應用系統工程與RFID技術於養生館服務管理系統之開發

管志宏[1]
[1]僑光技術學院工業工程與管理系助理教授
[1]E-mail: jhkuan25@ocit.edu.tw

摘要：本研究的目的是應用系統工程與RFID技術建立一套服務管理資訊系統，服務管理資訊系統包括營運收入、營運支出 、服務計時與帳戶餘額查詢、管理相關之統計與分析等四大部分，本研究分兩階段執行，第一階段應用Delphi軟體技術以及SQL資料庫建立管理系統，第二階段加入RFID技術於客戶消費記錄管理與查詢提升管理效能。系統開發應用系統工程手法與Delphi軟體技術。系統工程程序包含了需求訂定、概念設計、初步設計、細部設計與發展、後勤支援和維修，應用系統工程手法整合Delphi軟體技術，可以使得以低成本且符合顧客需求來開發新的產品，Blanchard 和Fabrycky的程序應用在本產品的開發上，其中包括需求分析、功能分析、功能配置和系統設計。服務管理資訊系統中的營運收入等四大部分，在本研究中均已開發完成並協助委託企業上線使用兩年，系統功能穩定，開發的功能完全符合顧客需求。

前言

研究背景：科技，是創造全球進步的原動力。自人類歷史以來，創造並累積了無數的科技，尤其是工業革命以後，科技的成長轉變更加劇烈；近年來，更是呈現知識爆炸的情形，已成為一個「資訊時代」；不僅是科技，社會以及企業都更加複雜，資訊的流動帶來了全球化的系統不斷複雜化，組成的元件緊密的連結，任何一個環節的錯誤都有可能帶來全面的失敗，因此整合各個方面的科技與知識並加以管理分析是現在必然的趨勢，唯有以系統工程的手法，整合所需的所有不同類別的科技，同時按照其程序管理與分析才足以應付目前所面臨越來越複雜的各種問題與需求以及有效利用越來越珍貴的資源。

系統工程是一種各學門間之處理方法包含以完整技術的努力來發展、確認一組與系統相關之人、產品、程序且經整合與考量生命週期平衡及滿足顧客需求之方案。在系統工程概論[1]中指出系統工程是一種確定系統的程序，運用這種程序來完成下列工作：

(1)使用功能分析、綜整、最佳化、定義、設計、測試評估等重複程序，將作業需求轉變為系統效能參數(System performance parameter)與所發展系統結構的說明。

(2)整合有關技術參數，保證一切物理，功能的通用性，以及計劃交互層面的配合，使總系統的定義與設計最佳化

(3)將績效生產性可靠率維護率操縱度與其他專門技術加以整合成為總工程工作。

系統工程是一種綜合管理與工程的學術，不是一種單純工程學。實際上，系統是一連串的程序，從消費者需求的確定，與工程師的設計、建造、以及企業家的生產以及最後到消費者的使用。

對於整個系統的生命週期，根據 Blanchard and Fabrycky 在 Systems Engineering and Analysis[2]一書中指出，可分為需求、概念設計與初步設計、細部設計與全型開發、生產組裝、產品使用、產品維修、淘汰與回收等。每個程序都包括一連串的步驟，在系統的生命週期中根據邏輯推進其最終目的在如何發展成一種最經濟有效的產品或系統。系統工程要求很多工程與管理專家的合作與共同努力，始能發揮整合科技的效能，完成真實世界所需的複合系統。2005 年 Hitchins[17]提出簡單也較為精簡的系統工程定義，此定義不像先前的定義僅侷限於航空產業，此更貼近於商業使用的定義更能令大家所採用，稍後 Hitchins 提出更為實用五個層次的模式的概念而傳統的系統工程是屬於第二層。Sheard and Lake[18]也將系統工程的標準與模式 MIL-STD-499B 和 EIA-IS 632 做了清楚的比較與分析，這份資料仍廣為澳洲與各界學者所採用。

需求分析在系統工程扮演重要角色，Darke 和 Shanks[19]提出以顧客觀點作為需求分析工作上的基礎，說明當用於系統需求時，觀點可以表示待開發的系統、系統的子系統，以及可能影響系統必須做什麼的系統環境中的系統，觀點組織為層次結構，以提供一種範圍並引導出整體的分析過程。Ross [20] 在 20 世紀 70 年代提出結構化分析方法，以圖形並採用一種層次結構方法運用至一系列模組化的藍圖，逐步求精直到找出解決方案為止。Yourdon [21]、De Marco [22]、Rumbaugh [23]、Shlaer 和 Mellor [24]則分別提出在需求概念定義上，用各種不同方法，例如層次結構、封裝、數據流程圖、狀態轉換圖、信息關係圖來表現功能、流程、實體、和事件。Elizabeth, Ken, 和 Jeremy [25] 探討了需求工程中可追蹤性的建立，以及捕獲可追蹤性的方法和能夠根據可追蹤性所導出的指標，透過這些文獻可以了解目前學術界關於知識管理結合系統工程理念之研究。

創新、速度、價值與全球化為中小企業升級轉型，創造新競爭優勢的動力。在競爭激烈的市場中，由於技術的快速改變，使得產品生命週期縮短同時產品市場也轉變為世界性的市場，如此使得產品創新開發工作更顯得重要。運用系統工程與管理於中小企業營運系統架構與產品創新開發架構之建置，以符合顧客的需求。因此，運用系統化思維，重整企業經營架構，提升效率、相互協調與支援，共同創造新的企業價值，將是未來產業趨勢。企業唯有不斷學習更新的觀念與手法，才能確保企業內部在不同的階段跟時間皆能掌握企業整體的目標和需求，維持企業生存與發展。

同時，另一種新科技－無線射頻辨識系統，也是世界各國所重視並積極發展與應用；根據 CNET Taiwan(2004)[3]科技資訊網中字彙寶典指出無線射頻辨識系統（RFID，Radio Frequency Identification），以下簡稱為 RFID，是一種先進的無線辨識技術，透過商品上的微晶片「標籤」，可以將資訊連至電腦網路裡，用以辨別、追蹤與確認商品狀態。劉澄昇等(2004)[4]指出 RFID 整體運作架構可分為四個主要的元件包含標籤(Tag)、讀取器(Reader)、天線(Antenna)以及後端的電腦系統。

關於 RFID 運作原理莊宜樟(2004)[5]指出標籤與讀取器採用偶合方式動作流程如下：

(1) 由讀取器發射 RF 訊號

(2) 標籤接收讀取器所發出的 RF 訊號，將此訊號轉換為直流電壓，以供給標籤能量

(3) 當標籤達到足夠能量後，讀取器會傳輸資料訊號到標籤

(4) 當標籤接受到資料後，將資料解調出來，解調後資料用來控制標籤中數位電路的操作標籤將處理過的資料或原先被儲存於標籤裡的資料傳回讀取器，讀取器接收資料後，便傳給讀取器的控制單元處理。同時於帝商科技網[6]中提到 RFID 系統具備以下的優點：

(1) 體積小

傳統的磁性條碼受限於體積，不易嵌在較小的物品上，RFID 則不然。日立（Hitachi）甚至已經發展出厚度僅有 0.1mm、面積為 0.4mm X 0.4mm 的微型 RFID 晶片，薄到可以嵌入紙幣中；因此 RFID 的迷你體積可以隱藏在各種物品裡面。

(2) 主動式提供資訊

仗著無線通訊的優勢，RFID 具有主動提供產品資訊的功能，因此運用於消費市場中，客戶不需要抵達櫃台即能結帳；甚至，當客戶推著推車在賣場移動時，賣場中的感應器便會自動統計推車中商品的售價，當商品即將售完，還可以自動通知商家補貨。

(3) 容量、速度與安全性

RFID 除了儲存的資料量遠比傳統條碼多、不容易被偽造外，辨識讀取速度每秒可達 250 個標籤，這種多工成效遠比傳統條碼一次掃瞄一個（單點連線流程，line-of-site）高得多，自然可以免除前述的困擾。

(4) 耐久性

一般傳統紙製或塑膠材質的條碼有時會因下雨、或潮濕的環境，及搬運的過程中遭致毀損而難以辨識。RFID 具有可重複使用數十萬甚至數百萬次以上的特性，其材質也能夠被放置於較為惡劣的環境中，因此比條碼更具有耐久性，自然成本也較為節省。

RFID 的應用已多樣化，利用其特性與優點，可與其結合應用的範圍非常廣泛，醫療、食品、安全、管理…等各行業，都已經有許多人投入研究，在國外許多公司已用來做製程管制(彈性製造、外包）、供應鏈管理(物流中心、運輸、訂貨、退貨）、倉儲管理(庫存、備份件)等，RFID 更使得當今之企業資源規劃(ERP）、條碼和自動化技術有更高層次之改善,Chappel 等人[7]研究應用 RFID 技術於製造程序上,可獲得至少 8%之投入成本。Chappel 等人之另外一份研究報告[8]指出應用 RFID 技術來解決庫儲不準確的問題，如 Dong Li , Ou Tang , Christopher O’ Brien[9]等人提出將此技術應用於食品供應鏈的追蹤，對於新鮮度非常重要的食品，針對其出廠、上架的時間以 RFID 技術追蹤，並依照時間自動調整價格，同時滿足顧客的權益也減少了廠商的損失。Konrad Lorincz, David J. Malan[10]等人也構思一套應用 RFID 的醫療系統－緊急處理的感應網，利用 RFID 追蹤技術，掌握院內重症病患的行蹤，以及其病歷、主治醫師、醫療情形等與病人相關的資訊，以便於當病患有緊急情形時，可把握黃金的救援時段，即時處理。J.H. Kuan、C.K.Chung、G.L. Lai[11] 應用教育部產學案完成 RFID 系統與門禁系統之整合,開發一套中介系統與現有市售門禁系統結合，來提升其系統安全的效能。此門禁系統，由於每輛車內均配有電子標籤而使得入口

