

Fig 4 Costumed children on stilts (Picture from discoverhongkong.com)

3.3 Value

Participation is the best way to experience the unique culture of Hong Kong traditional festivals.

Hong Kong's major traditional festivals are full of colour and happiness, with crowd of people going out to join the celebrations. Colourful decorations, parades in float, bun making and bun scrambling come together to be a unique festival- Cheung Chau Da Jiu Festival. It reflects the Cheung Chau villagers' worship to Pak Tai, their God.

Nowadays, the Cheung Chau Da Jiu is not merely a preserved culture among the villagers but intangible cultural heritage for the world. Every year, thousands of tourists come to Cheung Chau for this highlighted event, taking photos of young children with made up resembling deities and witness the Bun Scrambling.

Beyond the economical benefit to the tourism industry, the unique Cheung Chau Da Jiu is precious that it is a gift from our ancestor

3.4 Arrangement & rule

Training on Bun Tower Climbing

After the enrolment period of the Bun Scrambling Competition, the organizing committee will deliver 150 quotas to the applicants. Those granted with quotas then will be required to attend the training on Bun Tower Climbing which is a 10 hours course split into 3 days. This course is safety training on Bun Tower Climbing organized by the Hong Kong Mountaineering Union and mainly aims at the prevention of falling during the competition. Applicants who have completed the training on Bun Tower Climbing can enter to another stage: The selection of the finalists for the Bun Scrambling Competition.

Selection Process

The selection process is as follow: Applicants need to reach a designated height of Bun Tower and hit a signal object. The shorter the time the applicant use, the higher his/her score is. The 12 applicants with the highest scores will be invited to take part in the Bun Scrambling Competition with a minimum requirement of 2 quotas for women.

The Competition

The 12 applicants will be given 3 minutes of time, they have to climb up the Bun Tower to grab as many Bun as possible and go back to the ground and land with both feet within this 3 minutes. If applicants fail to do so within this specified time, the applicant will be disqualified regardless of his/her scores. The Bun Tower is divided into three zones which composed of bun carrying different scores. The lower zone is made of bun with one score each while the middle one is made of bun with three score. For the upper zone, the buns located there carry the highest score among the whole tower which award the applicant 9 points for each bun collected. The finalists who grab the largest numbers of buns with the highest scores within the specified time and area will be the winners. In case of a tie, the positions of the participants will be determined by their scores in the selection of finalists.

3.5 Issue & challenges

Tedious Calculation Process

Under present arrangement, Staff will calculate the cumulative scores of each applicant by counting the buns collected one by one and times the points that particular bun carry after the 3-minutes competition ends. The shortcoming of this method is that it takes a relative long time to calculate the scores and result in an 'anti-climax' of the event. This greatly affected the smoothness of the whole competition and made the whole event less entertaining. The audiences should be given a chance to witness the whole counting process, as it is one of the most exciting moments in the competition. By applying the RFID technology into the event, the competition result can be calculated within a short period of time, so that the whole counting process can be displayed to the audiences, filling the time gap and making the competition more completed.

Increase transparency avoid calculation mistake

Although there is not much complaint about the transparency and accuracy of the competition, there is still plenty room of improvement in these two aspects. The occurrence of different human errors, like calculation mistake, counting mistake is inevitable, yet can be minimized if RFID technology can be applied. For example, the marks on buns carry different scores can be hard to distinguish, especially when the staff has to finish the counting process in short period of time. With the RFID chips implanted in the buns, as all the necessary information like the scores carried can be shown, the possibility of error can be minimized. This can also increase transparency of the competition, thus enhance the confidence of applicants and participants to the competition. Application of RFID technology can help to provide accurate and reliable result in this case.

Challenges on Reuse of Bun

The Organizing Committee of the Bun Scrambling Competition intended to reuse the used buns every year due to environmental reason. However, it is difficult to implement this policy in real world because there are always missing buns after the competition; no matter it is taken by some applicants and audiences or simply lost in the crowd. It is believed that this situation can be improved by tracking the buns with RFID chips and reader; as a result, loss can be reduced. Even though some of the buns still cannot be traced back, the RFID system can also help in giving a brief record of buns available and making the arrangement process easier.

4. Application of RFID

4.1 Principle

In order to achieve the objectives of our project, RFID technology is applied into the Bun Scrambling Competition by installing a ***Simultaneous Score-counting System (SSS)***.

When the readers on the participants detect the buns with RFID tags, signal will be sent to the central computer for score counting. At the end, the buns with RFID tags will be scanned once again by the RFID readers to obtain the final results of each participant.

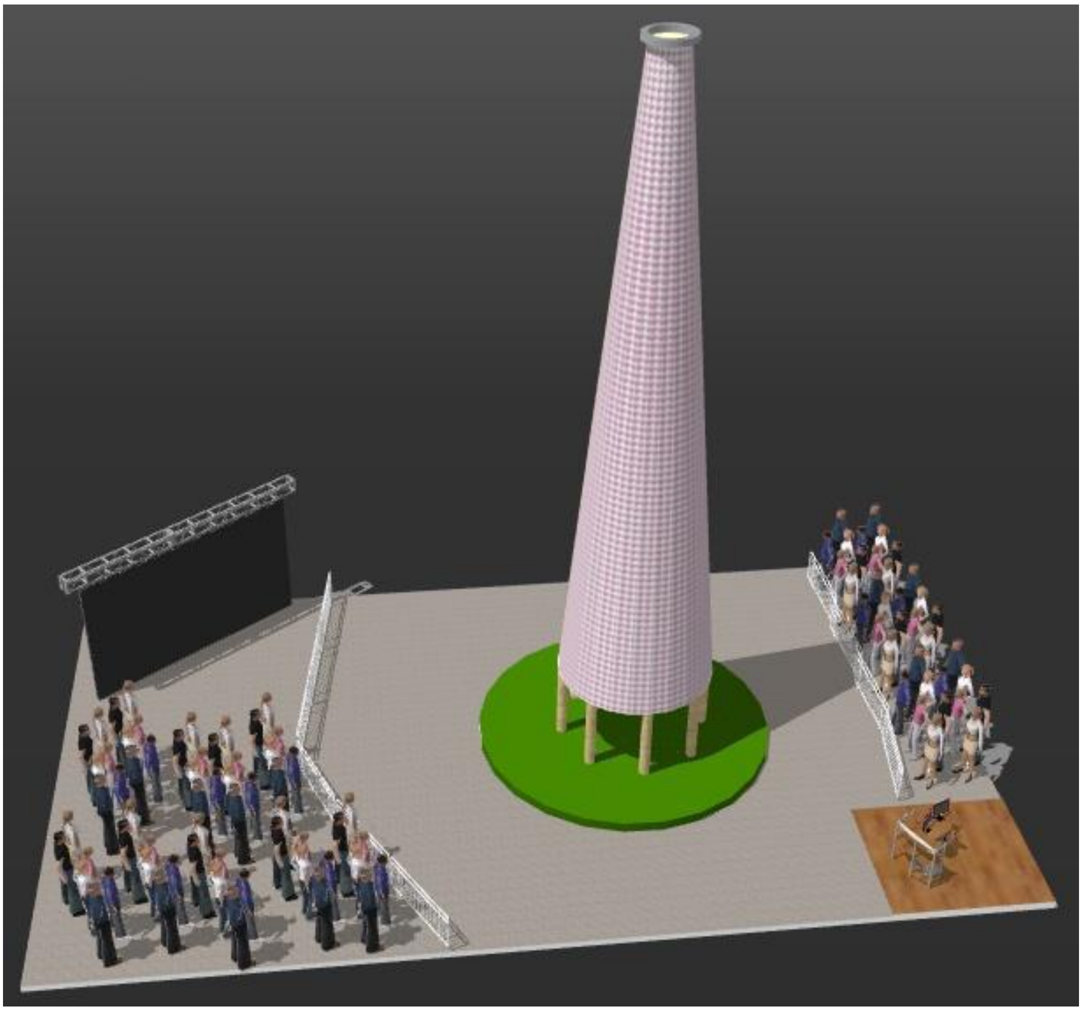


Fig 5 Simulation of Bun Scrambling Competition

4.2 Design and Apparatus

The design is simple and requires few apparatus. The apparatus adopted are listed as follows:

(i) RFID tags (attached to plastic buns)

(ii) RFID reader and transmitter

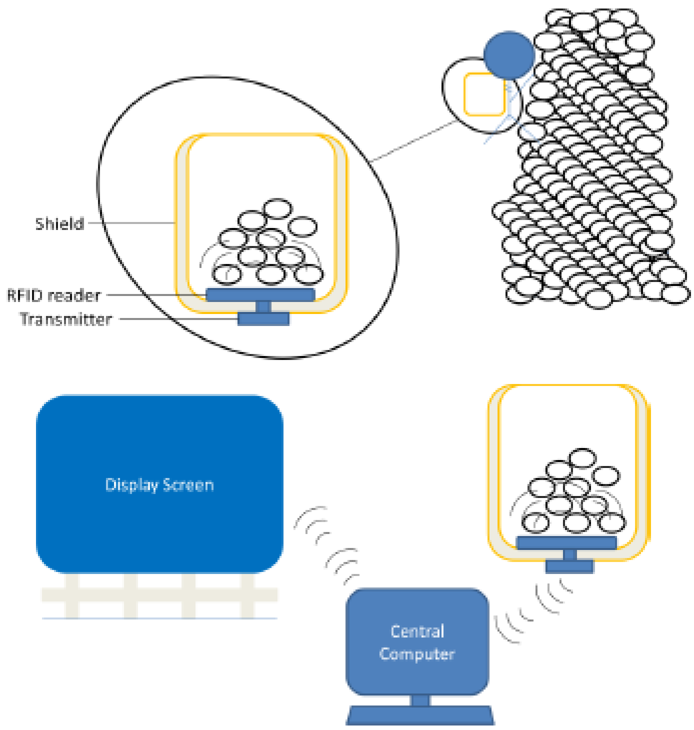
(iii) Shielded basket

(iv) Central computer and display screen

Design

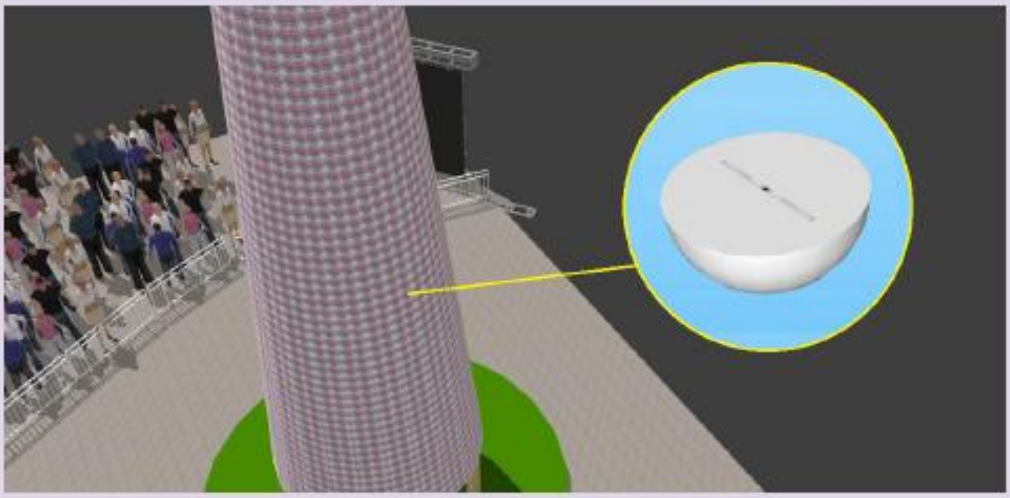
The buns on the bun towers are RFID-tagged. The central computer and display screen are connected for broadcast purpose, waiting for the signal from the RFID reader.

Special attention is drawn to the design of the bridge, the RFID reader and transmitter in the shielded basket. The basket is shielded on three sides so that the RFID reader only detect buns in the basket, but not those nearby on the bun tower (which could be quite close to the reader as the contestant was collecting buns from the tower). The transmitter connected to the reader, however, shall be placed outside the shielded basket so to communicate with the central computer. The figure below helps explain the design and layout out of the apparatus:

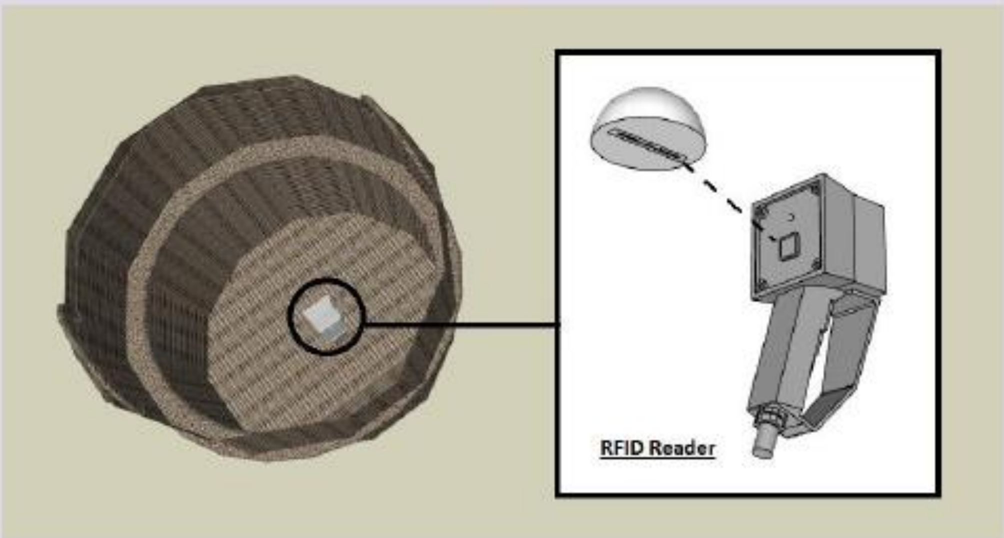


4.3 Mechanism

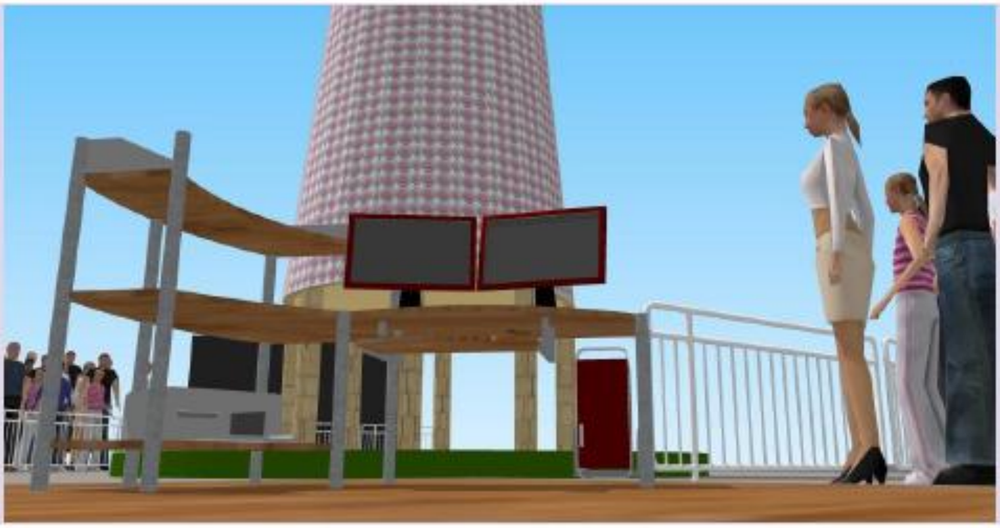
1) Installation of RFID tags	The buns at higher level account for more points. Buns are RFID tagged with various point data and placed to the bun tower at the corresponding height level.



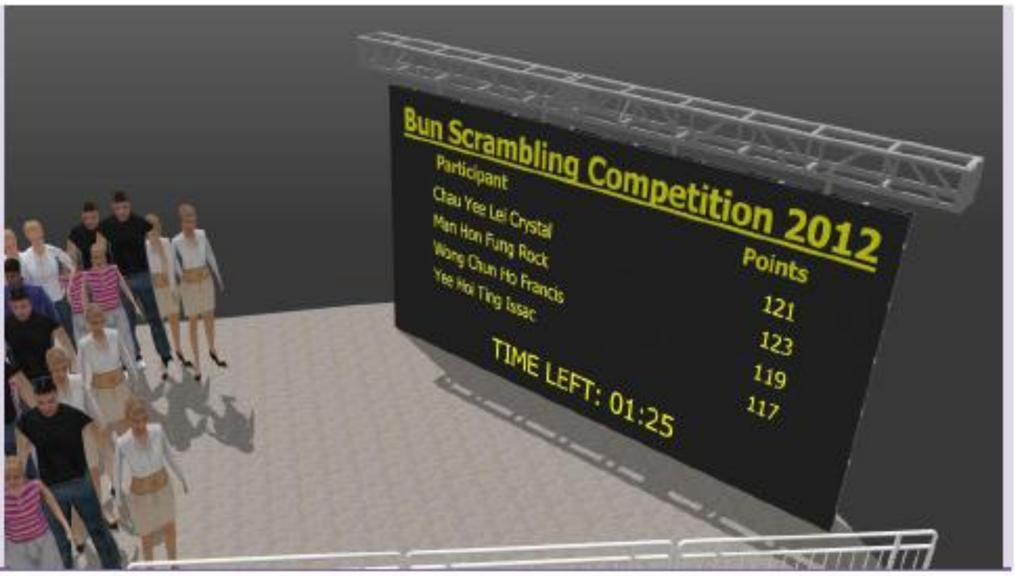
2) Detection of RFID tags	Each participant carries a shielded basket with RFID reader installed at the bottom for collection of buns. As the contestant put collected buns into the basket, the RFID reader could detect the point data on the tags. The transmitter connected to the reader then communicates the data with the central computer.



3)Procession of central computer	Signal receiver is connected to the central computer to receive signal from the reader. The computer could then process the real time cumulative point of each participant.



4) Connection with the screen	The real time statistic is broadcasted to the audience through the display screen to enhance the excitement. However, during the last minute of the competition, the screen could be shut off to temporarily secrete the result.



5) Final counting by RFID reader	Once the competition ended, one single RFID reader could be used to bulk scan each contestant's basket in front of all audience (for fairness). After this final counting the result of the bun scrambling competition could be announced. Detailed statistics could also be shown (like numbers of buns in various levels, the peak time of getting points) to the participants and the audience. It ensures the accuracy and enhances the speed of the point-counting.

4.4 Strength and Benefits

The adoption of the RFID technology in the bun scrambling competition, as denoted in the objectives also, gives the following benefits and strength.

Innovativeness and extensibility

Bulk scanning is made possible by RFID technology and is adopted in various industries. Yet it is never mentioned to be adopted in traditional festival, like the Cheung Chau Da Jiu. The creativity demonstrated makes the festival more appealing and interesting to general public, thus facilitate the promotion of the tradition.

We believe the proposal to be not merely a single effort, but an implication on possible direction in promoting traditional culture. We aim to make improvements and create discussions, through incorporating new technologies to traditions. No matter it is objection or agreement obtained from the public, their awareness on the issue is increased. Not every sole idea would be feasible to real adoption, but, the impact induced would definitely be a positive endeavour in promoting the traditions.

Accuracy and efficiency

Currently, the buns collected by each contestant are hand-counted, which is lack of accuracy and efficiency. Great human error and human resource are involved in the bun points counting. Furthermore, the transparency of such practice is low that the audience actually does not witness the counting process.

Under the proposal, the buns each contestant collected would be in turns counted by the same RFID reader, right in front of the audience. The accuracy and fairness are greatly increased. Efficiency is also increased, in terms of both time and labour force.

Enhanced excitement

Currently, audience only see the process how contestants snatch the buns into their basket but have absolutely no idea on how exactly the contestants are performing. With the proposal adopted, accumulative bun points could be counted and broadcasted real time as the contestants are collecting buns. The makes the competition more viewable and exciting.

The real time broadcast is suggested to be suspended during the last minute in order to secrete the result temporarily. The result would be known during the final count witnessed by the audience.