大門可以自動開啟，開啟的同時也可將資料庫內之車籍資料與利用數位攝影機拍到的畫面同時顯示在螢幕上，並進行檢核比對。此系統也完成了可靠度測試，此系統已實際安裝於台中市北屯區錦繡中國社區進行實地測試，管志宏、何岱鑫[12]在現場實地測試過程中發現訊號與介面傳輸距離的問題，造成系統的訊號不穩定，修改系統的網路設計使得系統穩定的運作。J.H. Kuan、H.C. Chang、C.K. Chung [13]，配合中科院航空研究所專案管理的要求，應用 RFID 開發完成文件管理系統，應用此文件管理系統可有效管理與追蹤專案計畫所擁有的各類文件，提升專案單位的管理效率。在利用 RFID 技術來定位方面，Ni, Liu, Lau and Patil [14] 應用主動式 RFID 建立位置感測雛型系統，其測試結果顯示，供應商需協助解決使用上的三個主要的問題；電子標籤應直接提供信號強度、標籤追蹤有較長時間的延誤和電子標籤間性能的變異，方能在不斷成長的市場上競爭。Chen, Chiang, Chu, Huang, and Tsui [15]也應用 RFID 技術來減少因環境因素所引起的位置定位準確度問題，J.H. Kuan、G.L. Lai、Y.S. Wang [16] 配合社區管理的需求，應用系統工程的手法進行，需求分析、功能分析與配置，並搭配使用 Delphi、SQL 資料庫、Zigbee 與 Visual Studio.NET 以無線傳輸方式和電波訊號強度解決網路安裝與不規則停車場區域定位問題，成功發展一個包括門禁控制系統與車位管理系統的整合系統，自動管制汽車的進出與停車是否依規定停放，可以減輕管理員之工作負荷與避免疏失。 管志宏[25]配合顧客批量生產線要使用 RFID 追蹤製造令的需求，應用系統工程的程序搭配使用知名系統工程軟體 CORE，不但能節省 30%的系統開發成本，更能在上線使用後，快速滿足顧客的需求。Mark Roberti[26]認為下一代的 RFID 技術將帶入更高層次的功能，將過去做不到的事情變為可能，美國軍方及 NASA(太空總署)分別支持「RF Controls」及「Mojix」兩個公司進行研究，前者正在祕密進行 ITCS（Inventory Tracking and Control System，庫存追蹤與控制系統）的發展，其主要的目的是應用航太科技之「束導向相列天線，beam－steerable Phased-array antennas」，來進行電子標籤的 3-D 定位，此天線又稱「Smart 天線」是一個敏感的接收器，包括了一個陣列天線，一個 EPC 取器，一個高功能控制器及一個訊號處理器，可使用比傳統 RFID 系統較少的 RF 能量，並有較遠的距離，更能改善不利於傳統 RFID 系統之貨架材料(例如：金屬或液體)並能濾除雜訊，利用區域法(Zonal approach)於電子標籤的定位。NASA 支持 Mojix 公司發展的 STAR(Space Time Array Reader)具有類似功能，有效在範圍更高達 10 萬平方尺的空間以被動式的電子標籤定位，其精度可達 1 尺以內。ITCS 及 STAR 的開發目前均在選擇的倉庫內祕密的進行實地測試。John Edwards[27]強調 RFID 技術不只是幫助企業更有效率的運作，同時亦能保護環境，在美國費城(Philadelphia)的 Recycle-Bank 公司，以 RFID 技術提高該市的廢棄物回收率，該公司藉著提供一個有 RFID 電子標籤的回收筒追蹤每個家庭的回收。回收車在收取時會將回收重量透過電子標記錄於車上電腦，當回收車返廠時，再以無線網路將重量存至資料庫，Recycle-Bank 啟動此計畫，希望在 2008 年能將公司業務提昇 3 倍，此做法經統計可使得參與的家庭每戶平均有每週 8 元的收入(回收的越多收入相對增加)，更可使得市政府節省垃圾掩埋場地的花費，對參與的家庭、Recycle-Bank 公司以及市政府三方面均獲益的三贏策略。

研究目的：本研究的目的是應用系統工程與 RFID 技術建立一套服務管理資訊系統，服務管理資訊系統包括營運收入、營運支出 、服務計時與帳戶餘額查詢、管理相關之統計與分析等四大部分，本研究分兩階段執行，第一階段應用 Delphi 軟體技術以及 SQL 資料庫建立管理系統，第二階段加入 RFID 技術於客戶消費記錄管理與查詢提升管理效能。系統開發應

用系統工程手法與 Delphi 軟體技術。系統工程程序包含了需求訂定、概念設計、初步設計、細部設計與發展、後勤支援和維修，應用系統工程手法整合 Delphi 軟體技術，可以使得以低成本且符合顧客需求來開發新的產品，Blanchard 和 Fabrycky 的程序應用在本產品的開發上，其中包括需求分析、功能分析、功能配置和系統設計。服務管理資訊系統中的營運收入等四大部分，在本研究中均已開發完成並協助委託企業上線使用兩年，系統功能穩定，開發的功能完全符合顧客需求。

系統工程方法與物件導向程式設計

系統開發流程：本研究主要使用之方法包括：(1)以系統工程與管理的方法來進行產品架構需求分析、功能分析，有效分析顧客需求和產品開發間之關聯性，萃取擬出必要性及可行性需求，做為進行系統規格之擬定及產品設計的基礎(2)在系統工程程序的建構上，將使用 Vitech 公司發展之 CORE 軟體可收事半功倍之效，(3) 以 Delphi 和 SQL 資料庫來作為發展中介軟體的工具。除了上述方法外，還特別融入「系統工程」所強調的下列要求：(1)使用由上而下的開發方法(2)強調生命週期的觀念，如圖 1 所示。

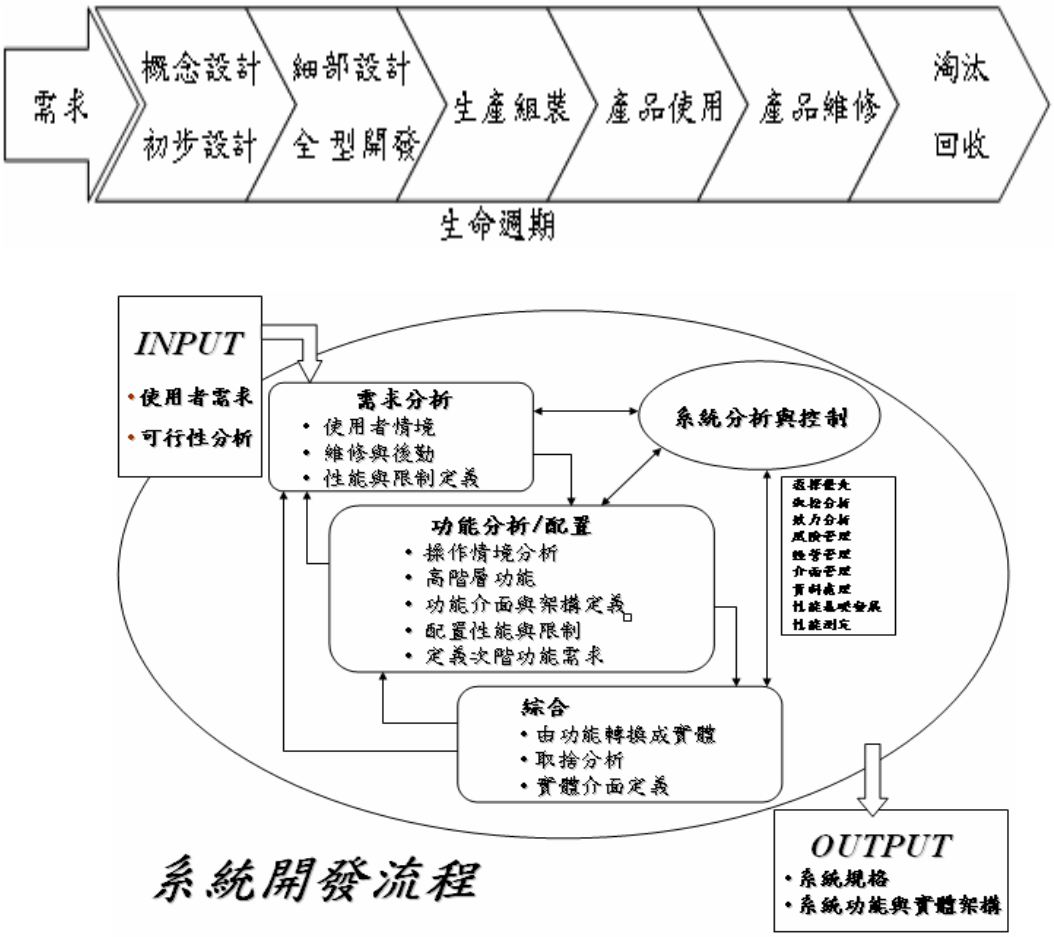

圖 1 系統開發流程圖

Vitech 公司 CORE 軟體之應用：依據國際系統工程學會(INCOSE)，所完成有關系統工程與管理工具軟體，需具有可追蹤性原始需求，使系統工程師能與顧客的需求來源連接並且能提供在系統開發時與後續需求文件間之可追蹤性。由 INCOSE 所建議的相關軟體中 CORE [9]為較優軟體之一。CORE 軟體的主要功能包括：整合系統設計的知識庫、系統定義的語言（SDL)、動態繪圖顯示產生功能、文件自動產生功能等。

物件導向設計軟體之應用：以 Delphi 和 Access 資料庫來作為發展中介軟體的工具，本計畫所設計之系統利用以下之資訊技術：採用視覺化的程式設計工具、視窗化的人機界面、多層架構式程式設計及利用企業網路/網際網路等資源。視窗作業系統與其應用軟體提供多工的操作環境及友善的使用者介面，已成為目前資訊系統前端作業平台的主流。開發視窗軟體的程式語言及工具，也配合這種趨勢有了重大的變革。開發程式的物件包括：整合性的開發環境、視覺化的畫面設計、物件導向的程式設計等功能。在視覺化的畫面設計方面，我們開發程式是使用目前最普及的，由 Borland 公司所發展 Delphi 開發工具，所提供的各類設計元件直接加到表格中，作為設計使用者操作介面及與資料庫連結、運算等功能。其中兩個主要的設計方式為物件導向程式設計與多層架構的程式設計。

建立系統的 Behavior Model

本系統主要是用於計時制的服務業，例如腳底按摩養生館、美容護膚 SPA 養生館等，主要有四個組成部分，營運收入、營運支出 、服務計時與帳戶餘額查詢、管理相關之統計與分析，營運收入主要是輸入顧客來店的服務項目、計算消費金額、收費方式、RFID 收款儲值及啟動服務倒數計時，確保服務品質，服務完成後由系統紀錄收費金額（或從 RFID 儲值卡扣除)、計算服務人員收入，營運支出部分包括服務用品採購支出、服務人員薪資支出，服務計時與帳戶餘額查詢部份，包括配合不同服務項目在服務人員服務之前已 RFID 電子標籤感應啟動倒數計時並將服務項目列入工作紀錄、顧客可隨時在服務櫃檯查詢 RFID 儲值卡內餘額，其它與管理相關的統計分析包括查詢某段時間服務人員的工作紀錄、顧客來店的消費紀錄、顧客來店消費的優惠紅利、久未來店消費的顧客名單查詢等功能。

本系統主要任務有：應用 RFID 電子標籤來儲值可有效提高管理的效率，尤其該行業是論件計酬，每天均需統計服務人員的收入，以及營業額，每半個月發餉一次，而且在業務繁忙時人力不足的情況下常需臨時聘請支援師傅，酬勞計算方式根據師傅的服務經驗而有所不同，使用資訊科技配合 RFID 的技術對管理效率與服務品質的提升有相當大的助益。本系統必須每天提供即時協助給使用者、必須做到下列事項：(1)使用者的環境必須要具備區域網路(2)使用者必須是在室內使用且必須要有放置電腦及安裝 RFID 讀取器及數字顯示器的位置。根據 Blanchard[2]所定義的需求，經常思考下列的問題：(1)預測需求的型式和數量為何?(2)上列的元素（element）要放在何處?(3)要如何使用這個系統，要使用多久?(4)使用這個系統的環境為何? (5)要如何維持這個系統?誰來維持?要維持多久? 需求必須完整的描述使用者的需要（Need)，這些需求應該列入系統設計的目標而且一定是可量測與可展示的。需求包括：反應時間、特殊狀況的考量、MTBF、MTTR、可用度。

圖2說明系統需求的轉換與規範的形成，圖3為系統需求樹狀階層圖。根據系統操作需求，進行功能分析，在系統工程所謂的功能是指以特定的行動（可以是單獨或一連串）達成需

求的目標，本系統必須能執行開啟PC後自動起動服務管理系統，系統必須在2秒內回應使用者的輸入；本系統必須能在10公尺以外的讓使用者輸入使用者身份並啟動時間倒數顯示；本系統必須能儲存/更新顧客儲值資料與營運資料，並能計算營收與員工薪資等相關資料；本系統的MTBF必須在符合8760小時，MTTR是24小時，必須在一小時內能恢復系統正常運作。

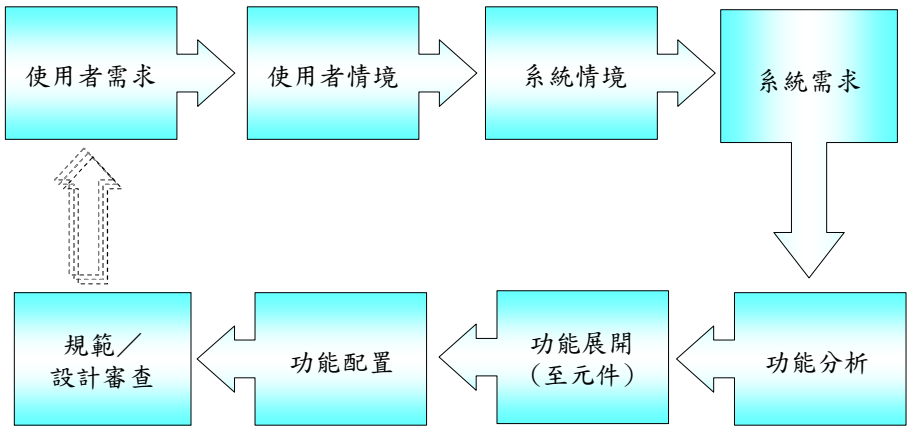

圖 2. 系統需求的轉換與規範的形成

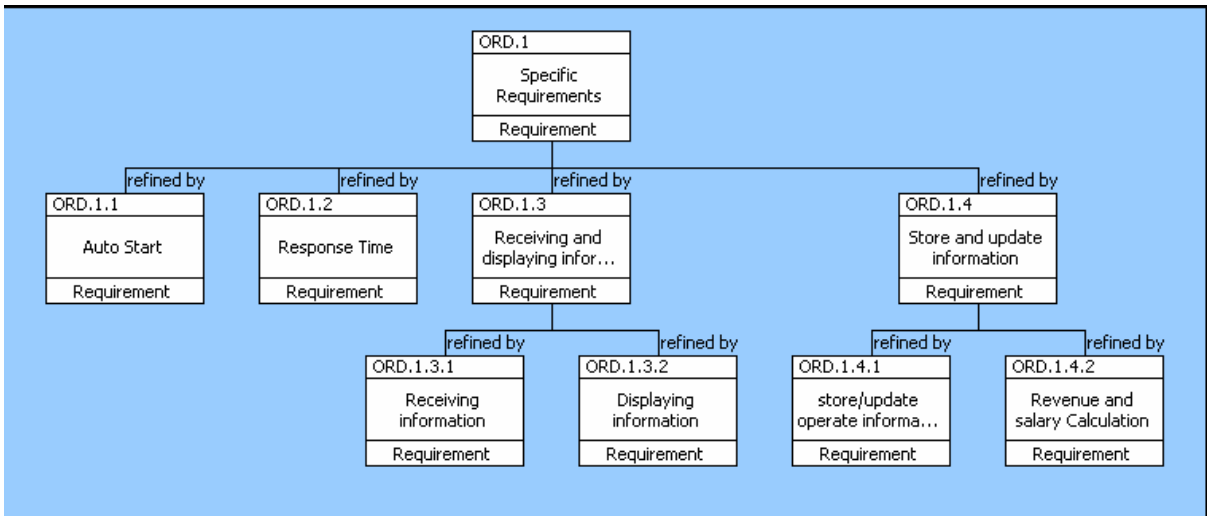

圖 3. 系統需求樹狀階層圖

圖 4 為系統第 1 層的功能流程方塊圖（FFBD），在正常使用情況下，RS232 網路轉換器（Converter）和數字顯示器必須維持開機狀態，且在電腦開機後需開啟養生館管理系統軟體，前述的四個主要功能在正常運作時需則一啟動，圖 5 為系統第 2 層的功能流程方塊圖（編號 5 部分），表示在收到非會員（Client）與會員（Member）的服務需求後，系統會根據輸入的服務項目計算應收帳款與服務時間並指定服務人員，服務人員在開始服務時以其專屬電子標籤感應 RFID 讀取器啟動倒數計時顯示器，系統會自動將該服務人員之工作記錄存檔，服務完成後，系統輸入非會員所交付的現金，而會員則交付 RFID 儲值卡感應 RFID 讀取器透過系統扣款。CORE 軟體也提供 N2 圖說明各功能間之資訊流（data flow），圖 6 系統對應圖 5 之 N2 圖。