4.5 Development of Idea

The idea could be described as a popped-up solution. The team members were performing a RFID project in school, and coincidently get known from the news that the Cheung Chau Da Jiu (Jiao Festival) being recently endorsed as the Intangible Cultural Heritage. The team members, in the stage of brain storming, wondered if the RFID technology could be applied in the Jiao Festival and started the investigation.

The bun snatching is possibly the most impressive event of the festival and catches much of the members' attention. The developed idea is to take advantage of the bulk scan property of the RFID tag and ease the bun counting process. The counting time can hence be greatly reduced (currently done by hand counting).

The team later intends to make the bun counting real-time and allow audience to witness the whole process, to enhance the transparency and excitement. A display screen is hence included in the design.

4.6 Standard

In the proposal, RFID technology is adopted in the process of bulk scanning existing buns in the basket. The applicable could be achieved with passive and non-rewritable RFID tags on the buns. The required reading distance for the reader is approximately one metre (the height of the basket).

The ISO/IEC 15693 systems could be adopted for the intended use in the proposed design. The systems work at 13.56 MHz and could reach a maximum read distance up to 1.5 metres. Such read distance allows all buns in the basket being detected, without being affected by the nearby buns on the tower.

5. Conclusion

Cheung Chau Da Jiu is one of the most impressive and characteristic Hong Kong traditional festivals, that worth our attention to. With our proposal, we aim to make improvements to the eye-catching bun scrambling competition.

Through adoption of the RFID technology, the bun counting process would be more efficient and accurate. The audience could also witness the whole counting process, so to increase the transparency and fairness. With the displayed real time statistic, the competition become more exciting and the audience would be more involved. All of the above makes the competition more viewable and complete.

Beyond the direct improvements in the competition arrangement, the incorporation of RFID technology into the bun scrambling competition could draw public's attention to the Cheung Chau Da Jiu Festival. It is a way to raise people's awareness and to promote the culture.

Mixing old and new, incorporating technology into traditions. It is the team's fundamental believe that such methods would help promoting and preserving traditions. The belief needs not to be necessarily implemented, but discussed and spread. Every discussion, or possibly adoption, is regarded as a positive endeavour, and all together accounts for the success some day.

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Hong Kong U-21 RFID Awards 2011 香港 U-21 無線射頻識別大獎 2011

Gold Award 金獎

Most Innovative EPC/RFID Application

最具創意 EPC/RFID 應用

Project title 項目名稱: Resources Management System for Robot Institute Hong Kong(RIHK)

Students 學生:Chan Yun Chak, Leung Fai Yiu, Suen Hing Chuen, Tang Yue Tsun
梁暉燿、陳潤澤、孫慶泉、鄧譽駿
Supervisor 指導: Elaine Cheung 鄭慧鈴

Abstract:

As Robot Institute Hong Kong (RIHK) facing the problem of missing expensive inventories during the courses and delivery and there are many human mistaking during the delivery stage, the author develop the Resources Planning System mainly for keeping track the inventories details in the delivery stage and check-in/out processes by using different technology like RFID or barcode.

This report will present the project background information, objective of our project, Potential commercial values, work of procedures and the final outputs.

Partnership between industry and academia:

Robot Institute of Hong Kong (RIHK) was established in 2003, has been a pioneer in robotic education, is committed to providing high quality academic robot technology learning program. Hong Kong now has more than 50 primary and secondary institutions in the network; more than 18,000 primary and secondary students have attended our courses. Build a good environment for student learning.

Robot Institute of Hong Kong will continue the future development of high quality science and technology education courses, teaching resources can be fully expected to play; Condense professional instructors, and accumulated experience, develop an educational institution with teaching and research, the enhancement of training of students of multiple intelligences and Encourage creativity. Meanwhile strengthen the cooperation with local academic interaction. Participate in robot contest in order to enhance our Institute of Hong Kong, and even robots international contribution to education and importance.

Project Objective:

Currently, the staffs need to check out each inventory and the parts of inventory by barcode scanner, make sure that the inventories correspond with packing list. He needs to check carefully, because some parts in the box which are not belong to the box. Thus, the staffs put the parts back without any notice or record and it will waste too much time and waste much space to storing the paper.

We should develop a system to supports the RFID technology for the check in/out of the inventories, using RFID technology can reduce the human mistakes and increase efficiency. Finally, we have chosen the VB.NET to develop our system.

Issues / challenges your project attempted to address:

The RFID device provides a good environment for packing inventories and checking inventories that can reduce much manual work. But the RFID device is hard to handle because the detection is not stable so we need to do many work to improve the detection accurate. Also the RFID device cannot use on the web-based system directly because of the API.

Project extensibility and scalability

In this project, we have develop 3 different system, web-based system, android system, and the VB system, and only the VB system can support the RFID technology, The further development in our system, we would like the support the RFID technology on the web-based system.

Work of procedures:
Check in inventories:
When the borrowed inventories come back, the logistics coordinator will check in the borrowed inventories by barcode sensor or RFID sensor

Check out inventories:
After packing list is generated, Logistics coordinator will check out the inventories of the packing list by barcode sensor or RFID sensor.

Steps:
1. User selected a packing list which is waiting for check out.
2. User checks the inventories by RFID or Barcode sensor or manual.
3. System display inventories which are checked and the number of the checked inventories by RFID.
4. If some of the inventories are not checked, the system will show them to user to confirm whether the inventories are really lost.
5. When checking the packing list by RFID, some inventories maybe checked which is not related to checking packing list, the system will remind the users to throw away the inventories.
6. User confirms the checking of packing list.

Practicality, user-friendliness demonstrated:

The design of our system is user friendliness. It not only creates a great User Interface for the user, but also provides some tooltips or remind message for the users. Usually, the users need the time to think about what they are doing, so a good User Interface design and the remind message can also guide the users to access our system.

Our project can fully meet the requirements and the project objective, our system can help RIHK to reduce human error and increase the efficiency.

Other types of award:

Our project got the outstanding project award in the IVE IT Discipline Graduation Project Show 2011 in this July.

Why do you think your project deserves an award?

Our project also got the outstanding project award, and it is an industrial project. Our project can fulfill the user requirements and we have fully integrated our system with their proposed system .And we also have a great usage of the RFID technology in the Check in & out process, it can let users to increase the efficiency and reduce the human mistakes.

The above information has shown that our project contain creativity, usability and practicality. So I think our project deserve an award.

The Taiwan EPC Architecture Award
EPC 暨物聯網標準專題競賽
首獎

項目名稱 Project title: PARFILO
學生 Students:王柏今、王添麟、胡淑茹、陳志成
指導 Supervisor: 王樹仁博士

Abstract:

The accounting principle-based inventory counting operations must be executed periodically by industries. The purpose of inventory counting is to make sure the consistency of inventory computer record with physical inventory amount. The accounting record of stock surplus and shortage can be adjusted accordingly. However, a great amount of time and human power must be involved during inventory counting operations. In the process of making the computation of inventory amount, the identification of SKU and searching for physical inventory, errors inevitably occur during the heavy duty processes of inventory counting.

The dynamic real-time item identification capability of RFID and object localization technology have been introduced and integrated into PARFILO (PAssive RFID-enabled Inventory LOcalization / Stock Counting and Replenishment System). PARFILO has four main function modules as follows. 1. Single item localization - integrating the experimental RFID antenna distance vs. read count regression quadratic equation (DRR) + calculating the distance between RFID antenna and tracked tags by the aforementioned quadratic equation. Then, the received signal strength indicators (RSSI) can be generated by using Friis transmission equation. Finally, the estimated coordinates of tracked tags can be calculated by using K-nearest-neighbor (KNN) algorithm in just one minute. 2. Products counting – converting the EPC code into products information associated with merged amount based on localized items and calculating the stock surplus and shortage. 3. Inventory replenishment - acquiring inventory amount from list of stock counting and generating replenishment plan based on the reorder point policy. 4. Purchasing receiving – real-time identifying received RFID tagged purchased items based on replenishment plan and merging amount of products.

PARFILO system can be operated real-time with WWW remote control process for conducting tagged item localization functions under unmanned automatic situation. PAFILO system also has been conformed to the global specifications of EPCglobal

RFID Architecture Framework.

第1章 緒論

1.1 前言

無線射頻辨識系統 RFID (Radio Frequency IDentification System) 由於 Wal-Mart 與其他相關單位的重視，RFID 已經是未來產業間的重要發展趨勢，若能充份運用 RFID，便能夠動態及時掌握產品流動與準確的追蹤辨識特性。

存貨盤點管理在供應鏈管理當中扮演相當重要的角色，為確保存貨電腦與現場實際之料帳一致性，進行存貨現場實地盤點工作，據以進行存貨帳面盤盈與盤虧調整，因此盤點結果及其時效性，將嚴重影響存貨補貨採購計劃決策及時性與正確度，可能提早或延後採購，因少買商品則造成賣場缺貨顧客流失，又因多買商品則造成賣場多餘閒置的商品，產生可觀的無謂存貨持有成本增加。因為落實存貨盤點工作，一直是各大企業所重視的頭痛課題，是一件非常耗費時間且投入大量人力的工作，其中確認存貨商品庫存數量的多寡、商品品項是否正確與尋找商品正確擺放位置等工作，往往加重盤點人員工作負荷而發生錯誤；雖然因存貨盤點的次數頻繁越多，存貨數據就越精確完整，但是隨著盤點次數的增加，卻也造成另一種企業成本的耗費。

若能導入 RFID 無線射頻辨識系統來進行商品存貨盤點及補貨管理，並充分運用 RFID 能夠動態及時掌握產品流動與準確的追蹤辨識特性，再增加物體定位功能，進行存貨及時動態性自動定位盤點，可以使盤點工作的效率大幅提升，減少人工盤點成本，並且可連續對存貨進行盤點，隨時監控存貨商品的庫存數量，提高盤點準確性與及時性，管理者也可以及時進行補貨採購計劃的決策，降低缺貨風險與存貨囤積的持有成本。運用此系統設計方法優點，不僅可確認存貨狀況，追蹤商品實際擺放位置，更可以評估存貨管理績效，進一步提昇公司的經營成果。

1.2 研究目的

- 訪查及蒐集傳統存貨盤點人工運作機制資料，分析其優缺點，研判導入被動式 UHF RFID 標籤定位盤點系統之技術可行性，其能提升存貨盤點效能。
- 研究相關於 RFID 定位演算法之發展現況，從中蒐集資料並分析各定位方法之特性與優缺點，設計適用於 Passive UHF RFID Tag 定位盤點之演算法。
- 導入符合 EPCglobal RFID Gen 2 標準規範之 RFID 讀取器、天線、中介軟體設備，建置 RFID 整合資訊網路平台，設計被動式 RFID 定位盤點暨補貨系統整合介面。
- 進行大量現場實驗導出 RFID 讀取器與天線在固定時段可讀取到 Passive RFID Tag 標籤次數與其距離關係之傳遞迴歸模式，運用 Friis transmission

equation 計算 RFID Tag 接收訊號強度 RSSI 及整合 K-Nearest Neighbor (KNN)演算法求解被追蹤 RFID Tag 定位物件座標值。

- 運用 LabVIEW 圖形程式語言暨 MySQL 資料庫網路系統，設計開發符合 EPCglobal RFIDArchitecture Framework 規範標準之 Passive UHF RFID Tag 存貨定位盤點暨補貨系統。
- 運用 RFID 系統做自動化存貨盤點與補貨，並隨時掌握貨物數量，在處理大量的貨物時，能夠更為快速，並可降低庫存、人力成本，隨時調整商品存貨數量，達到補貨零時差，並減少物流中由於商品送錯、偷竊、損害和庫存、出貨錯誤等造成的損耗。
- 利用 RFID 的標籤作貨物自動點貨的方式，讓存貨有效減少，補貨情況比過往使用條碼快速，並且也減少因為過度訂貨量所造成的貨物囤積問題。

1.3 研究重要性

- 在傳統存貨盤點的機制裡，由於人工操作失誤，經常發生倉庫存貨會計料帳與實際盤點品項數量不符的嚴重問題，運用被動式 RFID 標籤定位盤點系統，將有效降低消除此現象的發生。
- 盤點耗費大量人力是傳統存貨盤點機制裡常遇見的問題，而 RFID 定位盤點系統，將能徹底消除人力投入，做到隨時隨地都處於盤點的情況。
- 開發運用被動式 UHF RFID 標籤定位盤點系統，將可提昇缺補貨採購時效性與數量的正確度。
- RFID 系統在存補貨應用上，使得資訊透明化、增加傳遞的即時性、正確性與完整性，使得企業的決策可以更加準確，並可以有效改善供應鏈長鞭效應的問題。
- 搭配 EPCglobal RFIDArchitecture Framework 規範標準開發之存貨盤點系統，可使企業與全世界接軌，提升商品進出口的機會，為商品創造更高的經濟效益。
- 由於目前 RFID 定位多採用主動式 Active 標籤，但主動式標籤價格昂貴，若運用在存貨盤點上，勢必相對增加設備投資成本，若能開發被動式 UHF RFID 標籤定位盤點方法，可以大大降低設備成本，對企業最具實質的幫助。

1.4 研究流

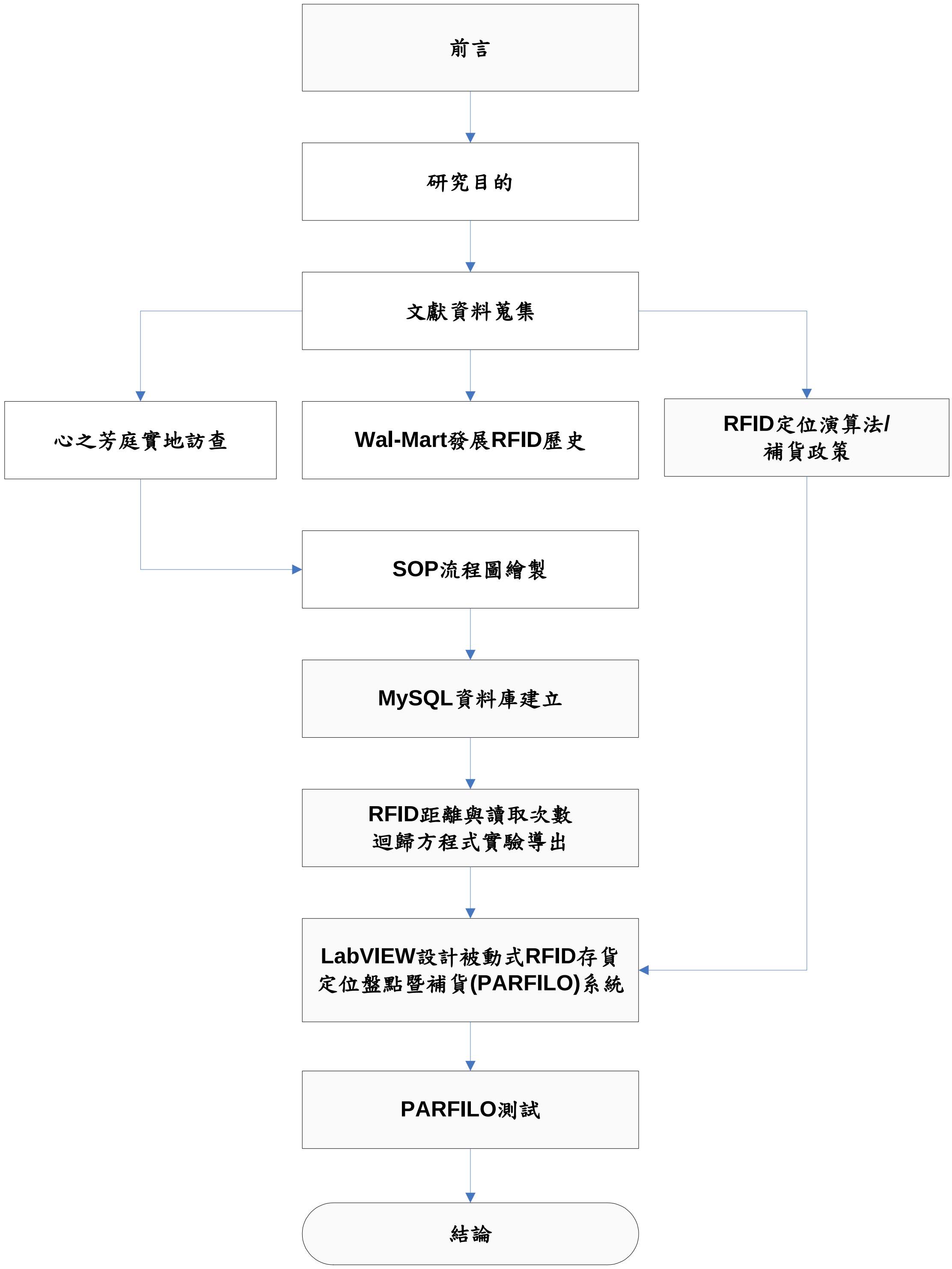

圖 1 研究架構

第2章 文獻探討

2.1 國內外 RFID 定位方法

2.1.1 定位方法

Jeffery Hightower et al. (2000)利用自製且符合需求的 RFID 設備，率先提出使用 RFID 訊號強度定位法，完成可以定位未知物件的 SpotON 系統。SpotON 系統定位方法是利用 RFID 讀取器、許多主動式 Active RFID Tags，建構一個具一定涵蓋範圍的室內無線拓璞；對於環境底下許多 Tags 而言，分別針對環境內某一個未知座標的追蹤物件，進行相對訊號強度計算的動作，這個計算動作是由 RFID 讀取器端收到未知座標物與感應標籤之間相對的訊號強度資料，透過中介軟體系統加以分析，最後，以該資料分析推算出該未知追蹤目標的位置。

LANDMARC (Location Identification based on Dynamic Active RFID Calibration)(2003)主要是沿襲 SpotON 方法，運用相對訊號強度估算主動式 RFID Tags 距離的方式來測量未知物件的位置，這是目前行動定位的技術當中最常見一種測量方式。

陳嘉懿(2008)定義目前在定位技術上有以下 4 種技術：訊號強度法(Received Signal Strength Indicators, **RSSI**)、收訊角度法(Angle of Arrival, **AOA**)、收訊時間法(Time of Arrival, **TOA**)、收訊時間差法(Time Difference of Arrival, **TDOA**)：

(1) 訊號強度法**RSSI**：

訊號強度法為事先建構環境的訊號傳播衰減模型，當量測點偵測到訊號後，藉由對應模型與此訊號的強度來決定與訊號發射源的距離。經由三個量測點畫出的距離圓之交點即是決定訊號發射源的位置。由於無線電在室內傳播呈現多重路徑干擾衰弱與遮蔽效應，所以接收訊號強度與再開放空間傳播結果會有很大的差距，於是預估的傳播距離將產生誤差。

(2) 收訊角度法**AOA**：

利用收訊角度技術定位是一種常被討論的方法。其所利用的工作原理係使用具有方向性天線(Directional Antenna)或是天線陣列(Antenna Array)的量測點來決定出無線訊號的來源方向。當有兩個量測點接收到訊號發射源的無線訊號時，各朝訊號源的方向畫一直線，則此兩條直線在平面的交點就可以視為訊號發射源的位置。這種技術的誤差原因包括有天線角度解析度以及多路徑效應等。其中，多路徑傳播效應是指當量測點附近的物體反射訊號發射源所發射的無線訊號時，如果此反射訊號也傳送至量測點的天線，將使量測點認為所接收到的訊號是從反射物的方向傳過來，造成量測點誤判或混淆。

(3) 收訊時間法**TOA**：

由訊號發射源發射到量測點的訊號傳播時間可知，將訊號傳播時間乘上傳播速度(光速計算)，則可得到兩者間的距離。當量測點收到訊號發射源的無線訊號時，以量測點為圓心，計算出來的距離為半徑畫圓，則訊號發射源將會位於此一圓上。當有三個量測點可以畫出圓時，所交會的交點即是訊號發射源的位置。但因訊號一般是以光速傳播，速度非常快，所以即使只有極微小的時間讀取誤差，也將形成極大的距離誤差。