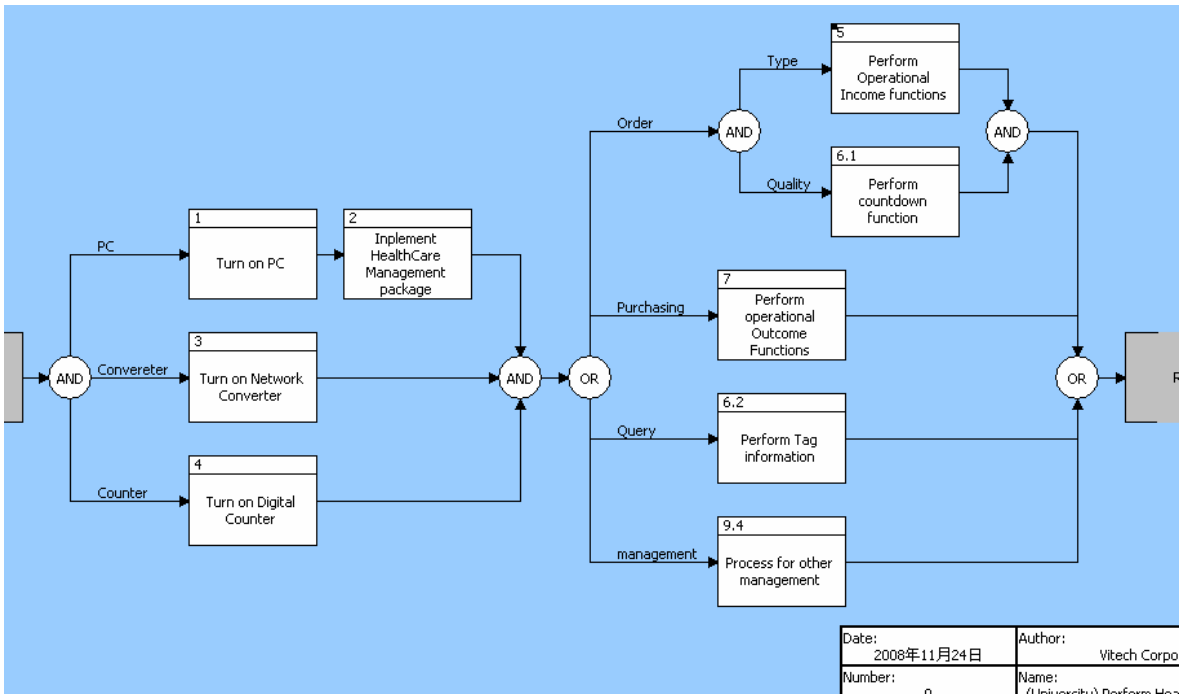

圖 4. 系統第 1 層的功能流程方塊圖

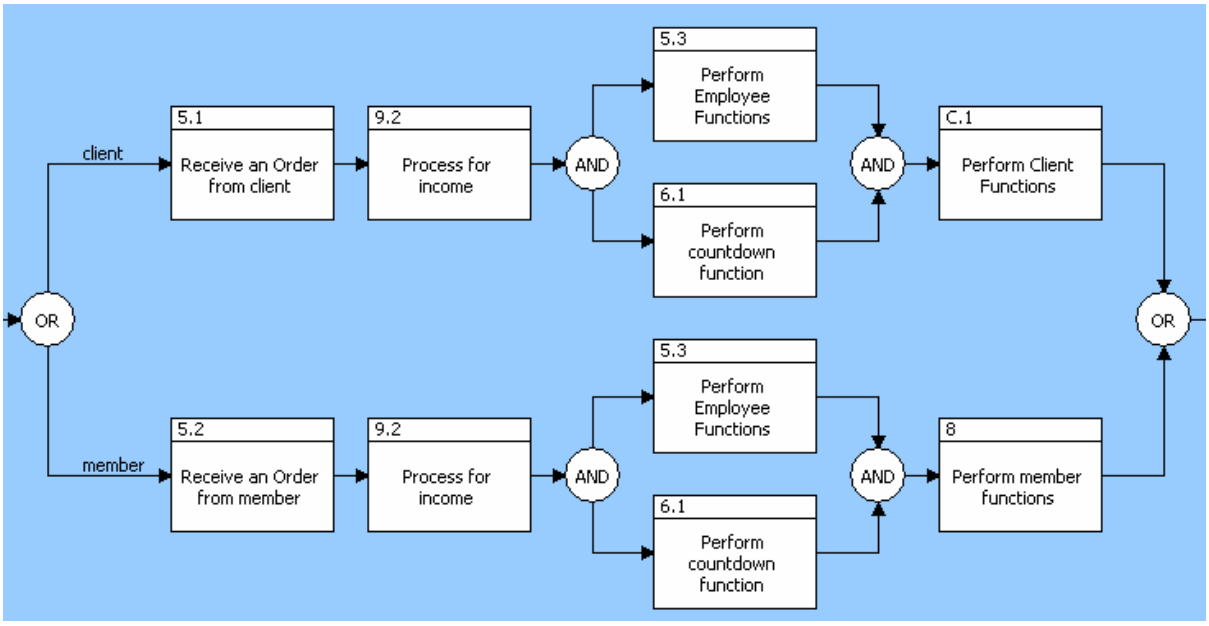

圖 5. 系統第 2 層的功能流程方塊圖（編號 5 部分）

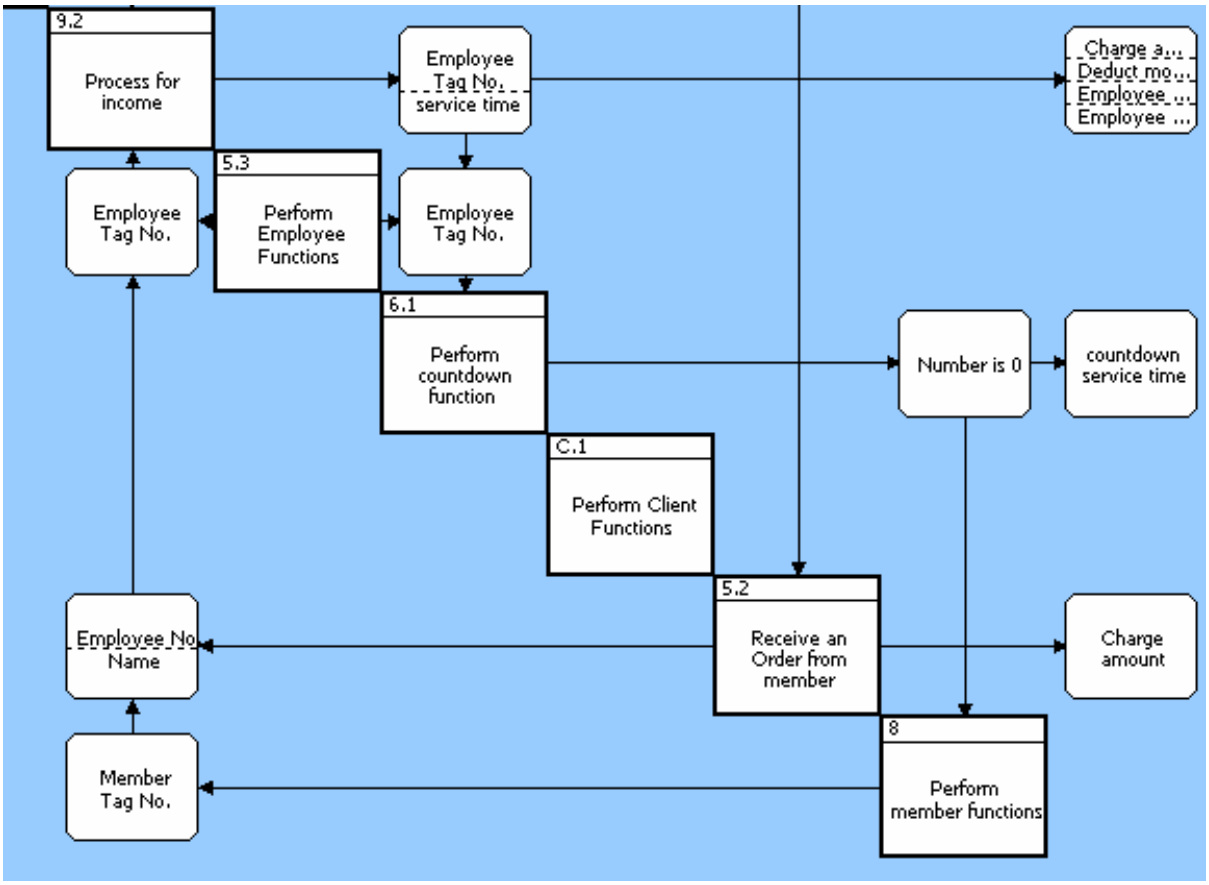

圖 6. 系統對應圖 5 之 N2 圖 N2 圖

系統工程的方法除了針對所要設計的系統功能進行分析外，對於所處環境也必需加以瞭解，本系統以外之元素（Element）還包括非會員顧客（Client）、建築物、手機基地台、區域網路（能連接網際網路），這些圖所顯示的功能分解是根據美國NTIS（National Institute of Standards and Technology）與FIPS PUB 183（Federal Information Processing Standards Publication 183）規定編纂，可清楚顯示功能分解與各功能之輸入、控制、輸出與機制（ICOM：Inputs, Controls, Outputs, Mechanisms）。

建立系統的 Physical Model

在完成需求分析與功能分析後，可利用CORE軟體建立需求vs.對功能的樹狀圖，確保系統的每項需求都有對應的功能來達成，在完成所有的功能項目後就可進行功能配置並完成硬體的設計，圖7為系統硬體樹狀圖，圖7-1第1層與第2層SYS.1.3的展開，圖7-2第1層與第2層SYS.1.2的展開，圖8為系統硬體間之關聯圖（Physical Block Diagram），為了能確保系統從原始文件到系統需求、功能、硬體間相關連性，應用CORE軟體完成由原始文件至硬體架構之追蹤體制圖如圖9所示，圖10為本系統之實體安裝說明圖。

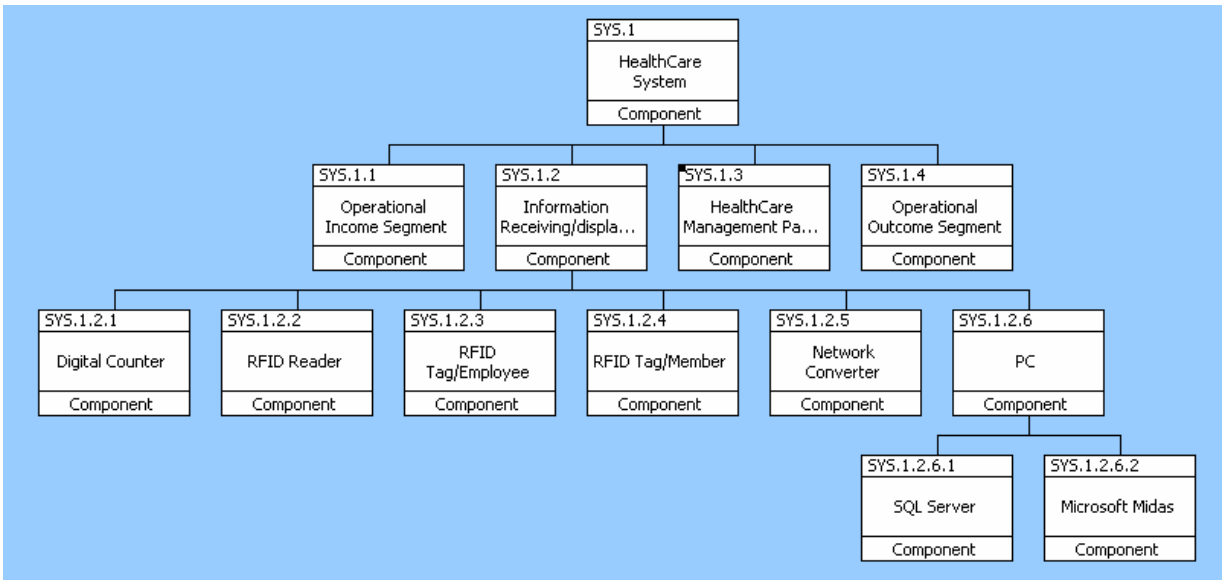

圖7-1 系統硬體樹狀圖（第1層與第2層SYS.1.3的展開）

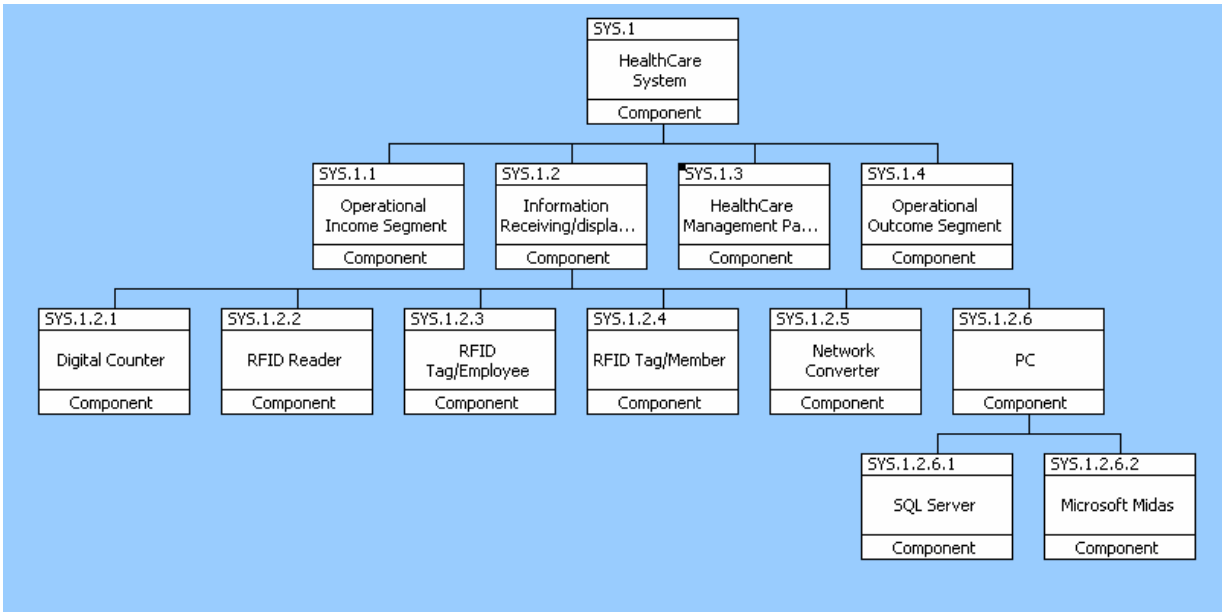

圖7-2 系統硬體樹狀圖（第1層與第2層SYS.1.2的展開）

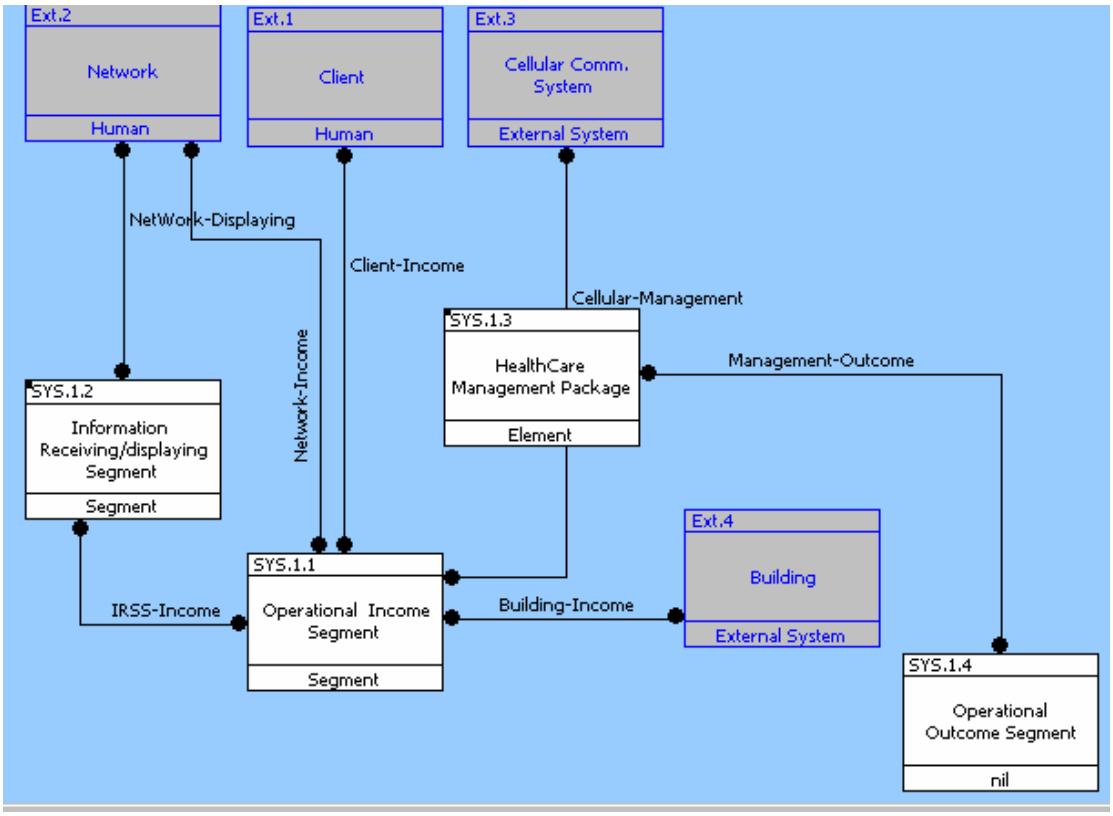

圖8　系統硬體間之關聯圖（第1層Physical Block Diagram）

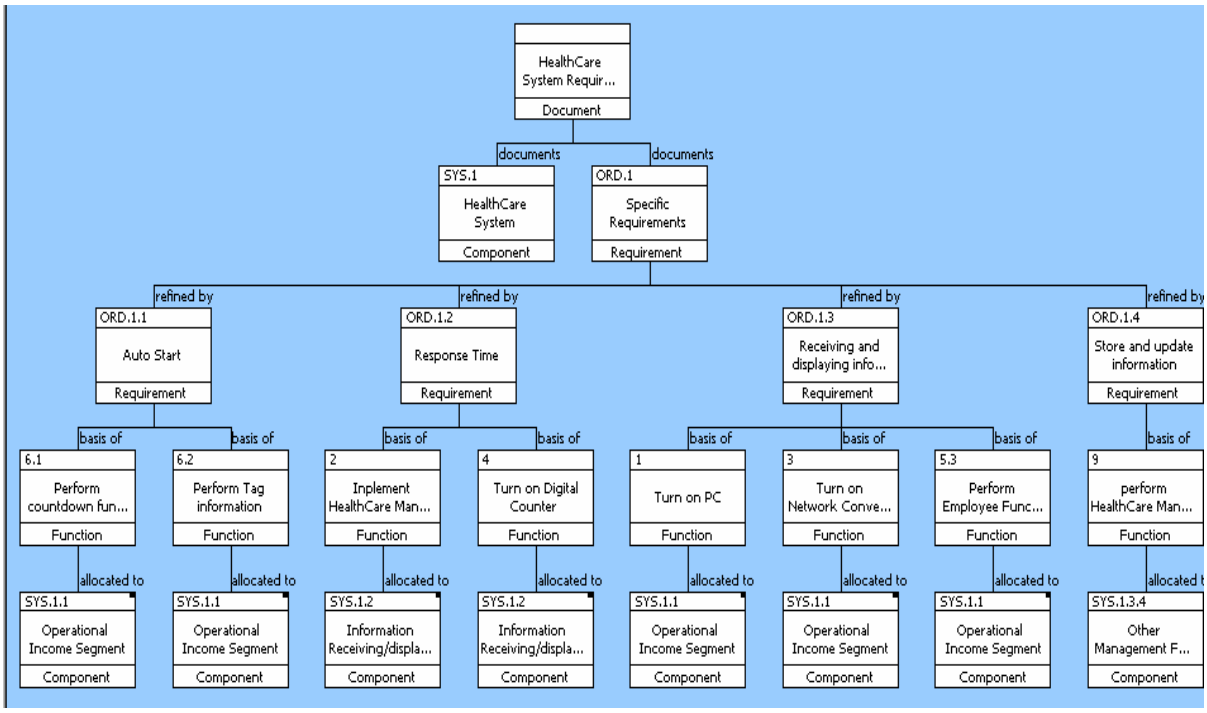

圖9　原始文件至硬體架構之追蹤體制圖

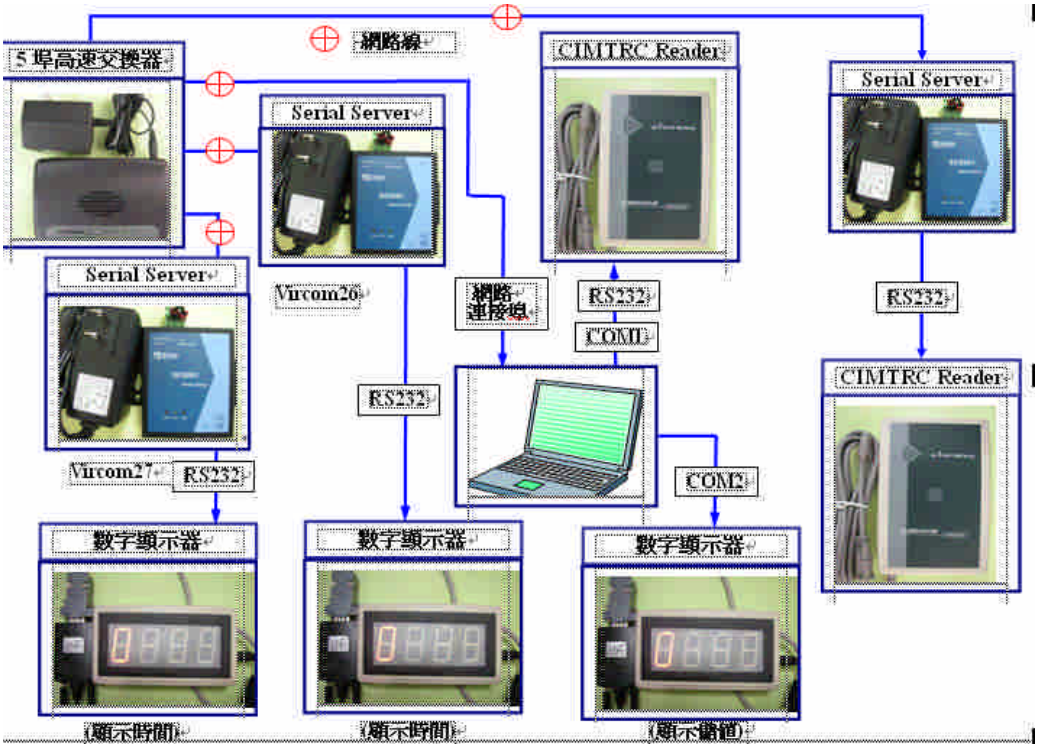

圖10　系統之實體安裝說明圖

結論

本研究應用系統工程的方法配合 Vitech 公司的 CORE 軟體，能將工作的時間縮短 50%完成系統的分析，其中包括 13 項操作需求，再根據需求訂出 24 項關鍵功能，完整建立系統功能配置細部設計所需的資訊，本研究結果顯示：

(1) 應用系統工程的程序能夠使得在分析新系統時，先由包含環境、外界系統及本身系統之概念架構開始，循序漸進的將需求、功能細分，再以功能配置方法獲得系統軟硬體，可順利得到滿足客戶需求的最佳化的結果。

(2) 使用 Vitech 的 CORE 軟體有助於系統需求與功能匹配的完整性，並藉由 CORE 軟體可從思考功能流程的同時，隨時新增、修改功能流程方塊圖，可快速的完成分析，使設計者與使用者有良好的溝通。

(3) 本研究結果可配合物件導向軟體的應用，進行功能項目制定時，可考量使用適當的表單及元件(元件盤上)配合功能的展開與配置。

(4) 本研究順利完成系統之系統需求樹狀體系圖、功能流程方塊圖、N2圖並將其展開至第三層，此結果可作為系統開發之重要依據。

本研究根據顧客的需求，完成兩個階段所需要服務管理系統，配合服務管理系統的需求以及應用系統工程手法，完成了基本資料、日常作業、營業資料分析等模組的程式撰寫，基本資料包括六個表單，日常作業包括七個表單，營業資料分析包括六個表單，也完成SQL資料庫的安裝，管理軟體的安裝與上線使用，在基本資料方面除了員工及客戶基本資料外也配合顧客需求增加服務項目、付款項目以及收入項目等基本資料的輸入畫面以及配合使用人員習慣的輸入方式，配合服務顧客運作的需要，本系統也擁有日常作業的紀錄與

統計功能，包括客戶購卷消費的紀錄、員工服務紀錄與營業所需的付收款紀錄以及收支統計，另外配合顧客關係管理的需要完成了來店客戶、未來店客戶與客戶購卷消費紀錄查詢功能，配合企業的會計的需求也完成了員工薪資、月/年營業報表，目前本管理系統已依計畫時程正式上線使用，也依企業社服務客戶品質提升的需求，目前本管理系統已依計畫時程正式上線使用年，也依企業社服務客戶品質提升的需求，成功應用RFID技術於客戶購卷儲值與服務時間透明化，同時提高管理效率與服務品質。

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自傳

管志宏.出生於 1955 年 5 月 9 日，1976 年畢業於空軍官校，1982 年獲得德州州立大學（Austin）航空碩士，主修計算流體力學，1982 年進入中山科學研究院參與 IDF 引擎的研發，1987 年獲得科羅拉多州立大學（Austin）航空博士，1998 年負責推動渦輪引擎自立研發，成功發展小型渦輪引擎，1999 年擔任中山科學研究院航研所副所長，2003 年退伍轉任教職， 積極從事系統工程與 RFID 系統之整合研究。

Development of healthcare service management system using systems engineering and RFID technology

Jyh-Horng Kuan
Department of Industrial Engineering and management, Jacob Institute of Technology
E-mail: jhkuan25@ocit.edu.tw

Abstract: The purpose of this research is to apply systems engineering and RFID technology to develop a service management information system, which includes the functions of operation revenue, operation expenditure, service timing and account balance enquiry, and management related statistics and analysis. This research is separated in two stages. In the first stage, Delphi software technology and SQL database are used to develop the management system, whereas in the second stage RFID technology is added in to the customer consumption record management and enquiry system to improve management efficiency. The development of the system is based on systems engineering and Delphi software. The process of systems engineering includes demand estimation, conceptual design, preliminary design, detailed design and development, logistic support and maintenance. Integrating systems engineering with Delphi software technology can facilitate to develop new product at low cost and upon customer's need. Blanchard and Fabrycky are applied in the development of our product, including demand analysis, functional analysis, function configuration and system design. Four main parts in the service management information system, including operation revenue, has been finalized. And we also assisted the enterprise to launch the system, which now has used for two years. The system performs stably and the functions we develop cater the customer's need completely.

Introduction