(4) 收訊時間差法**TDOA**：

此技術的基本原理是利用雙曲線上的點到兩焦點距離之差為定值的特性。首先利用時間延遲估算(Time Delay Estimation)技術先測得兩量測點接收到的訊號到達時間差，並轉換成距離後代入雙曲線的方程式中，以求得一組聯立雙曲線方程式。接著利用有效且快速的運算法則求得此聯立方程組的解，此解即為訊號發射源的位置。

<u>因為被動式RFID Tag標籤被讀取到時，所產生資料記錄，僅能提供產品電子碼EPC內容，及該Tagged物品被讀取到的次數。故以上定位方法AOA、TOA、TDOA恐無法適用被動式RFID Tag系統。本研究嘗試應用訊號強度法之RSSI結合Friis transmission equation (Friis 1946)，輔以實驗推導出待測物與RFID天線距離之傳遞迴歸模式，進而估算其座標位置。</u>

<UHF Passive RFID Localization>

***<u>RFID Tags: Positioning Principles and LocalizationTechniques</u>*<u>(2008)</u>**

本篇綜述了當前最先進的 RFID 定位技術，根據距離估計、現場分析或是突破限制等方法進行分類。RFID 標籤目前有被動式標籤與主動式標籤，根據標籤與設備的不同在環境規劃上也有不同的方案，例如有些定位方式需要設置參考標與特定設備，並進行誤差的校準。相反，一些技術設計，以更符合成本效益，更容易適應不同設備的利用率。當 RFID 應用在真實環境時，RFID 定位技術的擴展性和可用性方面有自己的重要特性。技術與方法的選擇將顯著影響著定位的準確度與整體成本和 RFID 系統的效率。

***<u>應用 RFID 技術於移動式機器人定位系統之研製</u>*<u>(2009)</u>**

此篇研究主要是運用 RFID 解決機器人因使用光編碼器定位方法時會產生累積誤差之問題，此篇研究運用灰預測法計算機器人之旋轉角度，提出以灰預測法結合 RSSI 定位法之灰導航定位系統。由實驗數據可知此系統可將機器人與目標點之距離誤差控制在半徑 60 公分內，可以降低誤差 75.22%，能夠有效地解決累積誤差的問題。

***<u>Localization Systems using Passive UHF RFID</u>*<u>(2009)</u>**

本篇探討當 Passive UHF RFID System 在室內環境裡的性質與特性。當被動式標籤 RFID 定位系統只運用 RSSI 值來計算位置時會有以下三點問題：第一

點，因為RSSI值容易隨著環境改變所以在計算位置時會有很大的誤差；第二點，一個 RSSI 值在同一監控區可以對應多個目標位置；第三點，即使是同家廠商出產的同一型號被動式標籤，標籤的標準性也不一定相同。為了增加定位的準確度，作者提議在 RSS 修正過程中減少標籤讀取時的變數，並且排除非重要性參考標籤，另外作者也建議搭配 K-nearest Neighbor (KNN) algorithm 增加定位準確度。

***RFID localization algorithms and applications—a review*(2009)**

此篇提到 RFID 技術若能結合定位與辨識的功能，在定位市場上將擁有獨特的優勢，另外也介紹現行的定位技術與定位的演算法。在演算法部分，作者介紹了 Multilateration 與 Bayesian inference 兩種演算法，經過驗證結果顯示，此兩種演算法皆可於被動式 RFID 定位所使用。Passive RFID Tag 定位系統目前正處於開發實驗階段，所以是個值得研究的領域，但相對也有許多挑戰須突破，歸類三點：

1. RFID 訊號在室內環境通常呈現多徑傳播，由於環境的影響會使訊號結構受到破壞，導致影響定位演算法的準確度。
2. 一般來說，定位演算法假設環境特性不隨時間所改變，但如果像貨物流動或是改變物品擺放位置等，可能導致環境的不穩定，這會影響數據的收集，並破壞訊號強度之間的關係和距離，所以為了演算法精準性，需考慮動態環境。
3. 每個演算法都有其優缺點，運用兩個或多個算法可能使定位準確度更好。

***Localization of Pallets based on Passive RFID Tags*(2009)**

這篇將 RFID 定位技術套入到物流產業裡，使物流業在減少成本的同時，也擁有識別與管理貨物位置的功能。本篇研究中，作者提出了一個方法，此方法即是將讀取標籤與整個 RFID 設備裝置在天花板上，這種方法可以有效改善幾個問題：首先，降低了設備成本。第二，它可以使用一般的讀取標籤，不需要使用到高性能的標籤。最後，它的維修成本與過程都可以大大的簡化。

***Object Localization Using RFID*(2010)**

此篇提到「定位」的關鍵就是要求速度快且位置估算要準確。作者提出了運用 RFID 系統做定位的一個架構，它主要是運用 RFID 讀取器的功率大小與參考標籤輔助校正的方式，經過實驗數據顯示，此方法可以在幾秒內準確定位 15cm 內的目標物。這樣系統架構符合低成本高效率的條件，並且可運用在不同的環境。

***Improvement of RFID based Location FingerprintTechnique for Indoor Environment*(2009)**

此篇運用指紋的方式搭配 RFID 系統做出定位的功能，而指紋方法的基本原理是找的目標物的位置的訊號，接著與資料庫裡的訊號資料做比對與更新，其主要步驟有二，第一，必須先建置資料庫，內容包含訊號和相對應的位置。第二，

計算目標物之位置。照著此步驟進行定位的實驗與數據收集，結果顯示，定位的準確度小於 35cm。

***RFID Reader Localization Using Passive RFID Tags*(2009)**

本文介紹了被動式 RFID 定位系統常見的計算方法，通常運用 RSSI 值與三角測量法的方式進行定位，但是，在室內的環境中 RSSI 值會因為障礙物碰撞，而產生減弱或是不穩定的現象，這種情況會導致定位的誤差，而此文章作者將研究如何減少定位之誤差。研究結果顯示 backscattered signal 的方法簡化了複雜的計算程序且符合成本效益。

***Indoor Localization Technique using Passive RFIDTags*(2009)**

此篇運用測量「角度」的方法來進行 RFID 定位的研究，首先將目標物放置於三角架上，並在環境中規劃參考標籤的座標，而目標物與參考標籤間的夾角即是我們要的參數，使用這種方式進行兩組不同距離的實驗，即 100cm 和 150 cm。實驗結果顯示，100cm 的實驗誤差約為 16cm，而 150cm 的實驗誤差約為 20cm，此結果也顯示此方法適用於 RFID 室內定位。

***Passive RFID-Based Indoor Positioning System, An AlgorithmicApproach*(2010)**

此篇提出了一個室內定位的演算法，類似 LANDMARC 的方法，使用了被動式標籤當做參考標籤佈置於偵測的環境中，運用參考標籤所提供的資訊與後端軟體執行演算法的計算，求出目標物的座標位置，實驗結果顯示，在 2D 的空間裡誤差值大約 1.05m，另外也發現若將參考標籤的間隔距離增加，誤差值也會相對增加。

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2.2 RFID EPCglobal 標準與 BarCode 差異比較

條碼(BarCode)的啟用是為了在百貨公司或超級市場應用科技以節省大量人力物力資源，於 1973 年正式啟用，並取名為"統一商品條碼"（Universal Product Code 簡稱 UPC)。在 EAN/UCC 系統中，商品的識別號碼都被轉成條碼形式。這種以條碼來表現識別號碼，最主要是為了方便利用機器來作資料的自動擷取，以提高商品資料讀取的效率。除了製造和物流過程可以共用相同的條碼之外，在 EDI 的訊息傳遞上，也可以使用這個號碼作為辨識和追蹤之用。

條碼或稱條形碼（BarCode）是將寬度不等的多個黑條和空白，按照一定的編碼規則排列，用以表達一組資訊的圖形識別元。常見的條碼是由反射率相差很大的黑條（簡稱條）和白條（簡稱空）排成的平行線圖案如圖 2。條碼可以標出物品的生產國、製造廠家、商品名稱、生產日期、圖書分類號、郵件起止地點、類別、日期等資訊，因而在商品流通、圖書管理、郵政管理、銀行系統等許多領域都得到了廣泛的應用。

條碼的種類：

條碼可分為一維條碼 (1D BarCode)、二維條碼 (2D BarCode) 及三維條碼 (3D BarCode)；一維條碼的應用仍為世界的主流，二維條碼及三維條碼相對可儲存更多的資料，但應用上並不普及，故我們集中介紹一維條碼。世界上約有２２５種以上的一維條碼，每種條碼都有自己的一套編碼規格，一般較流行的一維條碼有：UPC、EAN、Code 39 等，以及專門用於書刊管理的 ISBN, ISSN 等，由於不同條碼都有其獨特的編碼規格，有些可接納文字與數字並用，而大部份只可接納純數字的應用，有些對編碼的數位亦有限制，故此，不同格式的條碼有其不同的用法。

0 12345 67890 5 5 012345 678900

圖 2 條碼 BarCode

EPC 是一個可擴充的編碼系統，因應不同產業需求可作編碼上的調整設計，以利賦予物件品項獨一無二的編碼。標籤容量 96 位元其編碼結構如圖 3 所示，其基礎編碼方式(General Identifier-- GID)，將 EPC 碼結構分為四區塊如表 1 EPC 碼結構表：

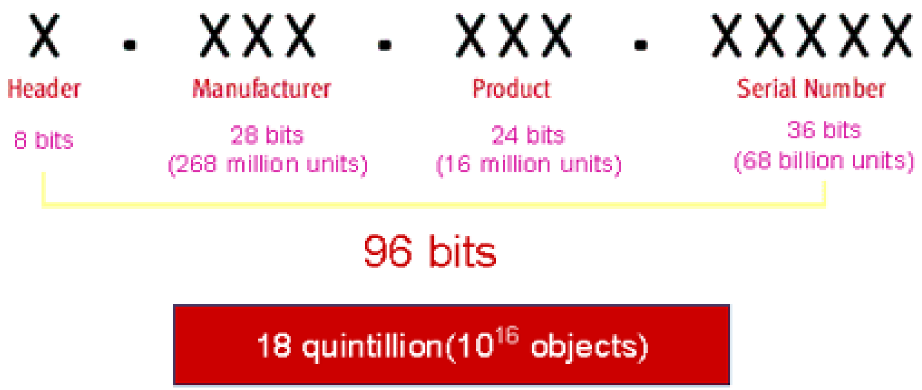


圖 3 EPC 96bit 編碼示意圖

表 1 EPC 碼結構表

標頭 **Header**	為 EPC 碼的第一部份，主要定義該 EPC 碼的長度、識別類型和該標籤的編碼結構。
一般管理者代碼 **Manufacturer**	具有獨一無二的特性，為一個組織代號，也是公司代碼，並負責維護結構中最後兩組連續號碼。
物件類別碼 **Product**	在 EPC 編碼結構的角色為辨識物件的形式以及類型，也具有獨一無二的特性。
產品序號 **Serial Number**	連續號也同樣具有單一的特性，賦予物件類別中物件的最後一層，使得同一種物件得以區分不同個體。

目前全球之商品，都靠著產品條碼來辨別產品身份。但是條碼只能記載著產品簡單的背景，例如生產商和品項名稱，而且還得透過紅外線接觸掃瞄才能讀取數據。更重要的是目前全世界每年生產超過五億種商品，而全球通用的商品條碼，由十二位排列出來的條碼號碼已經快要用光了。如表 2 BarCode 與 EPC Tag 之功能比較表。

表 2 BarCode 與 EPC Tag 之功能比較表

	條碼 BarCode	**EPC Tag**
讀取數量	只能一次一個	同時讀取多個 RFID 標籤資料
遠距讀取	讀取時需要光線	需要光線就可以讀取或更新
資料容量	儲存資料的容量小	儲存資料的容量大
讀寫能力	資料不可更新	RFID 電子資料可以反覆被覆寫 (R/W)

讀取方便性	需要可看見與清楚	在包裝內仍可以讀取資料
資料正確性	讀取有人為疏失的可能性	可傳遞資料作為商品與保全
堅固性	條碼污穢或損壞將無法讀取	在嚴酷、惡劣與骯髒的環境下仍然可讀取資料
高速讀取	移動中讀取有所限制	可進行高速動讀取
RFID 較條碼具有更多優越性如下： 1.資料可更新性與重複使用性 2.資料方便辨識及讀取 3.可同時讀取數個資料 4.安全性 ※同時也代表架構 RFID 成本更高		

2.3 EPC Architecture Framework 介紹

本研究所設計系統架構須遵循 EPCglobal Inc.,所設計之 RFID 系統標準結構框架 Architecture Framework。其中產品電子碼 EPC (Electronic ProductCode)構想源自於 MIT 麻省理工學院的一項與自動化辨識系統(Automatic Identification)相關的研究，沿用在第二次世界大戰已使用 RFID (Radio Frequency Identification)科技，進行創新應用。集結全球主要零售商，MIT 於 1999 年成立 AUTO-ID Center，以零售業為出發點的構想下，成功研發 EPC。

2003 年 10 月，Auto-ID Center 宣告將 EPC 技術移轉給 EPCglobal Inc.，由該公司於 2003 年 11 月成立，初期會員囊括有世界百大企業，以及著名的學術研發單位。EPCglobal Inc.負責 EPC 的註冊、導向 EPC 發展成為全球通用標準，代表 EPC 正式由學術研究進入商業應用階段。另外 Auto-ID 實驗室則聯合世界上六大著名研究學府：美國 Massachusetts Institute of Technology 、英國 The University of Cambridge、澳洲 The University of Adelaide、日本 Keio University、中國復旦大學以及瑞士 The University of St. Gallen，繼續進行 EPC 新階段相關研究。

EPC 碼為 EPC 系統關鍵的設計，為物件在資訊系統中的唯一代號，藉此物件相關資訊得以在散佈全球的 EPC 網絡中存取，進而建立信息交換標準。如今，EPC 碼被喻為新一代條碼(Next Generation Barcode)，編碼結構延伸自現行的傳統條碼，在物件信息描述上，更為豐富、詳細，並更具時效優勢。

EPCglobal 為致力於全球 RFID 標準的創造與應用，發展出 RFID 系統標準結構框架 Architecture Framework 期能在全球各地使用如圖 4 所示，並為支援結構的方案提供者創造利基。本研究所發展之 Passive RFID 自動定位盤點系統

及所購置導入之 RFID 讀取器、天線、RFID Tag、Middleware 須符合此標準架構(EPCIS)。其中三大主要功能簡述如下:

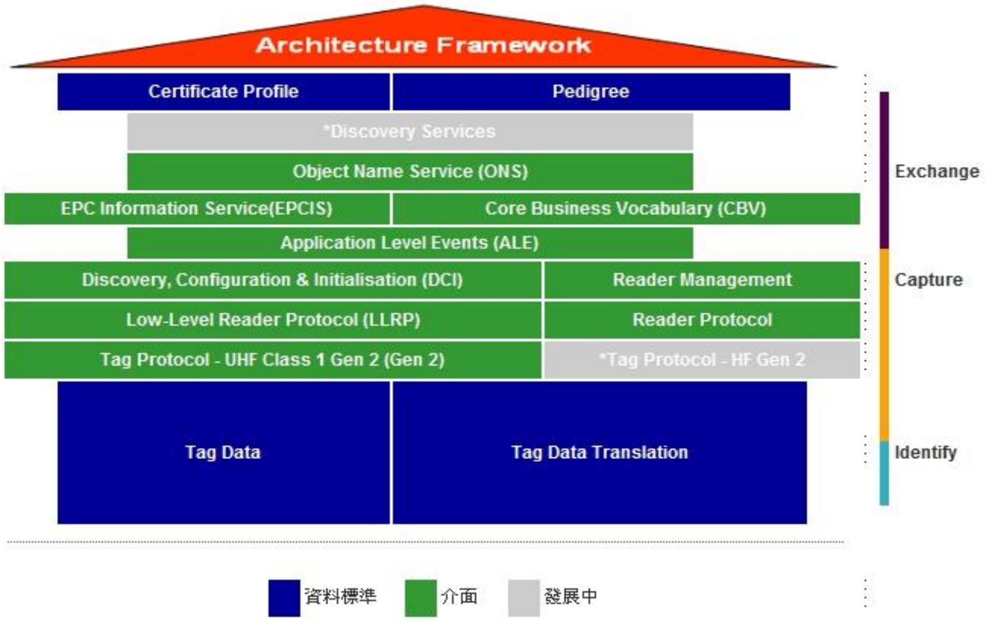


圖 4 EPCglobal Architecture Framework

Identify

使用者交換由產品電子碼 EPC 辨識的實體物件。對於大多數 EPCglobal 網路使用者，實體物件就像是貨物交易，使用者屬於這些貨物供應鏈中的一環，而實體物件交換便包括如運送、接收等類似行為。EPCglobal 結構框架定義 EPC 實體物件交換標準，確保當某一使用者將實體物件送至另一使用者時，後者能知道這個實體物件的 EPC 碼且能正確判讀。

Exchange

使用者藉由 EPCglobal 網路相互交換資料而受惠，更能掌握對於實體物件出了自家大門之後的行蹤。EPCglobal 結構框架定義出 EPC 資料交換標準，讓單一使用者能與另一位使用者之間藉由 P2P 互動來共用 EPC 的資料，並得以使用 EPCglobal 核心服務與其他共享服務以增加便利性。

Capture

為了共用 EPC 資料，每一個使用者在自己的應用範圍內為新物件編製 EPC 碼，藉由感應 EPC 碼來追蹤位置，並將該資訊收錄在組織中的記錄系統。EPCglobal 結構框架定義重要基礎建設元素需要收集與紀錄的 EPC 資料之介面標準，讓會員能以相容互通的構件配置自己的內部系統。

2.4 Wal-Mart 推行 RFID 系統發展過程

表 3 Wal-Mart 發展 RFID 歷程表

時間		發展 RFID 歷程
2003 年	6 月	Wal-Mart 當時的資訊長 Linda Dillman 為第一個宣布其最重要的前 100 位供應商強制試行 RFID 計畫。
	8 月	Wal-Mart 要求其全部的供應商在 2006 年底，在交貨之棧板和產品貼上 RFID 標籤。
	11 月	Wal-Mart 跟最重要的前 100 名供應商舉行會議，首先將先前的合格通知的必需品 100 個棧板和實例標籤在 2005 年 1 月被運送到美國德州三個物流中心。
2004 年	4 月	Wal-Mart 開始它指定物流中心在 Sanger、TX 的 RFID 藉由接收產品電子碼棧板試驗作為帶領八個供應商一部分測試。
	6 月	Wal-Mart 與最重要的 100 名和次 200 名供應商開會，並展示它的 RFID 標籤必需條件和時間線。這次 200 家廠商在 2006 年 1 月最後期限準備好開始棧板標籤，雖然物流中心交運什麼不是很明瞭。
	10 月	Wal-Mart 說它計畫開始與一家位於 Plano、Texas 的百貨店 Sam's club 進行 RFID 棧板標籤的試驗，開始地區性 RFID 計畫。
2005 年	1 月	許多家廠商，但並不是所有前 100 家廠商，開始將一些貼有 RFID 標籤的產品，運送到三家位於 Texas 的 Wal-Mart 物流中心。
	3 月	資訊長 Linda Dillman 說 Wal-Mart 在今年年底追蹤 600 家店和 12 個物流中心 RFID 能力。
	10 月	Wal-Mart 說它期待下 300 家供應商的高潮在 2007 年 1 月前開始運輸被 RFID 標記的棧板和試驗。
		Wal-Mart 贊助 Arkansas 大學專題研究論文發現 RFID 能夠減少 16%的庫存。
2006 年	1 月	Wal-Mart 說它與幾個供應商完成一個先導 RFID 計畫及 EPCglobal 產品電子碼產生的 RFID 為基礎先期交貨通知。
		假定在最後期限次 200 家供應商開始交運一些產品 RFID 標籤到一些物流中心，雖然相對少有任何意義的方式。
	3 月	Wal-Mart 說它是影響兩個概念驗證先導在使用 RFID 感應器標籤以外製造的常規與產品環境溫度影響供應鏈管理。