Research background: Science and technology is the motivation of world. Human beings have created and accumulated uncountable science and technology in the history, especially since the industrial revolution, the growth of science and technology becomes more dramatic. In the recent years, we even see the scene of knowledge exposure and enter into an information age. Not only the science and technology, but also the society and entrepreneur have become more complicated. The flow of information results in more complicated systems worldwide. The components are connected tightly, and a mistake in any segment may lead to a complete failure. Therefore, it is an inevitable trend to integrate, to manage, and to analyze science & technology and knowledge in all aspects. Only by employing system engineering methods, integrating different technology required, managing and analyzing the corresponding programs, can we address more complicate problems, meet more intricate requirements, and deploy the more precious resources in more efficient ways.

Systems engineering is an interdisciplinary methodology to develop and identify a human-product-procedure-linked program by comprehensively involving the complete efforts and technologies developed by different disciplines, which consider and integrate how to balance life-cycle and to meet customer's requirements. According to Introduction to Systems Engineering [1], Systems engineering is a deterministic systems program, which is used in the following areas:

(1) Apply iterative processes including functional analysis, synthesis and integration, optimization, definition, design, testing to translate the need of operation to system performance parameter and the statement of the system structure.
(2) Integrate corresponding technology parameters to ensure the physical and functional compatibility, and the cooperation in the planning interface, so as to optimize the definition and design of the whole system.
(3) Integrate the parameters of performance, productivity, reliability, maintenance ratio, maneuverability into other expertise, so as to format the whole project operation.

Systems engineering is not simply engineering, but a methodology integrating management and engineering. In fact, systems are composed of a serial processes, from the demand estimation, design and construction by engineers and manufacturing to the use of the consumers. As for the life-cycle of the whole system, according to Blanchard and Fabrycky in Systems Engineering and Analysis [2], it can be divided into demand, conceptual design, preliminary design and detailed design, complete development, producing and resembling, use of product, maintenance, elimination and recycle. Each procedure composes a serial procedure; and the ultimate objective of each procedure is to evolve as a most economic and efficient product or system according to the logical flow within system life-cycle. Systems engineering requires the cooperation and efforts from many engineering and management experts, without which it is impossible to bring the efficiency of integrated technology into play, and to construct compound systems required by the real world. In 2005, Hitchins [17] proposes simple and compacted definition for systems engineering, which is not limited in the aircraft product as before and closer to the commercial use. Therefore it is commonly used. Later Hitchins proposes a more practical five-level definition, whereas the conventional systems engineering belongs to the second level. Sheard and Lake [18] also make a clear comparison and analysis between the measurement of systems engineering and MIL-STD-499B and EIA-IS 632, which is still popularly adopted in Australia and other countries.

Demand analysis plays an important role in systems engineering. Darle and Shanks [19] propose that demand analysis should be based on customer's perspective, indicating that when applying to system demand, perspectives could be interpreted into systems or subsystems under developing, or certain systems under the system environment that would trigger the systems to take required reaction. Perspective organization is a hierarchical structure. So it can provide a certain range, and to induct a whole analysis procedure. In 1970s, Ross [20] develops a structural analysis method, which applied graphics and a hierarchical structured method into a series of modularized blueprints, and gradually optimized in order to finally find a solution. Yourdon [21], De Marco [22], Rumbaugh [23], Shlaer and Mellor [24] all develop respective methods to define system demand; such as hierarchical structure, packaging, data flow chart, state transition graph, and object information model were used to define system functions, procedures, entities, and events. Elizabeth, Ken, and Jeremy [25] discuss the establishment and capturing method of traceability in demand project, and the indices that could be derived from such traceability. These papers provide an overview of recent academic research on the idea of the integration of knowledge management and systems engineering.

Innovation, speed, value, and globalization are SMEs' motivation to upgrade and transform, and to create new competitive advantage. In the fierce competition market, due to quick technology evolution, products life-cycles become shorter, and products markets become global markets. Hence the development of product innovation has now become more

important. Application of systems engineering and management to the establishment of SMEs' operation system structure and development structure of product innovation could cater to customer's need. Therefore, it is a future industrial trend to employ systematization conception to reorganize enterprise's operation structure, which would add value to enterprise by enhancing effectiveness and strengthening mutual cooperation and support. Without continually keeping update to new conception and technique, the internal part of enterprise could not take the reins of its whole objective and need in different stage and period, not to mention to survive and thrive.

Meanwhile, another technology – RFID has also been recognized and actively developed and utilized among countries all over the world. According to the CNET Taiwan (2004) [3] vocabulary dictionary, Radio Frequency Identification, or RFID, is an advanced wireless identification technology. Through attached microchip tag, article information could be linked to computer network, and its status could also be identified and tracked. Liu et al. (2004) [3] point out that RFID operation structure could be separated as four main components: Tag, Reader, Antenna, and back-desk computer system.

Regarding to the operation mechanism of RFID, Zhuang (2004) [4] indicates that Tag and Reader work in a coupling manner. The processing flow is as follows:

(1) Reader transmits RF signals;
(2) Tag receives the RF signals, which are then transformed to direct voltage to provide energy to Tag;
(3) When Tag is charged with enough energy, Reader would transmit information signals to Tag;
(4) After Tag receives the information signals, it would demodulate the signals. Demodulated signals are used to control the Operation Tag in the Tag's digital circuit. Operation Tag transmits back the processed information or Tag's stored information to Reader. After receiving the information, Reader would send the information to its control unit to process. Meanwhile, regarding to the RFID system, there are several advantages mentioned by Regal Scan Tech [5] as follows:

(1) The size of RFID is small.

Due to size constraint, traditional magnetic bar code is not easy to be embedded in small articles. But RFID does not have such problem. Hitachi even developed a kind of micro RFID chip, which is only 0.1 mm thickness and 0.4*0.4 square millimeter. Such RFID chip is so thin that it can be embedded in the paper currency. Hence, due to its mini-volume, RFID can be hidden in various articles.

(2) RFID can provide information actively.

With the advantage of wireless telecommunication technology, RFID has the function to actively provide article information. For example, when it is used in the consumption market, customers do not have to pay their bill in the cashier; moreover, when customers are moving their trolleys in the supermarket, the RFID sensors will automatically account the whole article price in the trolleys. And when certain article is sold out, it will also notify the supermarket manager to replenish it.

(3) RFID has advantage in storage capacity, processing speed, and security.

Besides the advantage of more storage capacity than traditional bar code and more difficult to be counterfeited, RFID's recognition and reading speed can reach 250 Tags per second. Such a multi-tag performance is far more effective than traditional bar code, which could only scan one tag in one time (Line-of-site).

(4) RFID is more durable.

Generally, traditional paper or plastic bar code would fail to be identified when it is placed in rainy or moisture environment, or damaged during transportation. But RFID has the reuse property, which means it can be used thousands and millions times. And it can also work in relatively harsh environment. Therefore RFID is more durable than traditional bar code, which helps to reduce cost.

With its characteristics and properties, RFID's application becomes versatile. Many scholars investigate the extensive use of RFID technology, ranging from medical treatment, food, security, management, etc.. Many foreign companies have employed RFID in many ways, to name a few, process control (flexible manufacturing, outsourcing), supply chain management (logistic center, transportation, order, return of goods), warehouse management (storage, backup copy), and so on. In addition, RFID has improved Enterprise Resource Planning (ERP), bar code, and automatic technology to a higher level. According to Chappel et al's research [6], RFID can reduce 8% working capital when it is applied to manufacturing. In Chappel et al's another research paper [7], RFID can be used to address the problem of inventory inaccuracy. Dong Li, Ou Tang, Christopher O' Brein [8] discuss the application of RFID to track food supply chain. Their research showed that it would both meet the customers' interest and reduce manufacturers' loss by utilizing RFID to track perishable products' manufacturing and on-shelf date, and to adjust product price automatically. Konrad Lorincz, David J. Malan, et al [9] also develop a RFID attached medical treatment system - Sensor Networks for Emergency Response, which use RFID-based tracking technology to locate a patient who requires immediate attention, and meanwhile to trace his relevant information such as case history, doctor-in-charge, treatment situation, and so on. Therefore when there is a need for an emergent response, such a technology could facilitate the rescuer to seize the vital time to take immediate on-field medical treatment. J.H. Kuan, C.K. Chuang, G.L. Lai [10] develop an RFID system coupling with the current entrance control system, which was also integrated with a middleware system, to enhance the present capacity of the security system, in their Industry-Academy Cooperation Project sponsored by Ministry of Education. The entrance can be opened automatically by using the new control system because each car having hung the Auto-tag inside the car itself will be checked carefully. The license information can be seen on the screen of the computer by Digital Video and by executing the new software developed in this paper. This new system was completed the reliability test, and also was conducted field test in Jinxiu China Community, North Cun District, Taichung City. In the field test, J.H. Guan and D.X. He [11] discover that the problems caused by signal and interface transmit distant would lead to unstable system signal. Therefore system network design is adjusted to stabilize the system operation. J.H. Kuan, H.C. Chang, C.K. Chung [12] develop a document management system using RFID technology in the project management program sponsored by Aeronautical Engineering Division in Chung Shan Institute of Science and Technology. Using this system, project manager could effectively manage and track various documents in certain project planning, so as to enhance management effectiveness. Regarding to RFID-based locating technology, Ni, Liu, Lau and Patil [14] utilize active RFID technology to develop a location sensing

prototype system. They pointed out that three major application problems that RFID vendors have to overcome in order to compete in a new and growing market: 1) none of the currently available RFID products provides the signal strength of tags directly; 2) the long latency between a tracking tag being physically placed to its location being computed by the location server; and 3) the variation of the behavior of tags. Chen, Chiang, Chu, Huang, and Tsui [15] also use RFID technology to solve the positioning inaccuracy caused by environmental factors. To meet community management requirement, J.H. Kuan、G.L. Lai、Y.S. Wang [16] combine systems engineering technique, which is used to carry out demand analysis, functional analysis, and configuration, with Delphi, SQL database, Zigbee and Visual Studio.NET technology, and employ wireless transmit technology and electric wave signal strength to tackle the network setup problem and positioning problems in the car park with irregular shape. They successfully develop an integrated system including an entrance control system and a parking lot management system, which could automatically control vehicles entering and leaving, and examine whether the car parking is complied with the regulation, which would result in relieving administrative officer's work load and reducing dereliction of duty. Z.H. Guan [25] combine systems engineering technology with famous systems engineering software – CORE to cater the customer's need for RFID to track manufacturing in batch product line, which would not only reduce 30% systems development cost, but also quickly satisfy customer's need when the system is launched. Mark Roberti [26] believes that next-generation RFID technology promise to bring a new level of performance previously thought impossible. Two companies that are still in stealth mode – RF Controls and Mojix – are sponsored by U.S military and NASA respectively. The former company is undergoing the development of Inventory Tracking and Control System, or ITCS, which mainly uses beam-steerable phased-array antennas, an aerospace technology, to locate a tag in 3-D. This antenna is also called Smart Antenna, which is a sensitive receiver consisting of an antenna array, an EPC-compliant reader, a powerful controller and a signal processor. The sensitive receiver allows the ITCS to use less RF energy than conventional RFID systems, which extends the read range well beyond that of a conventional system. The ITCS also allows users to take a zonal approach to tag location. Mojix system – called Space Time Array Reader (STAR) – can cover hundreds of thousands of square feet space, and read passive Tags with great precision – even within 1 square feet. ITCS and STAR both underwent secret field test in selected warehouses. John Edwards [27] emphasized that RFID could help businesses operate more efficiently while protecting the environment. Recycle-Bank, a Philadelphia-based company that works with municipalities to boost their recycling rates, through tracking each household's recycling activity by providing bins embedded with RFID tags. A reader-and-antenna system mounted on the sanitation truck records the weight of each pickup. When a truck finishes its route, it returns to its base, where data is transferred wirelessly to a Recycle-Bank server. Recycle-Bank hopes to triple its business during 2008. The statistics shows that households participating in the program earn an average of $8 per week, depending on how dutifully they recycle their house waste. In addition, Recycle-Bank's service benefits the local governments in the landfill fees. It turns out to be a win-win situation for every party involved: household, Recycle-Bank, and local government.