	4 月	Wal-Mart 它將在年中分階段撤銷使用 Gen 1 標籤而傾向於 Gen 2，在 6 月 30 日將不再接受 Gen 1 標籤的試驗和棧板。
		Dillman 辭去資訊長的職位，去帶領一個行政上的人力資源角色。Rolin Ford 站在物流供應鏈管理的前端成為資訊長。Ford 隨後採取較低的態度對 RFID 數據圖表。
2006 年	9 月	Wal-Mart 宣布在 2007 年 1 月 31 日前，Wal-Mart 的 3900 家店其中的 500 家，將會安置 RFID 讀取器。帶來 RFID 能力的產量，若發生了，Wal-Mart 將會增加 1000 台。
2007 年	2 月	Street Journal 在 Wal-Mart 的 RFID 進展上刊登一篇負面的文章。Wal-Mart 和一些供應商制止這個傳聞，Sara Lee 說他找不到價值。
	10 月	Wal-Mart 宣布它在 RFID 的戰略上有一個重要性的轉變，開始大量地中止棧板和試驗，Wal-Mart 集中於必需品將要支持三個重點區域： 一、Sam's Club 發貨。 二、Wal-Mart 的商店促銷的展覽品和產品。 三、看到 RFID 的作用在管理的精選區域上所測得的改善結果。
2008 年	1 月	Wal-Mart 宣布 Sam's Club 物流發貨處罰疏忽項未標籤 RFID 的產品，將起始於每一棧板$2，接著努力去做到$3。並且宣布 Sam's 首次展示標籤的棧板和可販售的單位。
2009 年	1 月	Sam's Club 戲劇性地已較低的損失從每一棧板 2~3 元到正好 12 分，為什麼 Wal-Mart 判斷它將會花費 Sam's 做的標籤。也許首是把展示的行程表先前所宣布一月向後推。
	2 月	Procter 和 Gamble 說在商品的經營和促銷上顯示證實 RFID 所帶來的好處，它要結束與 Wal-Mart 的 vu0 先導計畫，暗指 Wal-Mart 沒有按照資料執行改善商店的行事。
2010 年	7 月	從八月份起，Wal-Mar 零售商將放置可取出式的「智慧型標籤」在個別的牛仔褲和內衣上，加上以掌上型掃描器讀取。

第3章　研究方法

3.1　心之芳庭盤點與進出貨作業實地訪查分析

實地參訪心之芳庭並了解盤點與補貨的作業流程，發現其現行的盤點與補貨方式有以下缺點：

- 如圖 5 所示有些是 Lavender cottage 無法實際貼上條碼來進行盤點的重點

商品，也無法以讀取條碼來進行結帳作業，皆必須採用人工 KEY IN 的方式來進行結帳作業，像是食品類的牛軋糖與香草茶都是依重量來進行結帳與盤點，每顆糖或是精油皂的重量都不同，或大或小，或重或輕，條碼無法辨識，條碼只能辨識這是哪項商品，但是重量不同亦無法讀取到實際數值，故仍需使用人工秤重的方式來得知數據，雖然在結帳時，內部系統有先設置好介面，只需點選品項再進行輸入數量或是重量即可快速完成結帳，但是在盤點方面卻無法達到這樣的作業，仍必須依單逐一盤點各品項數量。

圖 5 心之芳庭商品

- 在每次的大盤，所有員工皆必須提早 2-3 小時(開店前)到公司去進行人工全店大盤點的工作，一不小心數錯，就必須從頭再算起，存貨的數量亦不是少少的數十個，也必須趕在開店前完成這些作業如圖 6 心之芳庭現行盤點作業流程，不然開店了，進銷貨數字改變了，一切盤點數字皆須重來，不但浪費時間也浪費人力，所以針對這方面我們想用 RFID 來解決此類的問題如圖 9 現行盤點作業導入 RFID 後作業流程。

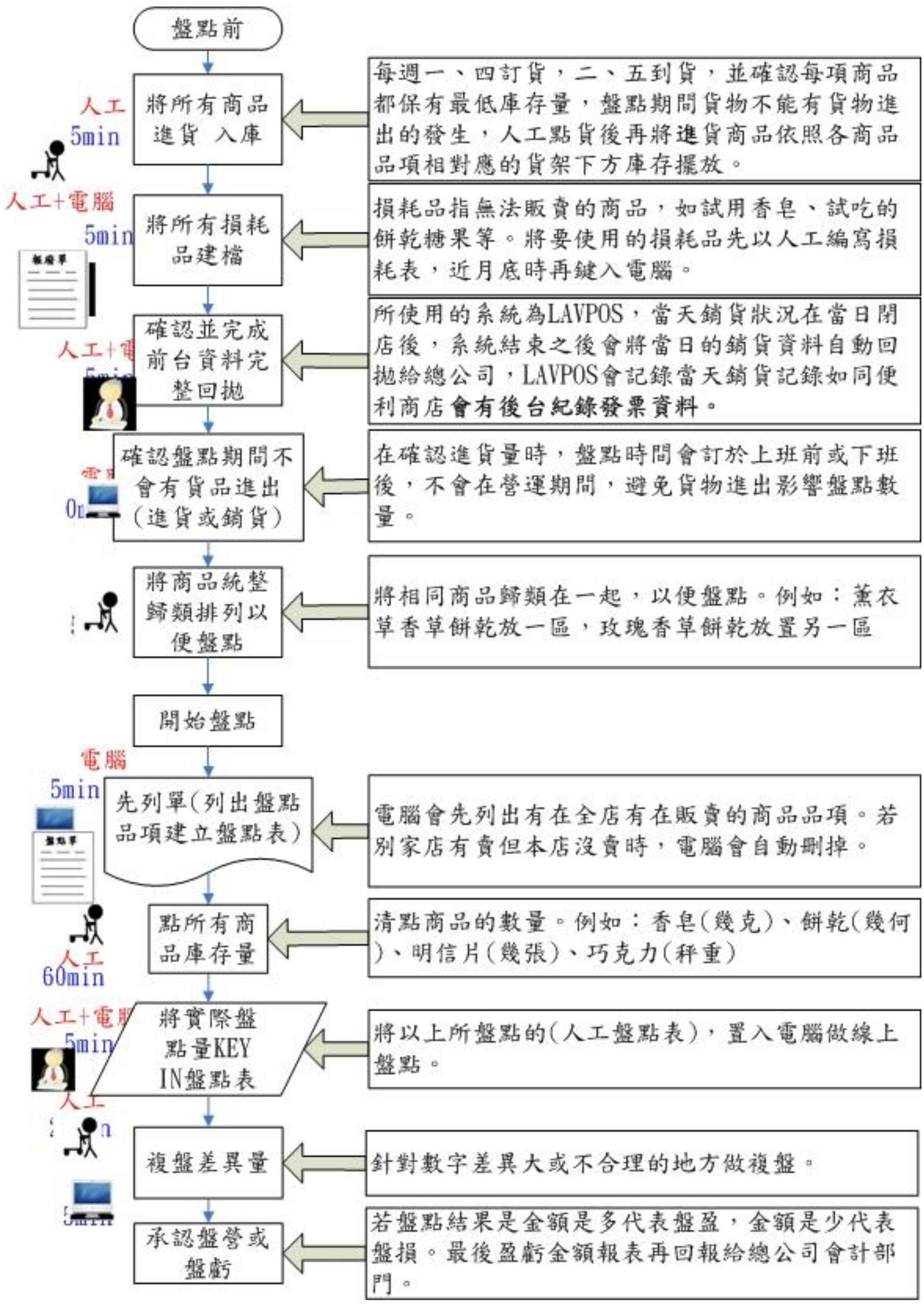


圖 6 心之芳庭現行盤點作業流程

- 人工盤點需要到達儲存貨品的位置，逐一清點每一商品所剩的數量，耗費時間也耗費人力。

- 固定的盤點時間，無法隨時了解商品的庫存量。
- 在下次盤點與進貨的期間，有些商品可能有低於安全存量或再訂購點(ROP)的風險，無法隨時了解庫存狀況和進行補貨作業的決策如圖 7 心之芳庭現行採購訂貨作業流程。
- 造成缺貨的風險，以致於顧客來店消費時，常常買不到所要的商品，空手而歸，顧客流失。商品可能大批量一次進貨，商品銷售沒有預期的好，使存貨囤積於倉庫，使得存貨持有成本增加，如圖 10 現行訂貨作業導入 RFID 後作業流程，可及時了解庫存狀況和決策補貨數量。

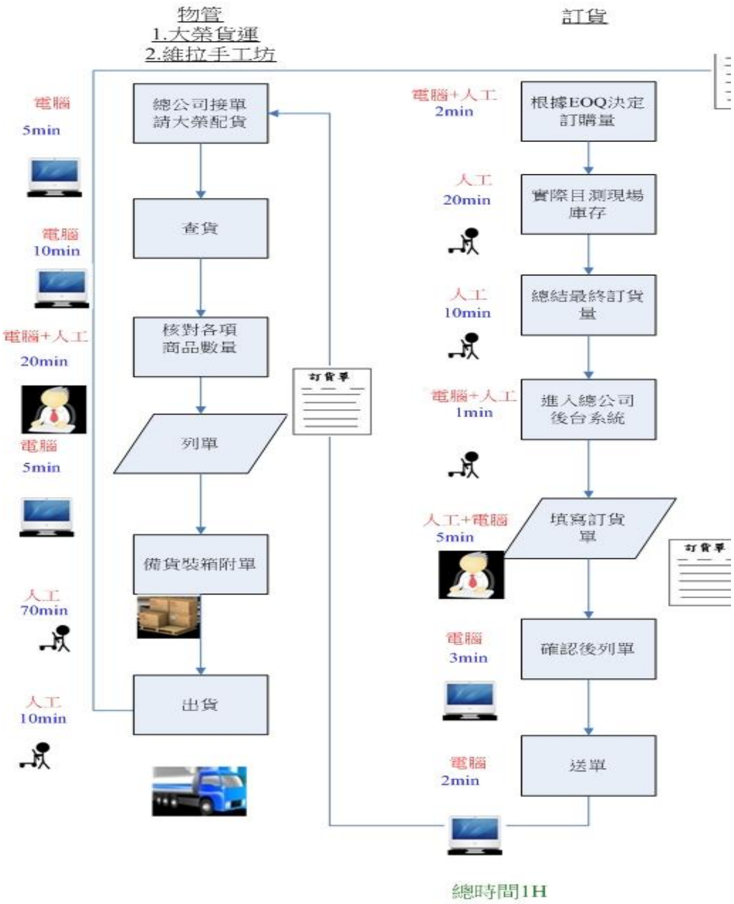


圖 7 心之芳庭現行採購訂貨作業流程

如圖 8 心之芳庭現行採購進貨暨顧客購買出貨作業流程，商品卸貨後必須先清點箱數，再開箱清點各箱商品裡的數量，要多耗費許多時間及人力，因此導入 RFID，可同時盤點數量與比對商品項目，減少作業流程與成本如圖 11。

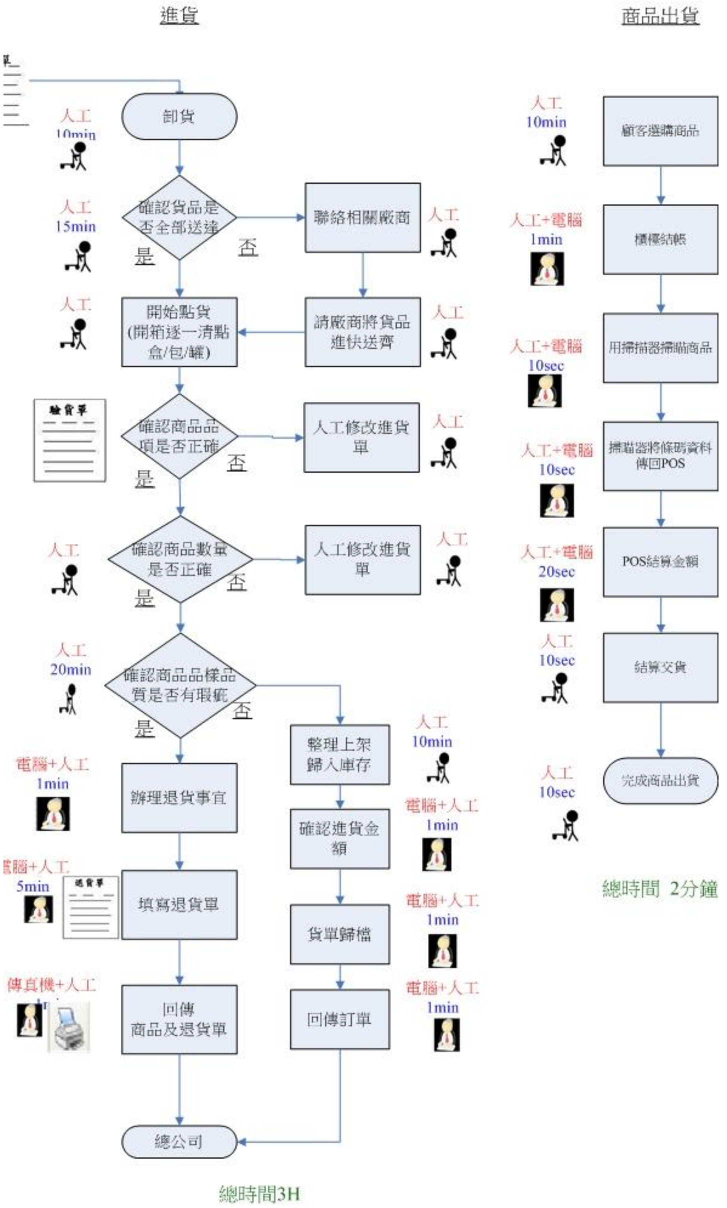


圖 8 心之芳庭現行採購進貨暨顧客購買出貨作業流程

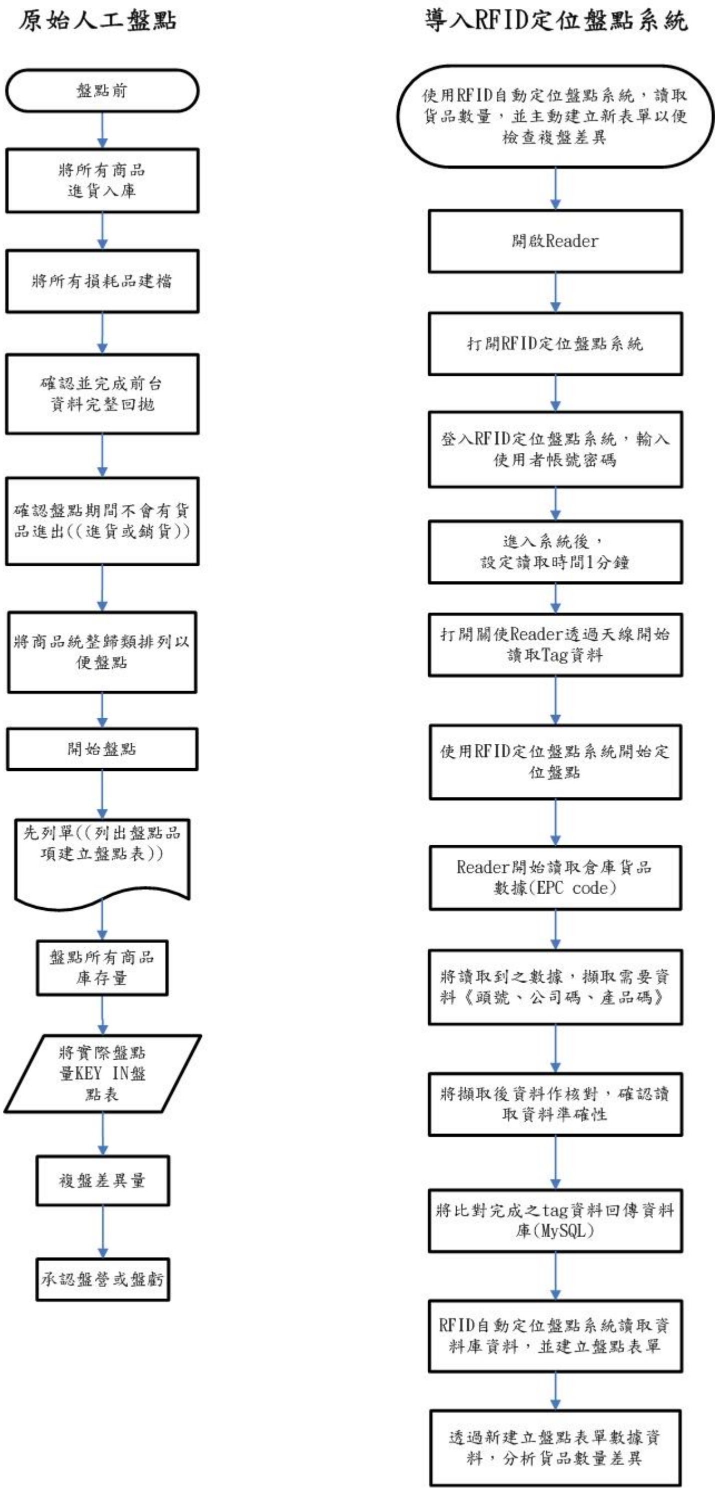


圖 9 現行盤點作業導入 RFID 後作業流程

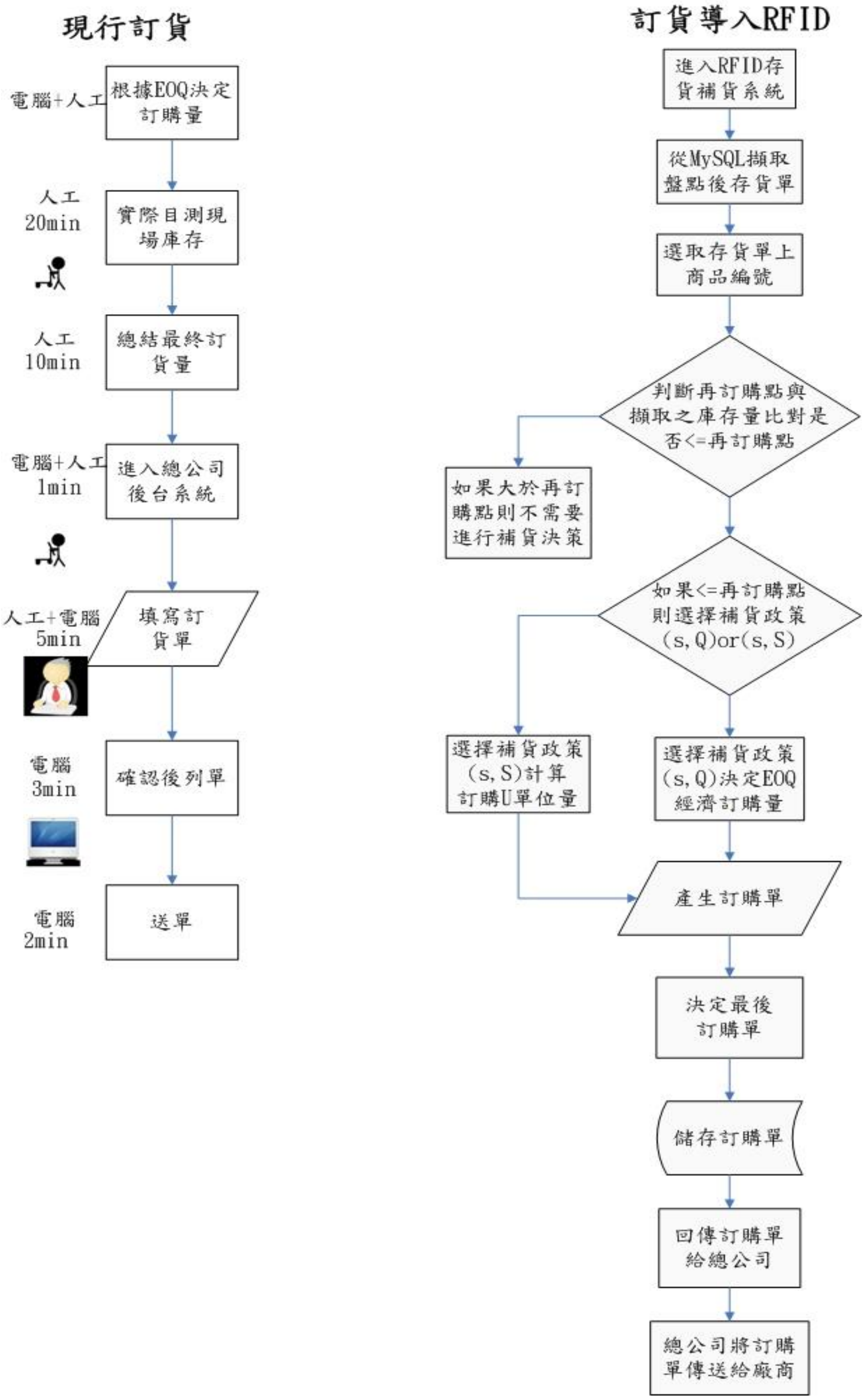


圖 10 現行訂貨作業導入 RFID 後作業流程

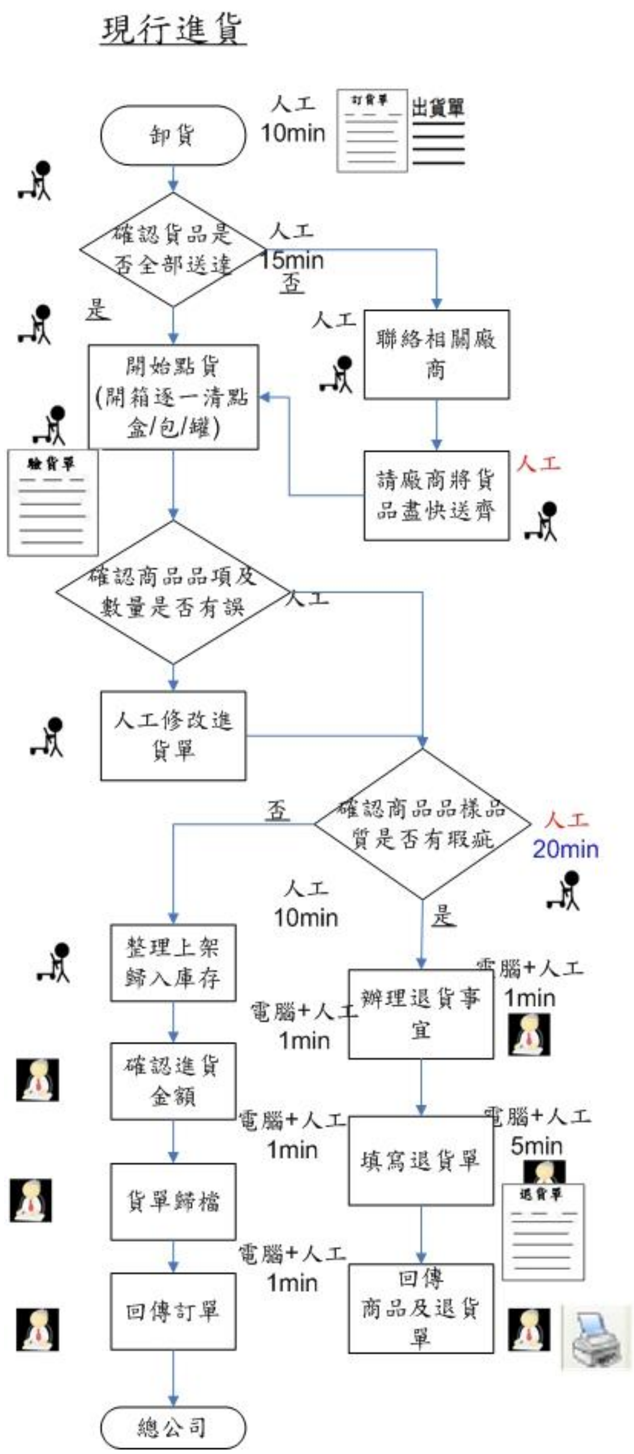


圖 11 現行進貨作業導入 RFID 後作業流程

3.2 被動式 RFID 定位演算法與趨勢線實驗導出

被動式 RFID 定位演算法中，共設計為四個階段步驟，第一階段為實驗導出 RFID 讀取器與天線在固定時段可讀取到 RFID Tag 標籤之次數與其距離關係的傳遞迴歸方程式 Readcount-distance propagation &regression equation；第二階段為依據讀取到 RFID Tag 標籤次數求解迴歸方程式之根而估算 RFID Tag 距離；第三階段為使用 Friis transmission equation (Friis 1946)計算出 RFID Tag 接收訊號強度 RSSI；第四階段運用 K-Nearest Neighbor (KNN)演算法求解被追蹤定位物件的座標值，運用此四個階段步驟，逐步導出建立被動式 RFID 存貨定位盤點演算法。

3.2.1 第一階段 Readcount-distance propagation &regression equation

3.2.1.1 導出二項次迴歸方程式-五個步驟

此階段是運用天線與待測物間距離關係在設定時段內所讀取到 RFID 標籤次數的實驗數據所導出的二項次迴歸方程式，此有五個步驟初步構想如下：

- Step1 規畫環境：擬定讀取範圍 5m*5m (天線發射有效範圍約 5m~6m)，天線與地面距離為 1m，待測物與地面高度距離 1m，天線與 RFID Tag 角度分為 0^0、30^0、45^0。
- Step2 設計實驗參數：距離點樣本數為 n = 20 個，每個距離 x 樣本讀取次數為 30 次，每次讀取時間為 1 分鐘，各距離樣本間隔單位為 0.25m。
- Step3 開始 RFID Tag 讀取實驗，記錄每個距離 x 之樣本讀取次數 y
- Step4 數據檢視篩選分析
- Step5 確認實驗並導出前述三種角度之二項次非線性傳遞迴歸公式，並由聯立方程式以 Cramer's rule 求解各係數 a_0 ;a_1 ; a_2：**<u>(註:本系統目前暫以 Excel 趨勢線功能求解如圖 17)</u>**

$$(n)a_0 + \left(\sum x_i\right)a_1 + \left(\sum x_i^2\right)a_2 = \sum y_i$$
$$\left(\sum x_i\right)a_0 + \left(\sum x_i^2\right)a_1 + \left(\sum x_i^3\right)a_2 = \sum x_i y_i$$
$$\left(\sum x_i^2\right)a_0 + \left(\sum x_i^3\right)a_1 + \left(\sum x_i^4\right)a_2 = \sum x_i^2 y_i$$

⇩

求解 a_0, a_1, a_2

$y = a_0 + a_1 x + a_2 x^2$ y = 標籤讀取次數 x = 天線與待測物間距離

以 Cramer's rule 求解係數 a_0、a_1、a_2 步驟：

Step 1 已知：

$x=a_0$、$y=a_1$、$z=a_2$

$$\begin{aligned} ax+by+cz&=j\\ dx+ey+fz&=k\\ gx+hy+iz&=l \end{aligned}$$

Step 2 當中的矩陣表示為：

$$\begin{bmatrix} a & b & c\\ d & e & f\\ g & h & i \end{bmatrix}\begin{bmatrix} x\\ y\\ z \end{bmatrix}=\begin{bmatrix} j\\ k\\ l \end{bmatrix}$$

Step 3 當矩陣可逆時，可以求出 x、y 和 z：

$$x=\frac{\begin{vmatrix} j & b & c\\ k & e & f\\ l & h & i \end{vmatrix}}{\begin{vmatrix} a & b & c\\ d & e & f\\ g & h & i \end{vmatrix}}\qquad y=\frac{\begin{vmatrix} a & j & c\\ d & k & f\\ g & l & i \end{vmatrix}}{\begin{vmatrix} a & b & c\\ d & e & f\\ g & h & i \end{vmatrix}}\qquad z=\frac{\begin{vmatrix} a & b & j\\ d & e & k\\ g & h & l \end{vmatrix}}{\begin{vmatrix} a & b & c\\ d & e & f\\ g & h & i \end{vmatrix}}$$

3.2.1.2 導出二項次迴歸方程式-實驗過程與結果

實驗方法：

將貼有 Tag 的三個箱子準備好，並將三個箱子分別放置在 0^0、30^0、45^0 的位置，Tag 位置與天線的位置呈現平行狀態，測試距離從 0.25m 到 5m，每 0.25m 為距離間距，再利用天線同時讀取三個 Tag，同時讀取一分鐘，每個距離重複 30 次讀取，最後將三種角度在 20 個不同距離之每分鐘讀取次數，個別平均讀取次數，將其平均次數與實驗樣本距離，導入演算法把物品的相對位置找出來，如此一來即可知道我們需要的貨物或商品的正確位置。測量時，避免週遭有金屬物體干擾電波，並且了解電波傳達距離的長度及效果，以防止測量次數因外在因素而受到干擾。。自 2010 年 12 月 6 日開始分批進行實際測試，投入總計約 60 小時，依據表 4 三角函數與距離關係表擺放 Tag 之距離，使用圖 17 實驗結果數據 (角度 0 度)，導入二階多項式如圖 18 以 Excel 公式推導與趨勢線功能求解流程。

實驗設備：圖 14 被動式 UHF Gen2 EPC Tag(編號：B7E2、460D、562C)、圖 12Reader、Computer、圖 13Antenna、圖 15 雷射測距儀以及擺放貨物的料架。

圖 12 Mercury4 Reader　　圖 13 Antenna

圖 14 UHF Gen2 EPC Tag　　圖 15 雷射測距儀

圖 16 實驗場地佈置

表 4 三角函數與距離關係表

15	30	45	60	Degree
0.259	0.5	0.707	0.866	SIN
0.966	0.866	0.707	0.5	COS
0.268	0.577	1	1.732	TAN
D15	D30	D45	D60	Distance
1.34	2.887	5	8.66	5
1.273	2.742	4.75	8.227	4.75
1.206	2.598	4.5	7.794	4.5
1.139	2.454	4.25	7.361	4.25
1.072	2.309	4	6.928	4
1.005	2.165	3.75	6.495	3.75
0.938	2.021	3.5	6.062	3.5
0.871	1.876	3.25	5.629	3.25
0.804	1.732	3	5.196	3
0.737	1.588	2.75	4.763	2.75
0.67	1.443	2.5	4.33	2.5
0.603	1.299	2.25	3.897	2.25
0.536	1.155	2	3.464	2
0.469	1.01	1.75	3.031	1.75
0.402	0.866	1.5	2.598	1.5
0.335	0.722	1.25	2.165	1.25
0.268	0.577	1	1.732	1
0.201	0.433	0.75	1.299	0.75
0.134	0.289	0.5	0.866	0.5

測試次數	日期	2011/1/19	2011/1/18	2011/1/19	2011/1/18	2011/1/19	2011/1/19	2011/1/19	2011/1/19	2011/1/19	2011/1/19
	距離	0.25M	0.5M	0.75M	1M	1.25M	1.5M	1.75M	2M	2.25M	2.5M
	角度	0度	0度	0度	0度	0度	0度	0度	0度	0度	0度
	Tag	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2
1		47	46	46	46	47	46	47	46	46	46
2		47	46	46	45	47	47	47	47	46	46
3		47	46	47	46	47	47	47	47	46	46
4		47	46	46	46	47	46	47	46	46	46
5		48	46	47	45	47	47	46	47	47	47
6		47	46	46	45	47	47	46	46	46	46
7		47	46	46	45	46	47	47	47	47	47
8		47	47	47	46	46	47	46	46	46	46
9		47	46	47	45	46	47	47	47	46	46
10		47	46	46	45	47	47	47	46	47	47
11		47	47	46	46	47	47	47	47	46	47
12		47	47	46	46	47	48	47	46	47	47
13		47	46	47	46	46	47	47	47	46	46
14		47	46	46	45	46	48	47	46	46	46
15		47	46	47	45	47	47	47	46	46	46
16		48	46	47	45	46	47	47	47	46	47
17		47	46	46	45	47	47	47	46	46	46
18		47	47	47	46	47	47	47	47	46	46
19		47	46	47	45	47	47	47	47	46	46
20		47	46	47	46	48	47	47	47	46	47
21		48	47	46	46	46	47	46	46	46	46
22		47	46	47	45	47	46	46	46	46	46
23		48	46	47	46	47	47	47	46	46	47
24		47	46	47	45	47	47	47	46	46	47
25		47	46	47	46	47	46	46	47	47	46
26		47	47	47	46	46	47	47	46	47	47
27		47	46	47	45	47	47	47	46	46	47
28		47	46	47	46	46	47	46	46	47	46
29		47	46	47	46	47	47	47	46	46	47
30		47	47	46	46	47	47	47	46	46	46
平均數		47.1333	46.2333	46.6000	45.5333	46.7333	46.9333	46.7667	46.4000	46.2333	46.4000

測試次數	日期	2011/1/19	2011/1/19	2011/1/19	2011/1/19	2011/1/19	2011/1/19	2011/1/18	2011/1/18	2011/1/18	2011/1/18
	距離	2.75M	3M	3.25M	3.5M	3.75M	4M	4.25M	4.5M	4.75M	5M
	角度	0度	0度	0度	0度	0度	0度	0度	0度	0度	0度
	Tag	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2	B7E2
1		47	46	44	44	46	46	46	46	46	47
2		46	46	44	44	46	45	46	46	46	47
3		46	46	44	44	46	45	46	46	46	46
4		46	46	44	44	45	45	46	46	46	47
5		46	46	43	45	46	46	46	46	46	47
6		46	46	44	46	46	45	46	46	46	46
7		46	46	44	45	45	46	46	46	46	47
8		46	46	44	44	46	46	46	46	46	46
9		46	46	44	44	45	45	46	46	46	47
10		46	46	44	44	46	46	46	46	46	46
11		46	47	43	45	46	46	46	46	46	46
12		46	46	45	46	45	45	45	46	46	47
13		46	46	44	44	45	46	46	46	46	46
14		47	46	43	44	45	45	45	46	46	46
15		46	46	43	44	46	45	46	46	46	47
16		46	45	44	44	45	45	46	46	46	47
17		46	46	43	43	45	46	46	46	46	46
18		46	46	44	45	46	46	46	46	46	47
19		47	44	43	44	45	46	46	46	46	47
20		46	46	43	44	45	45	46	46	46	47
21		46	46	44	44	45	44	46	46	46	47
22		46	46	44	44	45	44	45	46	46	47
23		46	46	44	44	46	43	46	46	46	47
24		46	46	44	43	45	45	46	46	46	47
25		46	46	43	44	45	45	46	46	46	47
26		46	46	44	45	45	44	46	46	46	46
27		46	46	44	43	45	45	45	46	46	46
28		46	46	44	44	45	44	45	46	46	47
29		46	46	44	45	46	44	46	46	46	47
30		46	46	43	44	45	45	46	46	46	46
平均數		46.1000	45.9333	43.7333	44.2333	45.4000	45.1000	45.8333	46.0000	46.0000	46.6333

Step1 x為距離、y為每距離平均讀取次數 x_i (角度0度)

Distance(m) Antenna Tag	readcount 讀取次數
0.25	47.1333
0.5	46.2333
0.75	46.6000
1	45.5333
1.25	46.7333
1.5	46.9333
1.75	46.7667
2	46.4000
2.25	46.2333
2.5	46.4000
2.75	46.1000
3	46.0000
3.25	46.0667
3.5	44.2333
3.75	45.4000
4	45.1000
4.25	46.9000
4.5	46.0000
4.75	46.0000
5	46.6333

Step2 根據公式計算所需之值

	i	x_i	x_i^2	x_i^3	x_i^4	y_i	x_iy_i	$x_i^2y_i$
	1	0.25	0.0625	0.015625	0.0039	47.1333	11.7833	2.94583333
	2	0.5	0.25	0.125	0.0625	46.2333	23.1167	11.5583333
	3	0.75	0.5625	0.421875	0.3164	46.6000	34.95	26.2125
	4	1	1	1	1.0000	45.5333	45.5333	45.5333333
	5	1.25	1.5625	1.953125	2.4414	46.7333	58.4167	73.0208333
	6	1.5	2.25	3.375	5.0625	46.9333	70.4	105.6
	7	1.75	3.0625	5.359375	9.3789	46.7667	81.8417	143.222917
	8	2	4	8	16.0000	46.4000	92.8	185.6
	9	2.25	5.0625	11.390625	25.6289	46.2333	104.025	234.05625
	10	2.5	6.25	15.625	39.0625	46.4000	116	290
	11	2.75	7.5625	20.796875	57.1914	46.1000	126.775	348.63125
	12	3	9	27	81.0000	46.0000	138	414
	13	3.25	10.5625	34.328125	111.5664	46.0667	149.717	486.579167
	14	3.5	12.25	42.875	150.0625	44.2333	154.817	541.858333
	15	3.75	14.0625	52.734375	197.7539	45.4000	170.25	638.4375
	16	4	16	64	256.0000	45.1000	180.4	721.6
	17	4.25	18.0625	76.765625	326.2539	46.9000	199.325	847.13125
	18	4.5	20.25	91.125	410.0625	46.0000	207	931.5
	19	4.75	22.5625	107.171875	509.0664	46.0000	218.5	1037.875
	20	5	25	125	625.0000	46.6333	233.167	1165.83333
Σ	20	52.5	179.375	689.0625	2822.9141	923.40	2417	8251.2

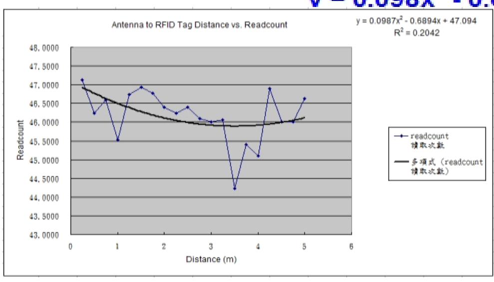
20	a_0	+	52.5	a_1	+	179.375	a_2	=	923.4
52.5	a_0	+	179.375	a_1	+	689.0625	a_2	=	2416.817
179.375	a_0	+	689.0625	a_1	+	2822.91406	a_2	=	8251.196

a	b	c		j
20	52.5	179.375	a_0	923.4
d	e	f		k
52.5	179.375	689.0625	a_1	2416.816667
g	h	i		l
179.375	689.0625	2822.91406	a_2	8251.195833

Step3 根據Cramer's rule導出a_0,a_1,a_2之係數

		j 923.4	b 52.5	c 179.375							
		k 2416.82	e 179.375	f 689.0625							
		l 8251.2	h 689.0625	i 2822.91406		1064786429	-	1062101804	=	2684625	
a_0	=		÷		=		÷			=	47.09409
		a 20	b 52.5	c 179.375		23105265.72	-	23048260.2	=	57005.57	
		d 52.5	e 179.375	f 689.0625							
		g 179.375	h 689.0625	i 2822.91406							
		a 20	j 923.4	c 179.375							
		d 52.5	k 2416.8167	f 689.0625							
		g 179.375	l 8251.1958	i 2822.91406		328285154.4	-	328324452	=	-39297.9	
a_1	=		÷		=		÷			=	-0.68937
		a 20	b 52.5	c 179.375		23105265.72	-	23048260.2	=	57005.57	
		d 52.5	e 179.375	f 689.0625							
		g 179.375	h 689.0625	i 2822.91406							
		a 20	b 52.5	j 923.4							
		d 52.5	e 179.375	k 2416.81667							
		g 179.375	h 689.0625	l 8251.19583		85765497.16	-	85759868.9	=	5628.255	
a_2	=		÷		=		÷			=	0.098732
		a 20	b 52.5	c 179.375		23105265.72	-	23048260.2	=	57005.57	
		d 52.5	e 179.375	f 689.0625							
		g 179.375	h 689.0625	i 2822.91406							

$$y = 0.098x^2 - 0.689x + 47.09$$



47.0941	a_0
-0.6894	a_1
0.09873	a_2

圖 18 以 Excel 公式推導與趨勢線功能求解流程

3.2.2 第二階段 RFID Tag Distance 反求解

此階段最主要是運用第一部份所導出的公式,進行待測物與天線距離的求算,目的是為了蒐集第三階段 Friis transmission equation 距離(d)的參數,如圖 19 被動式 RFID 定位演算法流程所示,此有兩個步驟初步構想如下:

Step1 讀取待測物之 RFID 標籤被讀取到次數。

Step2 將次數代入公式 $y = a_0 + a_1 x + a_2 x^2$,求解其根算出待測物與天線之距離 x。

3.2.3 第三階段計算 RSSI by Friis transmission equation

此階段最主要目的是求算 RSSI 值,因為在第四階段 K-Nearest Neighbor 演算法需要已知 RSSI 值,但被動式 RFID Tag 標籤系統並未提供 RSSI 值的資訊,因此由 Friis transmission equation 求得 RSSI 值,如圖 19 被動式 RFID 定位演算法流程所示,此有兩步驟初步構想如下:

Step1 蒐集 Friis transmission equation 所需的所有輸入參數之數據例如:

P_r =received power (dBm)

P_t = transmitted power (dBm)

G_t = transmitter gain (dBi)

G_r = receiver gain (dBi)

λ =c/f c=3*10^8m/s f =頻率 MHHz

d= 距離(m)

L= 遺失值 %

Step2 代入 Friis transmission equation 求算 RSSI 值,公式如下:

$$p_r = P_t \frac{G_t G_r \lambda^2}{16 L \pi^2 d^2}$$

3.2.4 第四階段估算 RFID Tag 座標值 by K-Nearest Neighbor algorithm

此階段主要目的是將第三部份所求得的 RSSI 值，導入 K-Nearest Neighbor (KNN)演算法，求得待測物(X,Y)座標的準確位置，如圖 19 被動式 RFID 定位演算法流程所示，此有兩步驟初步構想如下：

Step1 將 RSSI 代入 K-Nearest Neighbor 演算法，公式如下：

$$E_i = \sqrt{\sum_{j=1}^{m}\left(R_j - T_j\right)^2}$$

T_j：第j台RFID Reader讀取追蹤標籤的訊號強度。

R_j：第j台RFIDReader讀取參考標籤的訊號強度。

$$W_i = \left(\frac{1}{E_i^{\ 2}}\right) \Big/ \left(\sum_{i=1}^{k}\frac{1}{E_i^{\ 2}}\right)$$

W_i 表示第 i 個鄰近的 reference tag 參考標籤座標之權重因子。

Step2 求算待測物之(X,Y)座標

$$(x, y) = \sum_{i=1}^{k} w_i (x_i, y_i)$$

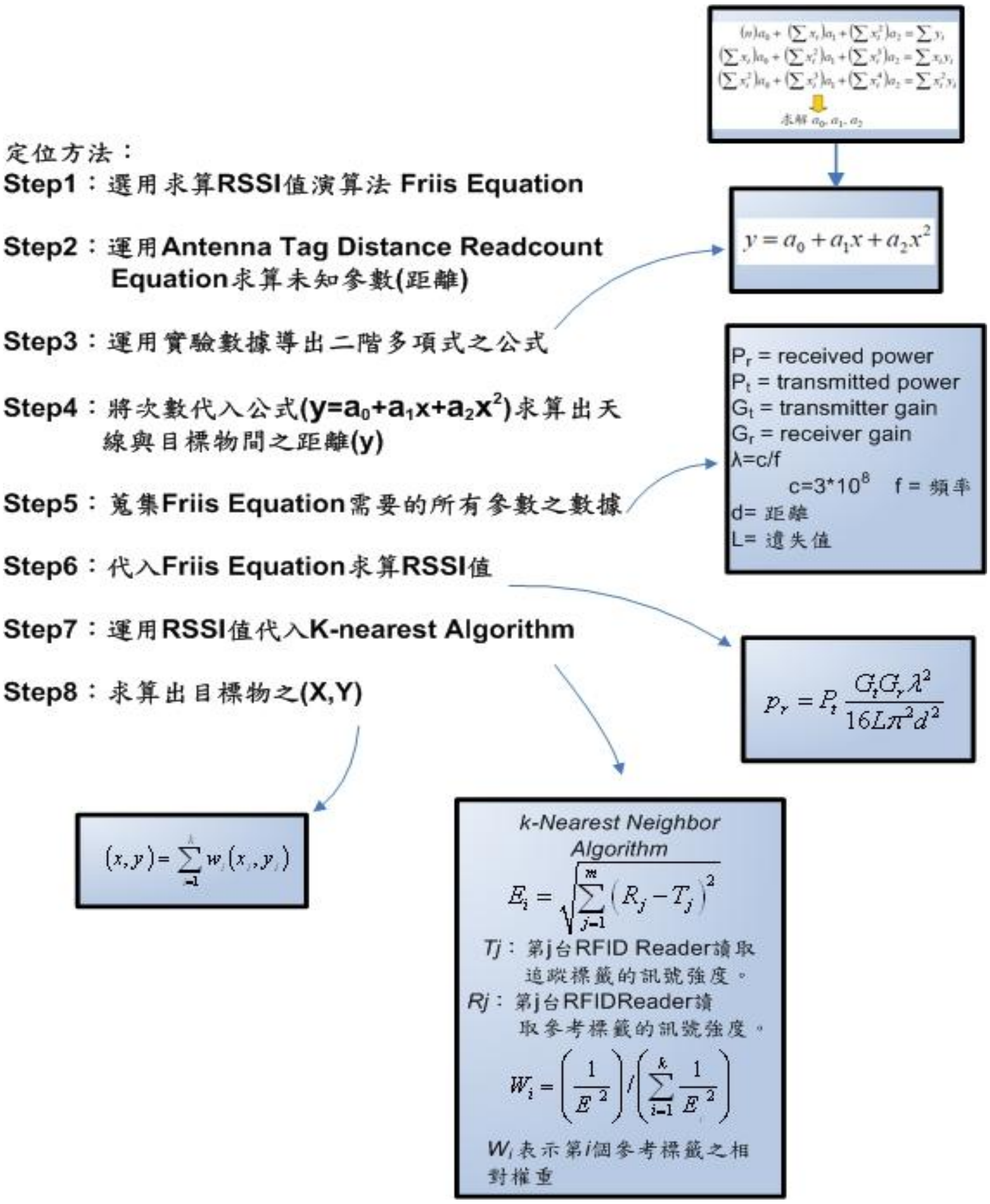


圖 19 被動式 RFID 定位演算法流程

3.3 連續盤點補貨政策(s,Q)、(s,S)

為有效執行存貨管理，必須制定存補貨政策，一般存補貨政策分為連續盤點制(Perpetual Inventory System)與定期盤點制(Periodic System)兩大類，本系統係用連續盤點制的方式，進行存補貨決策，下面說明連續盤點制：

- **<u>訂購點－訂購量系統(s,Q)(Order-Point, Order-Quantity System)</u>**

當庫存量降至再訂購點 s 時，一固定的數量 Q 即被訂購如圖 20。此系統優點是簡單不易發生錯誤，供應商對於下游需求是可預測的；但缺點是由於此模式

的不可修正性，當需求量大於訂購量 Q 時，將無法有效率處理。

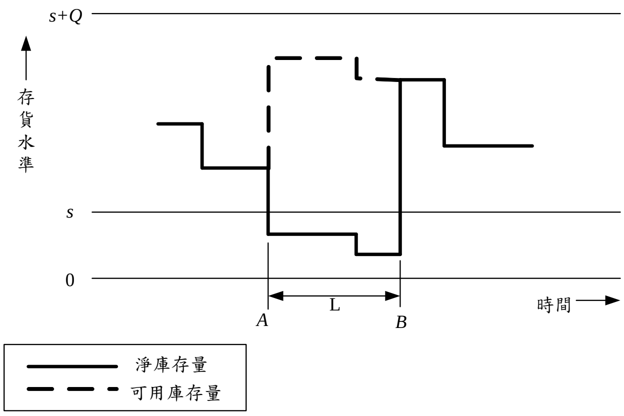


圖 20 (s,Q)存貨系統，在 A 時間設置訂單，在 B 時間接收訂單(資料來源：Silver et al.，1998)

- **<u>訂購點－滿足基準量系統(s,S)(Order-Point, Order-Up-To-Level System)</u>**

當存貨位置降至訂購點 s 時，即訂購 U 單位量，使庫存量增加到訂購目標 S，即 S=s+U 如圖 21。此系統優點為(s,S)存貨模式計算所得之總成本較(s,Q)模式小，但計算較繁雜；其缺點是(s,S)存貨模式中的訂購量為變數(variable)，導致供應商必須不斷變更訂購量。

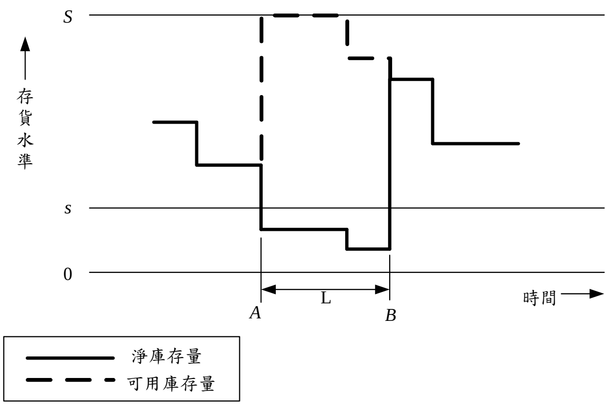


圖 21 (s,S)存貨系統，在 A 時間設置訂單，在 B 時間接收訂單(資料來源：Silver et al.，1998)

- **<u>經濟訂購量(Economic ordering quantity, EOQ)</u>**是要將存貨的儲存成本和訂購成本降至最低的訂購量。

最佳訂購量以 Q_0 表示：

$$Q_0 = \sqrt{\frac{2DS}{H}}$$

- <u>**再訂購點(Reorder Point, ROP)**</u>當現有數量減少到一個預定量時，便進行再預購。

在此假設需求與前置時間皆為常數，則再訂購點：

$$\text{ROP} = d \times \text{LT}$$

其中

d=需求率（單位／每天或每週）

LT =以天或週為單位的前置時間

- <u>**安全存量**</u>為應付需求或前置時間出現變異而超過預期需求的存量。

再訂購點會隨著安全存量而增加：

ROP =前置時間的預期需求＋安全存量

3.4 LabVIEW 與 MySQL

LabVIEW(Laboratory Virtual Instrument Engineering Workbench)是由 National Instrument 公司，於 1986 年所發展出的一種圖像程式語言(Graphic Language，稱 G 語言)，有別於傳統文字編輯方式，它是使用圖像物件函數的方式編輯程式，使得使用者更容易了解程式結構涵義。

LabVIEW 在儀器控制與量測方面，提供相當強大的功能，可透過 GPIB(General Purpose Interface Bus)當作與儀器的連接介面，如 IEEE-488、RS-232 通訊介面或是由 TCP/IP 網路通訊協定的方式與電腦連線，從事訊號量測、分析、數據儲存與資料截取等功能，提昇工作效率與數據資料的準確性。LabVIEW 除了帶給編輯程式者的方便性，最重要的部份是在人機控制面板的設計做到真正虛擬儀表功能，LabVIEW 主程式系統方面，可區分為三個主要部份：前置面板、程式方塊圖圖 22、圖像和連結器，在前置面板主要是提供使用者，設定輸入資料與顯示輸出，同時也提供輸入與輸出物件之選擇，程式方塊圖區主要功能為提供編輯程式者編寫程式的區域，便捷有效地操作複雜儀器之設定。本研究將整合 MySQL 資料庫系統與 LabVIEW 建立 RFID 網路平台。

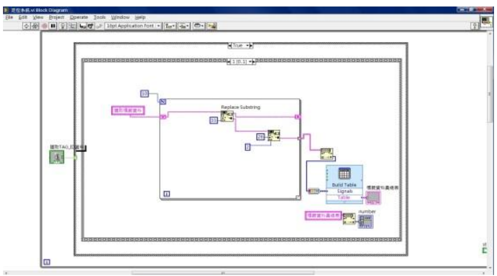


圖 22 LabVIEW 程式方塊圖

MySQL 資料庫

MySQL 是一個開放原始碼的關聯式資料庫管理系統，原開發者為瑞典的 MySQL AB 公司，該公司於 2008 年被 Sun 收購。2009 年，Oracle 收購 Sun 公司，MySQL 成為 Oracle 旗下產品。

MySQL 由於性能高、成本低、可靠性好，已經成為最流行的開源資料庫，被廣泛地應用在 Internet 上的中小型網站中。隨著 MySQL 的不斷成熟，它也逐漸用於更多大規模網站和應用，比如維基百科、Google 和 Facebook 等網站。非常流行的開源軟體組合 LAMP 中的「M」指的就是 MySQL。

MySQL 資料庫是免費的程式，屬於關聯式資料庫，使用 SQL(結構化查詢語言)，使用 SQL 可以連結 C、C++、Java、Perl、PHP 語言，而且也可在許多平台上運作，如：Linux、Windows、Sun Solaris ... 等，且支援微軟的 ODBC 規格的資料庫整合如圖 23。

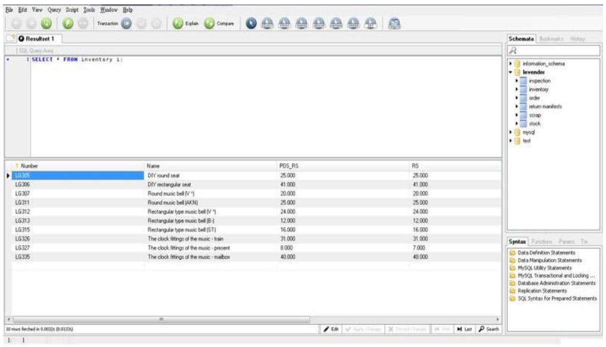


圖 23 MySQL 資料庫畫面

MySQL 管理與連接方式

- 可以使用命令列工具管理 MySQL 資料庫（命令 mysql 和 mysqladmin），也可以從 MySQL 的網站下載圖形管理工具 MySQL Workbench。前者是用來取代舊有的 MySQL Administrator 和 MySQL Query Browser。
- 應用程式可透過 ODBC 或 ADO 方式，經由使用 MyODBC 與 MySQL 資料庫連接。
- MS .Net Framework 下的程式（例如：C#、VB.NET）可透過 ADO.NET 的方式，經由使用 MySQL.Net 與 MySQL 資料庫連接。
- JAVA 程式可透過 JDBC 方式與 mysql 進行連線，mysql 官方提供了 JDBC 驅動程式。
- 可透過 mysql 用戶端軟體與 mysql 進行連線，如 mysqlfront, mysqlyog, mysqlbrowser 等。

3.5 系統架構

被動式 RFID 存貨定位盤點暨補貨系統之架構(PARFILO)如圖 23：

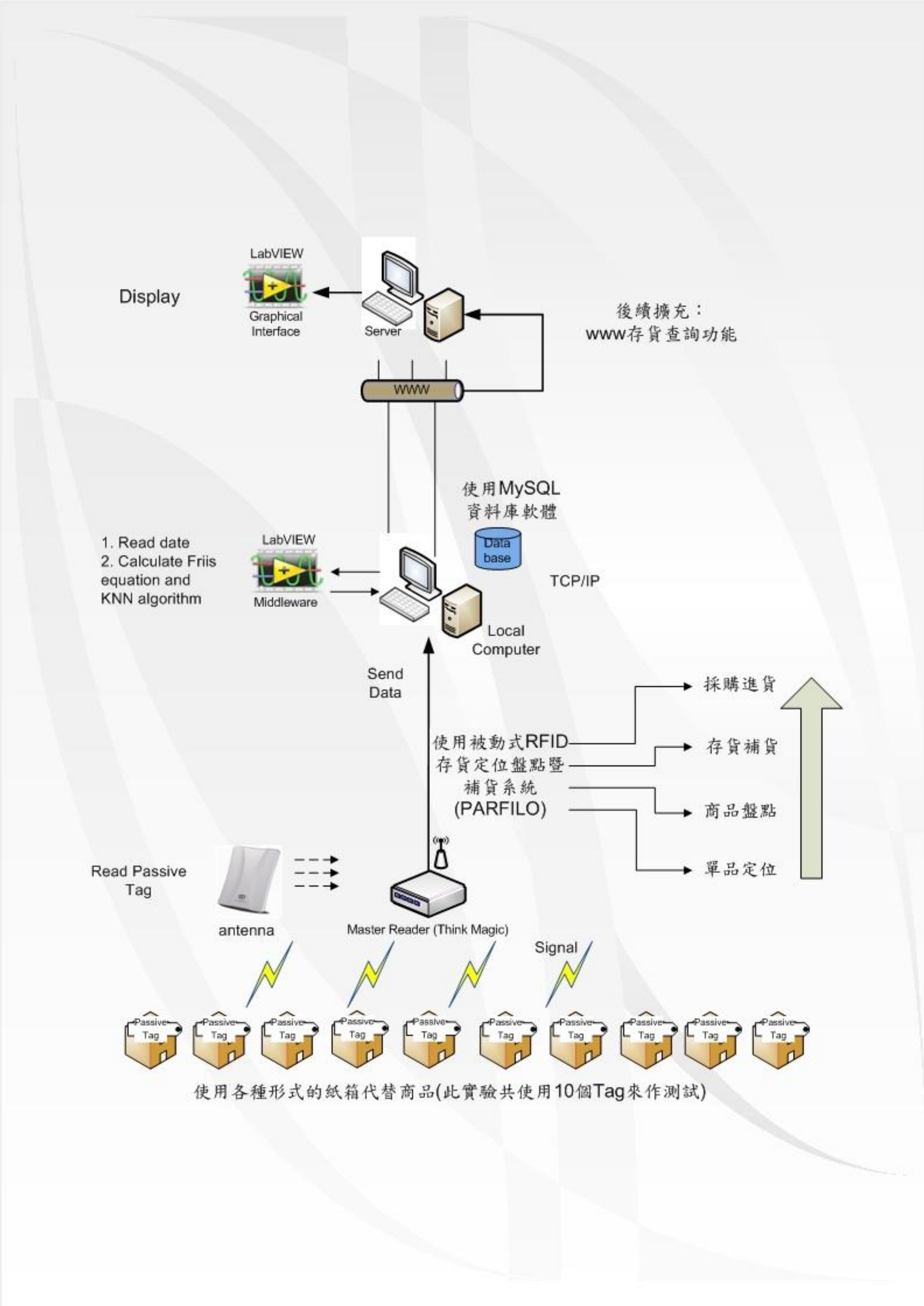


圖 24 被動式 RFID 存貨定位盤點暨補貨系統架構(PARFILO)

第4章 被動式 RFID 存貨定位盤點暨補貨系統(PARFILO)

4.1 PARFILO 系統簡介

PARFILO 是由 **PA**ssive **RF**ID-enabled **I**nventory **LO**calization / Stock Counting and Replenishment System 中擷取幾個英文字母作為命名，每項代表 PARFILO 系統設計使用之關鍵技術，「PA」，代表用被動式 Tag 標籤；「RF」，代表使用 RFID 無線射頻辨識技術；「ILO」，則代表存貨定位盤點。

PARFILO 系統(圖 25)下，包含四個子系統，分為「單品定位系統」(圖 26)、「商品盤點系統」(圖 27)/其操作步驟如圖 28、「存貨補貨系統」(圖 29)以及「採購進貨系統」(圖 30)。

4.2 系統功能畫面與步驟

圖 25 PARFILO 主畫面

<主畫面操作步驟>

Step1 開啟 Reader **Step2** 進入 單品定位 **Step3** 進入 商品盤點

Step4 進入 存貨補貨 **Step5** 進入 採購進貨 **Step6** 點選 停止

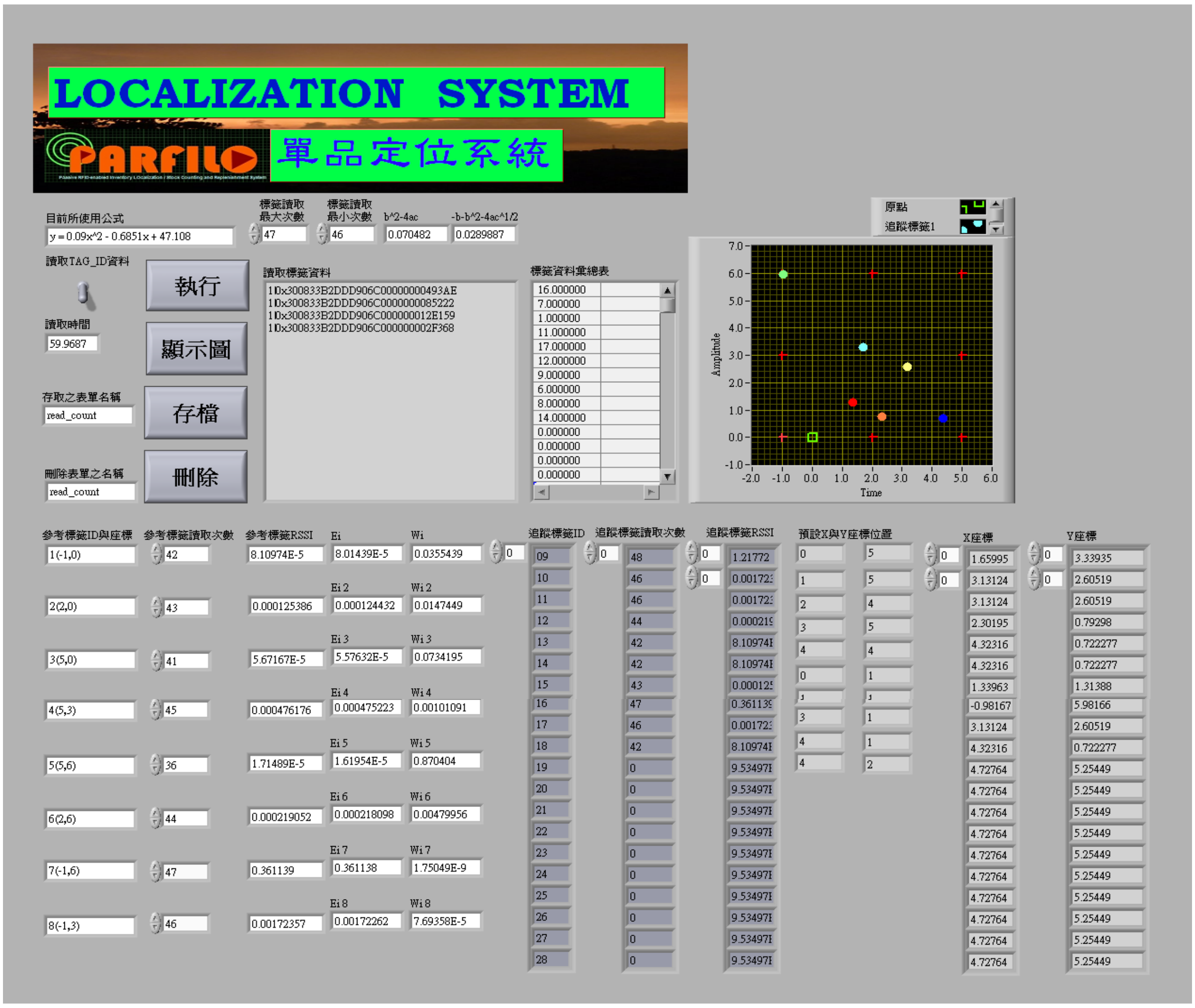
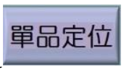


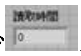
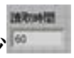
圖 26 單品定位系統畫面

<單品定位系統操作步驟>

Step1 進入 PARFILO，點選

進入系統。

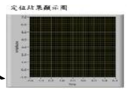
Step2 點選開始讀取。

Step3 等待讀取時間從 0 秒到 60 秒。

Step4 點選停止讀取。

Step5 點選

執行定位。

Step6 點選，將定位結果顯示於上。

Step7 點選

，將結果儲存於 MySQL 資料庫。

Step8 關閉程式，回到主畫面。

Step9 點選

停止主畫面。

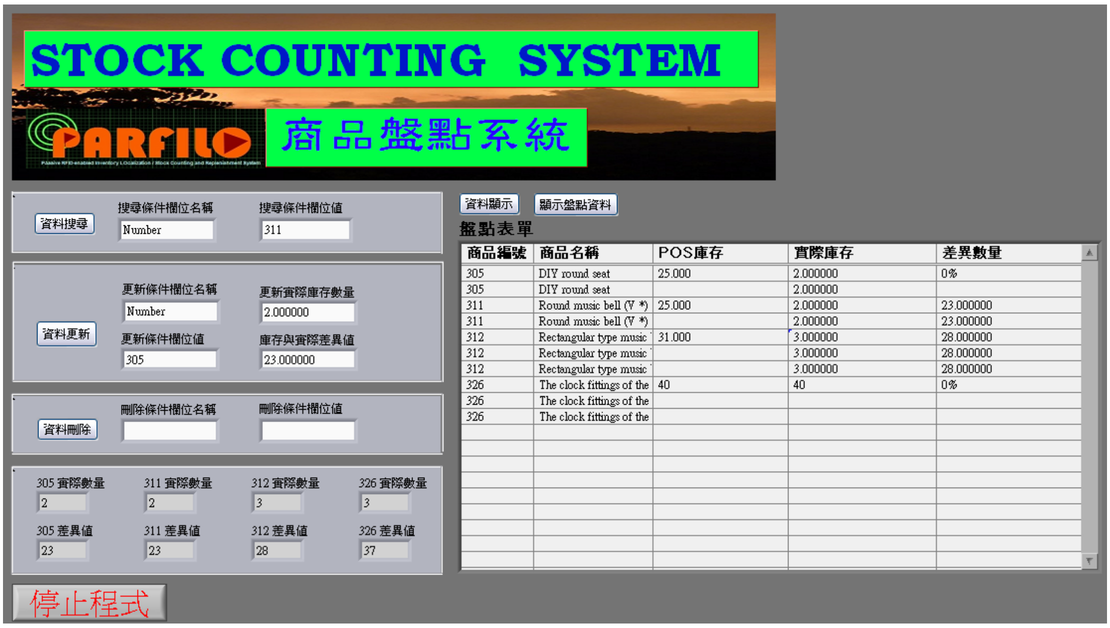


圖 27 商品盤點系統畫面

<商品盤點系統操作步驟>

Step1　PARFILO 主畫面，點選 商品盤點 進入商品盤點系統。

Step2 進入商品盤點系統時，會自動計算商品數量與差異值。

305 實際數量	311 實際數量	312 實際數量	326 實際數量
2	2	3	3
305 差異值	311 差異值	312 差異值	326 差異值
23	23	28	37

Step3 點選 顯示盤點資料 ，將單品定位之資料顯示在盤點表單上。

Step4 輸入要更新之商品編號於 更新條件欄位值 305 。

Step5 點選 資料更新 ，將盤點到的資料更新到資料庫。

Step6 點選 停止程式 ，停止商品盤點系統。

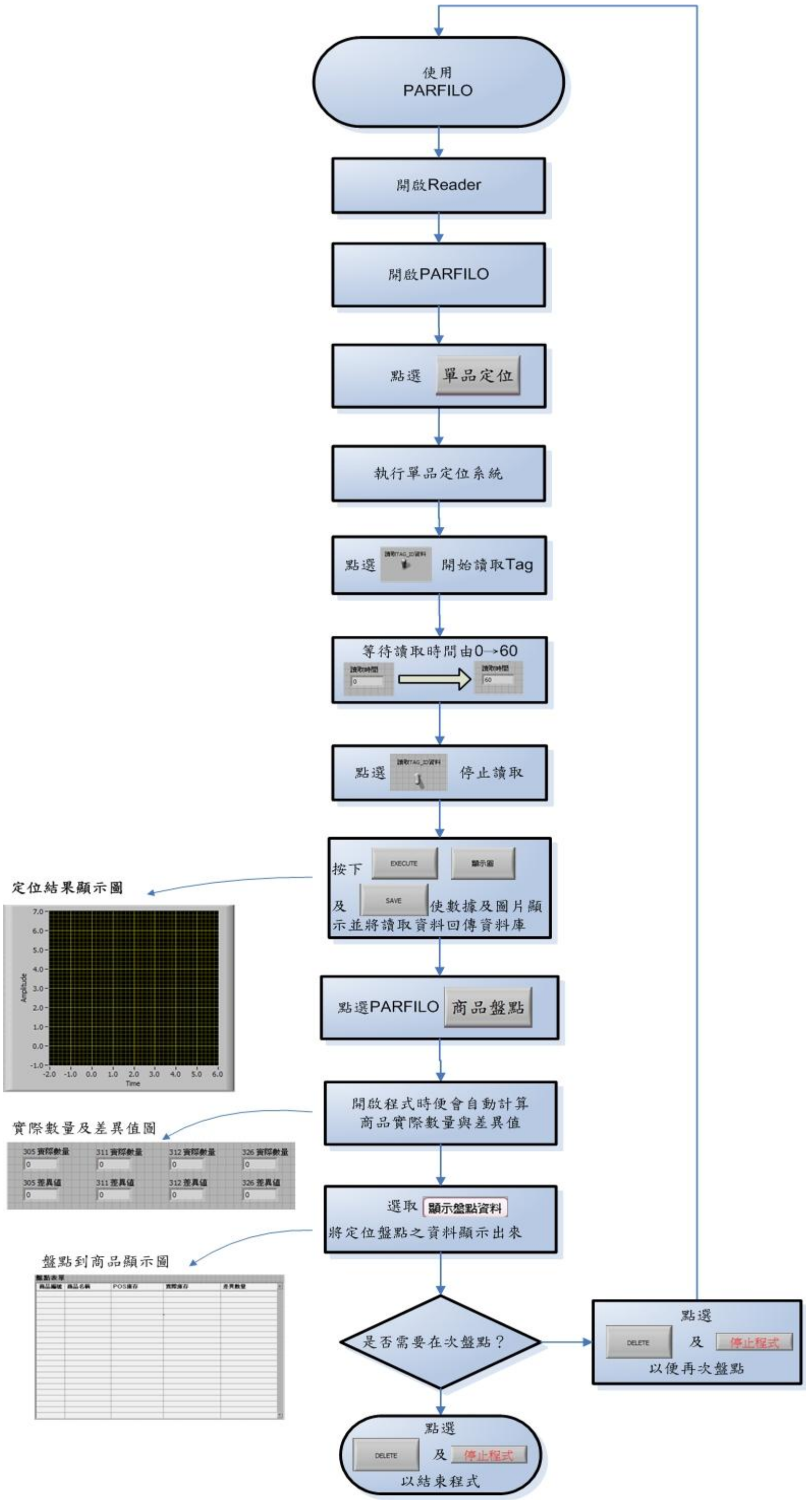
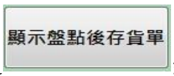


圖 28 單品定位與商品盤點操作流程

圖 29 存貨補貨系統畫面

<u><存貨補貨系統操作步驟></u>

Step1 點選

顯示盤點後存貨資料於盤點後存貨單上。

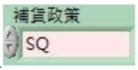
Step2 選擇

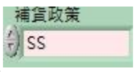
。

Step3 判斷

。

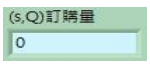
Step4 若需要補貨亮則到 Step5；若不需補貨則亮，並停止以下步驟或回到 Step2 繼續下一商品補貨判斷。

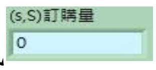
Step5 選擇補貨政策

或

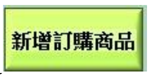
。

Step6 點選訂購量計算

，並顯示其選擇補貨政策計算之訂購量於對應之方格內

或

。

Step7 點選

，將須訂購之商品加入訂購單。

Step8 點選 清除訂購量 ，清除前一商品訂購量計算 (s,Q)訂購量 0 和 (s,S)訂購量 0 之數量，<u>**每新增下一筆需補貨商品重複 Step2~Step8。**</u>

Step9 若訂購單上商品訂購數量需要變更時點選 更新訂購量 。

Step10 若訂購單上之商品最終不須訂購時，點選 刪除訂購商品 ，可以刪除此項訂購商品。

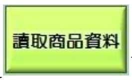
Step11 點選 停止 ，停止系統。

圖 30 採購進貨系統畫面

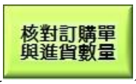
<u><採購進貨系統操作步驟></u>

Step1 選擇進貨商品的

。

Step2 點選

可以讀取進貨商品的資料。

Step3 點選

將讀取資料與訂購單相互比對，商品和數量是否有誤。

Step4 點選

清除檢驗完進貨商品，繼續 Step1~Step4 下一項商品進行比對。

Step5 點選

，停止系統。

4.3 LabVIEW 圖控程式畫面

單品定位系統程式方塊圖如圖 31

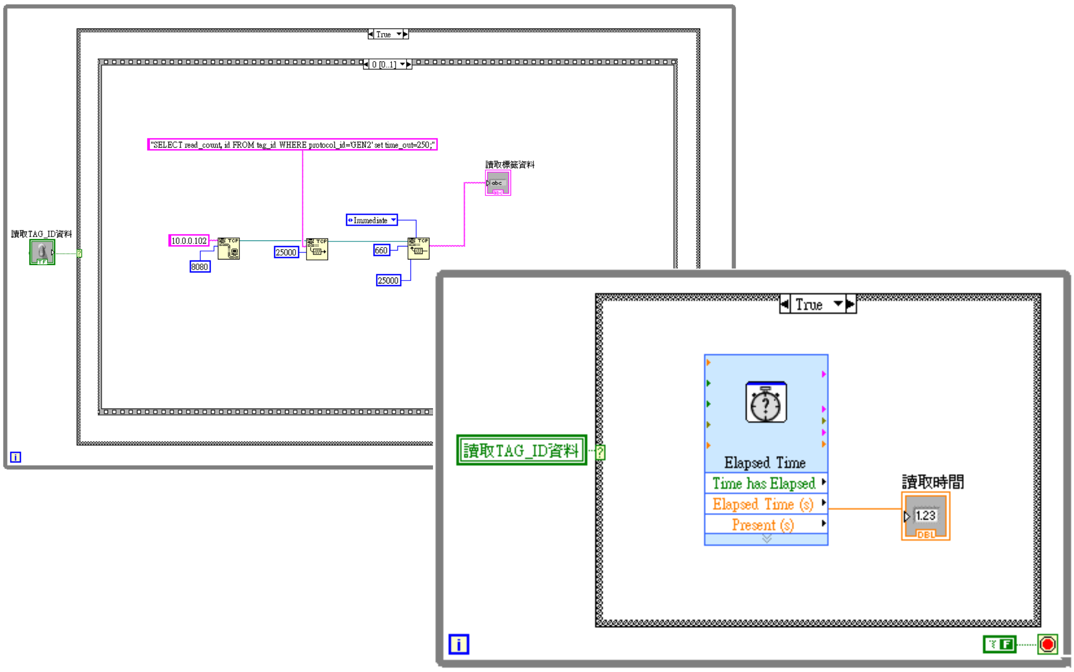


圖 31 單品定位系統程式方塊圖

商品盤點系統程式方塊圖如圖 32

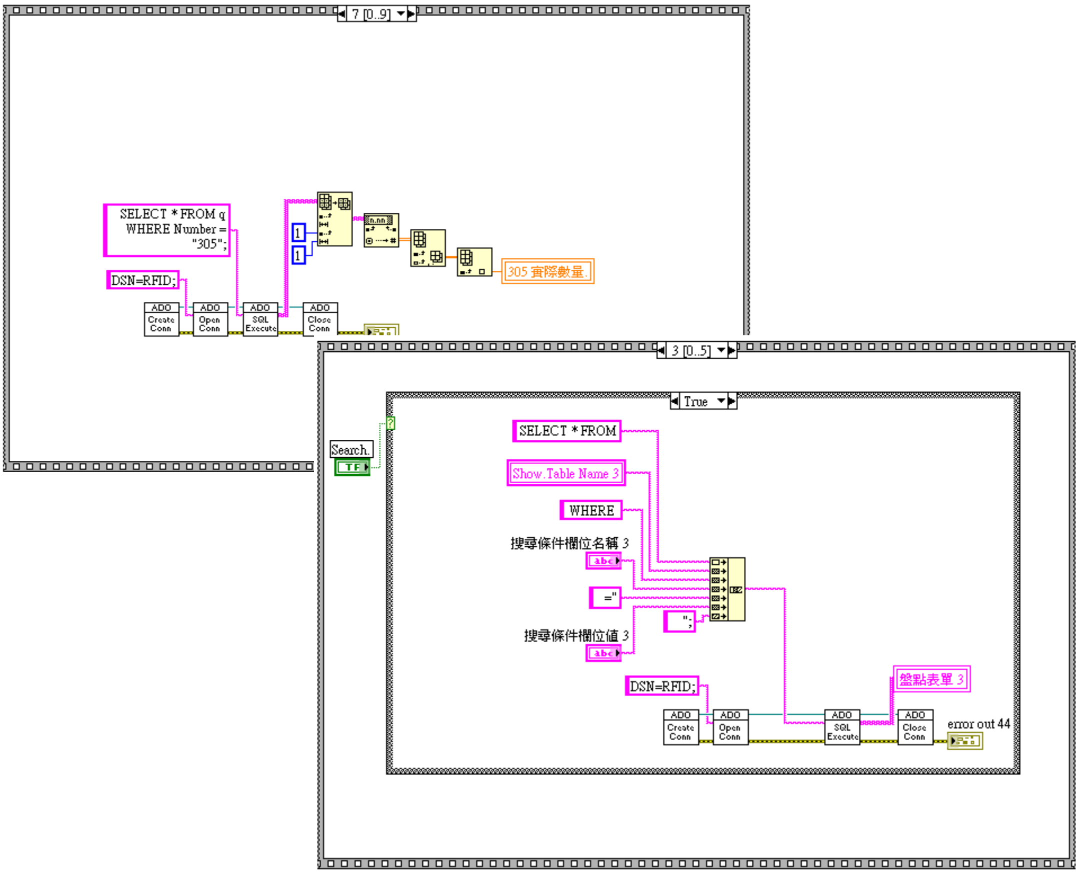


圖 32 商品盤點系統程式方塊圖

存貨補貨系統程式方塊圖如圖 33

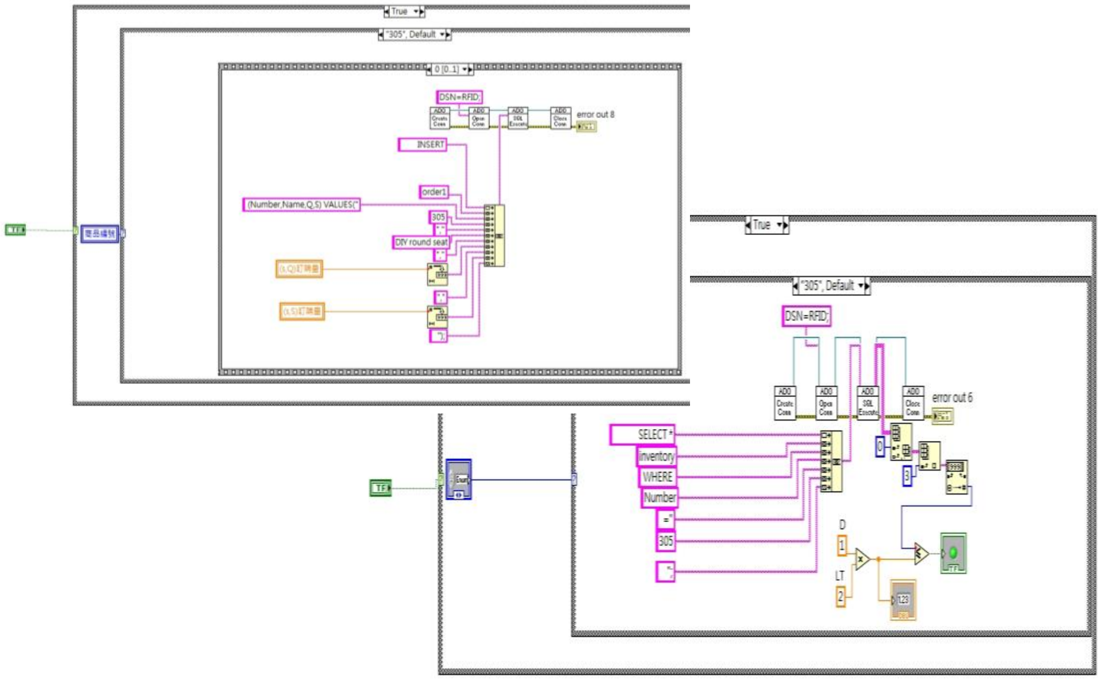


圖 33 存貨補貨系統程式方塊圖

採購進貨系統程式方塊圖如圖 34

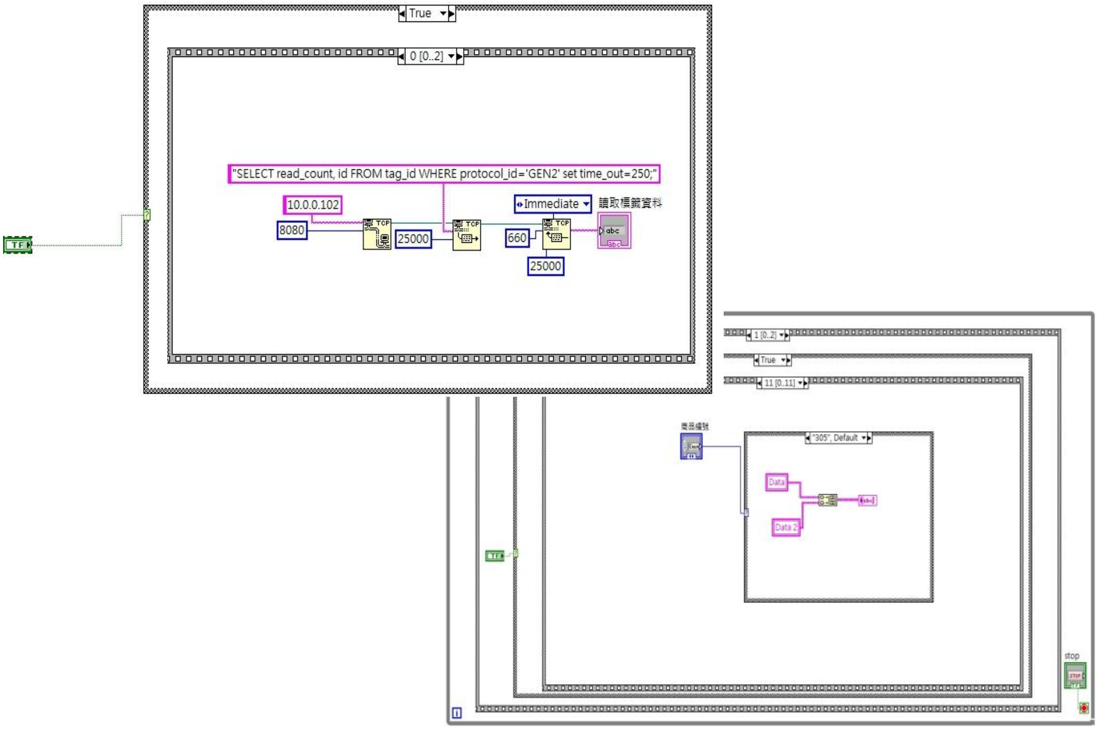


圖 34 採購進貨系統程式方塊圖

4.4 MySQL 資料庫畫面

MySQL 盤點後存貨單如圖 35

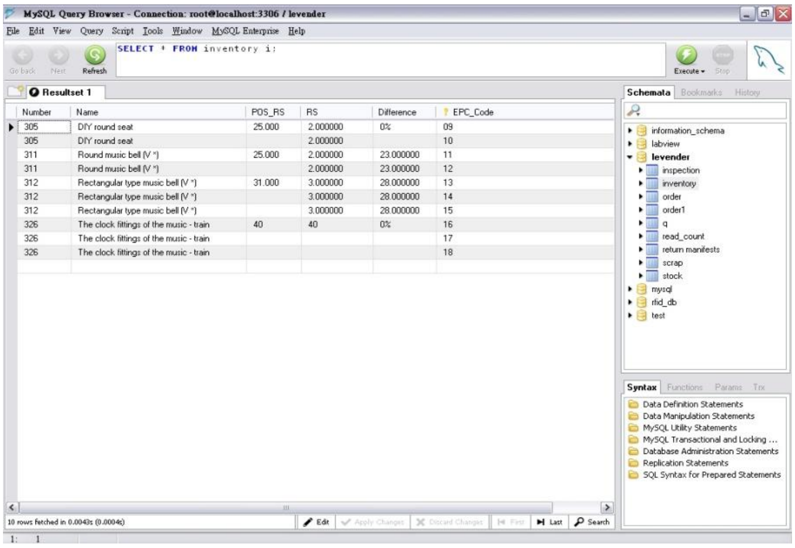


圖 35 MySQL 盤點後存貨單

MySQL 訂購單如圖 36

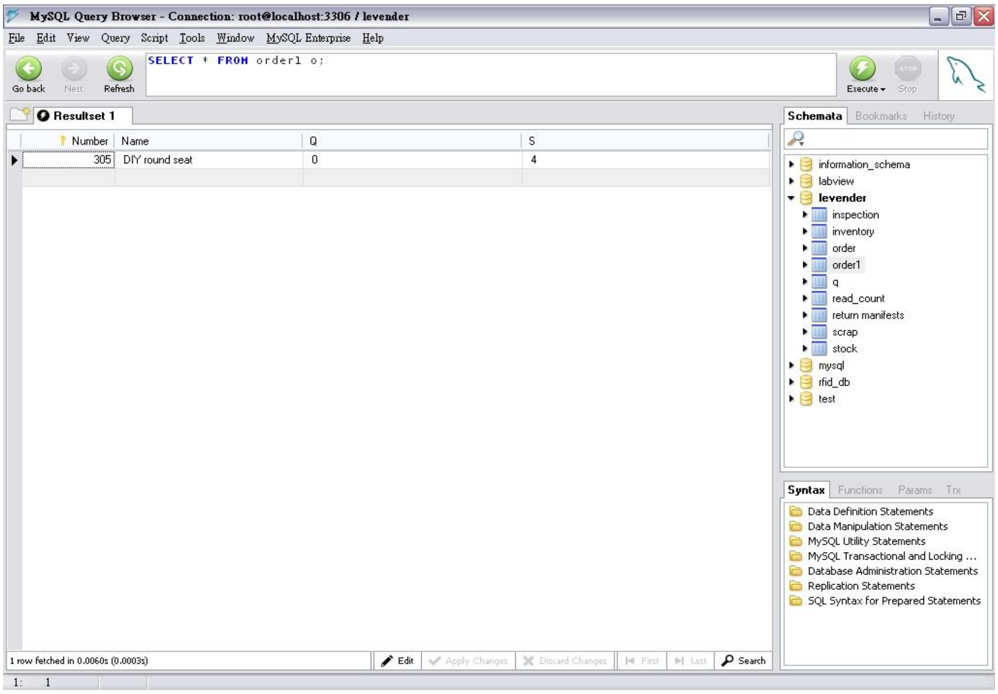


圖 36 MySQL 訂購單

第5章 被動式 RFID 定位盤點暨補貨系統 PARFILO 實作

5.1 實作與現場佈置

使用貼有被動式 Tag 的 10 個箱子，擺放我們預設的位置，再使用前面測試導出的公式去計算其 10 個被動式 Tag 的位置，做 10 次 1 分鐘的讀取次數。2011/4/11 工管大樓 502 室實驗測試，以下圖 37 為實驗場地佈置圖

圖 37 實作場地佈置

5.2 實作座標與精準度分析

NO 1	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	9.694775	101.7784	9.694775	23.22163	25.16411
2	10	25	125	16.19873	96.0819	8.801275	28.9181	30.22778
3	11	50	100	-16.765	107.888	66.76495	7.888	67.2293
4	12	75	125	-18.1117	136.4992	93.1117	11.49923	93.81909
5	13	100	100	17.1591	52.73173	82.8409	47.26828	95.37769
6	14	0	25	68.05515	91.70943	68.05515	66.70943	95.2977
7	15	25	25	-16.765	107.888	41.76495	82.888	92.81558
8	16	75	25	-8.47223	122.0171	83.47223	97.01708	127.9841
9	17	100	25	68.05515	91.70943	31.94485	66.70943	73.96365
10	18	100	50	53.49853	18.00368	46.50148	31.99633	56.44601

NO 2	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	49.99805	71.8467	49.99805	53.1533	72.97313
2	10	25	125	49.99885	73.31308	24.99885	51.68693	57.41499
3	11	50	100	50	0	0	100	100
4	12	75	125	49.99615	66.5307	25.00385	58.4693	63.59129
5	13	100	100	125	0	25	100	103.0776
6	14	0	25	-25	0	25	25	35.35534
7	15	25	25	45.75895	97.35233	20.75895	72.35233	75.27146
8	16	75	25	49.99615	66.5307	25.00385	41.5307	48.47671
9	17	100	25	45.75895	97.35233	54.24105	72.35233	90.42649
10	18	100	50	-25	0	125	50	134.6291

NO 3	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	46.9562	71.98933	46.9562	53.01068	70.81678
2	10	25	125	48.3393	73.35928	23.3393	51.64073	56.66999
3	11	50	100	12.5	37.5	37.5	62.5	72.8869
4	12	75	125	42.35948	67.42033	32.64053	57.57968	66.18778
5	13	100	100	58.32085	42.11008	41.67915	57.88993	71.33299
6	14	0	25	-25	0	25	25	35.35534
7	15	25	25	12.5	150	12.5	125	125.6234
8	16	75	25	12.5	37.5	62.5	12.5	63.73774
9	17	100	25	58.32085	42.11008	41.67915	17.11008	45.05448
10	18	100	50	-25	0	125	50	134.6291

NO 4	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	49.99805	75.00255	49.99805	49.99745	70.7075
2	10	25	125	49.99805	75.00255	24.99805	49.99745	55.89855
3	11	50	100	49.98615	75.01823	0.01385	24.98178	24.98178
4	12	75	125	49.9959	75.0054	25.0041	49.9946	55.8987
5	13	100	100	47.4808	79.92348	52.5192	20.07653	56.22573
6	14	0	25	-25	0	25	25	35.35534
7	15	25	25	50	100	25	75	79.05694
8	16	75	25	47.4808	79.92348	27.5192	54.92348	61.43203
9	17	100	25	47.4808	79.92348	52.5192	54.92348	75.99246
10	18	100	50	-25	0	125	50	134.6291

NO 5	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	5	34.75743	82.62068	34.75743	77.62068	85.04733
2	10	1	5	46.69285	76.65338	45.69285	71.65338	84.9826
3	11	2	4	87.5	150	85.5	146	169.1929
4	12	3	5	34.75743	82.62068	31.75743	77.62068	83.86598
5	13	4	4	73.90258	60.41095	69.90258	56.41095	89.82519
6	14	0	1	-25	0	25	1	25.01999
7	15	1	1	50	0	49	1	49.0102
8	16	3	1	34.75743	82.62068	31.75743	81.62068	87.58121
9	17	4	1	50	0	46	1	46.01087
10	18	4	2	87.5	150	83.5	148	169.9301

NO 6	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	43.935	78.0278	43.935	46.9722	64.31696
2	10	25	125	46.69245	76.65095	21.69245	48.34905	52.99239
3	11	50	100	67.5105	55.0112	17.5105	44.9888	48.27639
4	12	75	125	34.758	82.61238	40.242	42.38763	58.44766
5	13	100	100	67.5105	55.0112	32.4895	44.9888	55.49378
6	14	0	25	109.2696	96.76958	109.2696	71.76958	130.7314
7	15	25	25	50	37.5	25	12.5	27.95085
8	16	75	25	34.758	82.61238	40.242	57.61238	70.2752
9	17	100	25	67.5105	55.0112	32.4895	30.0112	44.2294
10	18	100	50	50	37.5	50	12.5	51.53882

NO 7	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	46.95928	78.02913	46.95928	46.97088	66.41865
2	10	25	125	48.9491	76.04625	23.9491	48.95375	54.49797
3	11	50	100	12.5	112.5	37.5	12.5	39.52847
4	12	75	125	12.5	112.5	62.5	12.5	63.73774
5	13	100	100	12.5	75	87.5	25	91.00137
6	14	0	25	115.8598	135.9234	115.8598	110.9234	160.3979
7	15	25	25	12.5	112.5	12.5	87.5	88.38835
8	16	75	25	42.36543	82.61325	32.63458	57.61325	66.21406
9	17	100	25	125	0	25	25	35.35534
10	18	100	50	96.74075	107.2821	3.25925	57.28208	57.37472

NO 8	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	34.76058	82.6173	34.76058	42.3827	54.81415
2	10	25	125	46.6936	76.6524	21.6936	48.3476	52.99153
3	11	50	100	74.9995	59.1452	24.9995	40.8548	47.89666
4	12	75	125	34.76058	82.6173	40.23943	42.3827	58.44232
5	13	100	100	75	69.41203	25	30.58798	39.50474
6	14	0	25	75	69.41203	75	44.41203	87.16323
7	15	25	25	75	50	50	25	55.9017
8	16	75	25	-25	112.5	100	87.5	132.8768
9	17	100	25	75	74.91583	25	49.91583	55.82642
10	18	100	50	75	74.60775	25	24.60775	35.07907

NO 9	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	125	49.99075	75.0023	49.99075	49.9977	70.70251
2	10	25	125	49.9987	75.00033	24.9987	49.99968	55.90083
3	11	50	100	40.86253	77.84988	9.137475	22.15013	23.96083
4	12	75	125	20.46495	86.83353	54.53505	38.16648	66.56389
5	13	100	100	58.80043	46.56105	41.19958	53.43895	67.47686
6	14	0	25	125	75	125	50	134.6291
7	15	25	25	20.46495	86.83353	4.53505	61.83353	61.99961
8	16	75	25	47.9269	75.54783	27.0731	50.54783	57.34139
9	17	100	25	87.5	0	12.5	25	27.95085
10	18	100	50	125	75	25	25	35.35534

NO 10	TAG_ID	D_X	D_Y	X	Y	X誤差	Y誤差	第三邊
1	9	0	5	41.49863	83.46028	41.49863	78.46028	88.75895
2	10	1	5	48.30275	76.68488	47.30275	71.68488	85.88522
3	11	2	4	-25	150	27	146	148.4756
4	12	3	5	12.5	37.5	9.5	32.5	33.86001
5	13	4	4	87.5	75	83.5	71	109.605
6	14	0	1	84.88078	56.55693	84.88078	55.55693	101.4461
7	15	1	1	86.3479	88.65083	85.3479	87.65083	122.3394
8	16	3	1	-25	150	28	149	151.608
9	17	4	1	125	150	121	149	191.9427
10	18	4	2	-25	0	29	2	29.06888

圖 38 實作測試數據

誤差平均		
TAG_ID	average X	average Y
9	40.85487	80.03744
10	45.18644	77.5445
11	35.40937	82.49125
12	27.39808	83.01395
13	62.31743	55.61605
14	47.80653	52.53713
15	38.58069	83.07247
16	21.13125	89.18654
17	74.96263	59.10223
18	38.77393	46.23935
平均	43.24212	70.88409

誤差平均	(絕對值)		
TAG_ID	average X	average Y	
9	37.14079	47.43523	
10	24.31518	47.38468	
11	27.81148	55.26032	
12	37.68492	38.46366	
13	49.23917	46.06013	
14	61.6423	43.21558	
15	29.67335	57.33861	
16	41.65476	62.71503	
17	40.2158	44.63839	
18	57.93279	41.0351	單位(cm)
平均	40.73105	48.35467	

第三邊	平均誤差
TAG_ID	
9	65.12681
10	58.74619
11	72.96305
12	64.44145
13	87.34827
14	84.07516
15	74.42003
16	86.75273
17	63.12194
18	83.86803
平均	74.08637

圖 39 實作測試分析結果

第6章　結論

6.1　被動式 RFID 定位盤點暨補貨系統研發意義

- 到各大賣場或便利商店去採買，看到他們的員工在盤點或補貨時，試想若用 RFID 來進行盤點作業流程，是否可以使盤點作業進行更加快速?
- 為了使盤點作業更加精確，確定物品是否存在於貨架上，所以我們決定以這個方向來進行我們 RFID 存貨定位盤點系統的研發，也衡量了各大賣場的貨架擺設間距，用來進行範圍內的使用 RFID 讀取距離定位測試。
- 實驗用以重複測試來抓取實驗的準確性；從實驗可以得知在哪個距離內，可獲得最準確的數據，此數據可用來決定 RFID 天線設置於貨架的哪個距離，可方便讀取，且不會有失誤率，或因為其他因素而導致讀取失敗，故決定擺放 RFID 前須考量許多因素，包括人為亦或是環境因素。
- 可應用於各大賣場亦或是便利商店…等地方，可減少人工逐一盤點的時間，也可大幅降低人力與時間。
- 大賣場之商品品類多達數千種，若是逐一以人工方式盤點，就算速度再快，也必須花上一整天的時間，更何況是在銷售量最多的時候，例如：過年、週年慶...等促銷活動時，進放倉庫的貨一定更多，以避免存貨短缺，也避免讓顧客買不到商品失望而歸，對公司而言，可以增加銷售量，也能避免獲利減少，減少顧客流失。
- 從顧客端開始到供應商，為了確保本身的存貨，其產品的存貨量逐漸增加，造成長鞭效應。為了使長鞭效應降低，利用 PARFILO 系統，隨時監管倉庫內剩餘之庫存量，並及時計算商品是否小於等於再訂購點(ROP)，可便於管理者即時透過 PARFILO 的存貨補貨系統顯示的結果，隨時進行補貨的決策。

- 供應鏈具有不確定性且難以控制，主要原因在於顧客需求的變化，因此不易預估訂單需求量的變動。使用 PARFILO 的存貨補貨系統，不一定需要大批量的進貨，根據需求量變化，調整每批進貨量，減少因為需求量的變化，所造成存貨囤積及降低缺貨風險。

6.2 RFID 實施前後效益分析

表 5 RFID 實施前後效益分析，參考(圖 9)、(圖 10)、(圖 11)

	現行人工盤點及進補貨作業	使用 PARFILO
效益分析比較	需歸類方可盤點	不需歸類
	盤點資料需自行整理統整	資料自動整理統整
	需比對先前資料	自動比對顯示
	需找到商品位置	可由螢幕顯示商品位置
	固定時間盤點與補貨決策	隨時盤點、隨時進行補貨決策
	人工 Key in 訂購商品於訂購單	直接新增訂購資料於訂購單上
	裝箱商品需開箱盤點商品及數量	無須開箱 RFID 掃描商品及數量

<u>PARFILO 效益</u>：

1. **免除盤點前人工歸類作業：**使用 RFID(PARFILO)時，Reader 會自動讀取盤點範圍內所有商品 EPC 標籤數據，故不需人工歸類再進行盤點。
2. **系統自動搜尋定位存貨徹底消除人工找物耗時工作：**PARFILO 有定位功能，因此尋找商品時可以由座標上搜尋到，不需在眾多的商品中尋找所需的，大量節省人力。
3. **自動及時登錄盤點結果資料：**使用 PARFILO 時，所得到的商品資料會自動整理好顯示在螢幕上，就不需要手寫並一一鍵入電腦裡，達到省時省力的效果。
4. **系統自動複盤差異量：**系統使用 PARFILO 時，資料讀取整理完後，會自動跟表單上的數據做比對，不需人工再逐一比對，可減少錯誤率發生
5. **隨時自動提出補貨建議：**針對即時盤點後的商品存貨量，自動判斷是否需要進行補貨。
6. **自動清點進出貨商品：**利用 PARFILO 在商品進出貨時，自動清點商品數量。

PARFILO 附加價值：

1. **即時防盜**：可在第一時間確認商品是否售出、是否置於貨架上，便於抓竊賊。
2. **歸位錯放商品位置**：可發現商品放置於錯誤位置，方便人員整理。
3. **隨時自動盤點**：可在任何時間盤點商品，隨時得知商品的存貨狀況，只需要操作一分鐘後，即可獲得商品的最新資料。
4. **遠端操控不需至現場盤點**：透過遠端操控就可以進行商品盤點及獲得最新庫存資訊。
5. **協助消費者找尋商品**：使消費者便於尋找某項商品的擺放位置。
6. **即時分析銷售狀況**：盤點系統隨時盤點，以便於獲得最新的銷貨狀況。
7. **避免缺貨**：隨時盤點，在任何時間都可得到最新的存貨資訊，即時補貨。