Research Objective: The objective of this paper is to use systems engineering and RFID technology to establish a service management information system, which consists of operation revenue, operation expenditure, service timing and account balance enquiry, and management related statistics and analysis. This research is separated into two stages. In the first stage, Delphi software technology and SQL database are used to develop the

management system, whereas in the second stage RFID technology is added in to the customer consumption record management and enquiry system to improve management efficiency. The development of the system is based on systems engineering and Delphi software. The process of systems engineering includes demand estimation, conceptual design, preliminary design, detailed design and development, logistic support and maintenance. Integrating systems engineering with Delphi software technology can facilitate to develop new product at low cost and upon customer's need. Blanchard and Fabrycky are applied in the development of our product, including demand analysis, functional analysis, function configuration and system design. Four main parts in the service management information system, including operation revenue, has been finalized. And we also assisted the enterprise to launch the system, which now has used for two years. The system performs stably and the functions we develop cater the customer's need completely.

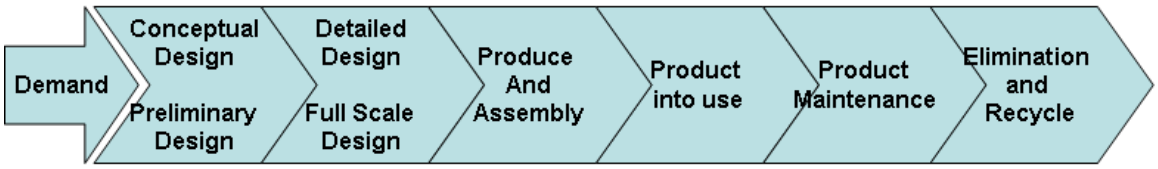
Systems Engineering Technique and Object Oriented Software Design

System development process: Main methods employed in this research include: (1) Systems engineering and management is utilized to carry out demand analysis and functional analysis, and to effectively analyze the correlation between customer needs and product development in order to extract the necessary and feasible needs, which is the basis of product design and drafting system specifications; (2) CORE developed by Vitech Corporation is a very effective software to establish the system engineering software; (3) Delphi and SQL database are used to develop middleware. Besides the methods mentioned above, this paper is particularly accomplished by the two notions stressed by Systems Engineering: (1) top-to-down way to develop; 2) emphasis on the conception of life cycle, as shown in figure 1.

Application of CORE developed by Vitech Corporation: According to INCOSE, the tools and software used to accomplish the systems engineering and management program should possess the property of traceability which can trace customer's original requirements. Hence system engineer could link to customer's requirements to their source. Such kind of tools provides traceability among the successive documents that are used to review the system development. Among tools recommended by the INCOSE, CORE is one of the relatively excellent software. CORE's main functions include integrated system design repository, system definition language (SDL), dynamic graphical view generators, automatic document generation, and so on.

Application of object-oriented design software: The system presented in the paper, whose middleware is developed by Delphi and Access database, is designed by the following information technologies: visualized program design tools, windows-based human-computer interface, multi-layer program design, enterprise network / internet, and other resources. Because windows-based operation system and application software provide multi-thread operation environment and friendly user interface, such a platform has become popular in present information system front end operation. This trend also promotes the significant innovation in the development of program language and tools of windows-based software. The objects in the developed software include functions of integrated development environment, visualized graphic design, object-oriented program design, and so on. As the most popular software development tool, Borland Delphi is used for the visualized graphic design. It provides various design elements, which could be directly added in the forms. The functions consist of designer's operation interface, linkage and operation with database, and

so on. There are two main design modes: object-oriented program design and multi-layer program design.



Product Life Cycle

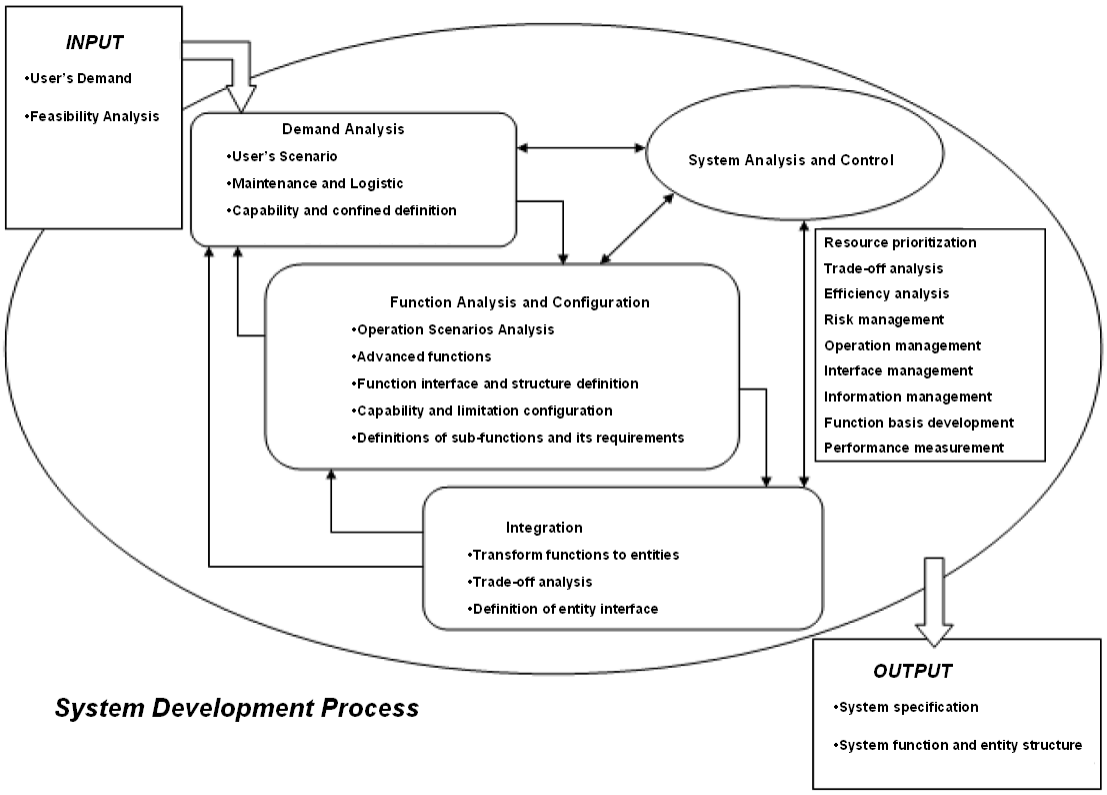


Figure 1: System Development Process Diagram

Developing System's Behavior Model

The system presented in the paper is applied to the service industry using time rate system, such as feet massage healthcare house, cosmetic skincare SPA house, and so on. The system consists of four main functions: operation revenue, operation expenditure, service timing and account balance enquiry, management-related statistics and analysis. The operation revenue function enables to input clients' services ordered, calculate consumption bills, identify charge methods, collect bills and top up account by RFID, and start service time countdown. To ensure service quality, when a service is over, the system will record the bill charged (or deduct from the RFID stored value card), and calculate employee's income. The operation expenditure part includes service items' procurement expense and employee's wages.

Functions of service timing and account balance enquiry include: 1) According to different service, before the employee provides the service, start service time countdown triggered by RFID tag, and keep the service type in his work record; 2) Clients can check the balance in the RFID stored value card whenever they want in the service counter. The functions of the remaining part of the management-related statistics and analysis include enquiring employee's work record in certain time lot, client's consumption record, client's discount and bonus using history, enquiring clients who do not pay a visit for a long time.

The system's major tasks include utilizing RFID tag for clients to top up their stored value card, which would enhance management efficiency. Especially for such kind of service industry, it has to record operation revenue and employee's income everyday, and to pay wages every half month. In addition, during the busy season when there are always short for hands, part-time or temporary staff are recruited and paid according to their experience. Therefore, information technology and RFID technology strongly promote the management efficiency and service quality. Because this system is required to provide immediate assistant to user everyday, the working environment should satisfy the following requirements: 1) Local area network should be equipped in user's working environment; 2) User should be indoor, and there should have enough room to place personal computer and to establish RFID reader and digital counter. According to the demand conception defined by Blanchard [2], the following points should be always kept in mind: 1) What is the model and parameter used to estimate demand; 2) Where the elements mentioned above should be placed; 3) How and how long to use this system; 4) Where to use the system; 5) How, who, and how long to maintain this system. The demand should wholly descript user's need, which should be included in the objectives of system design, and be measurable and displayable. The needs include response time, consideration in special situation, MTBF, MTTR, and availability. Figure 2 presents the transformation of system demand and formation of system specification; Figure 3 is a system demand layer tree. The system can also perform system functional analysis according to system operation requirements. In systems engineering realm, so-called function is to take certain actions (only one or a series) to complete the need satisfaction objectives. The system should have the following functions: 1) automatically start service management system when the personal computer is turned on; 2) respond to user's input in 2 seconds; 3) allow the user to input user ID within 10 meters and meanwhile start service time countdown; 4)store and update client's account information and service information, and calculate operation revenue and employee's wages and other related information; 5) system's MTBF should be within 8760 hours, MTTR be 24 hours, and can be restored to normal status within 1 hour.

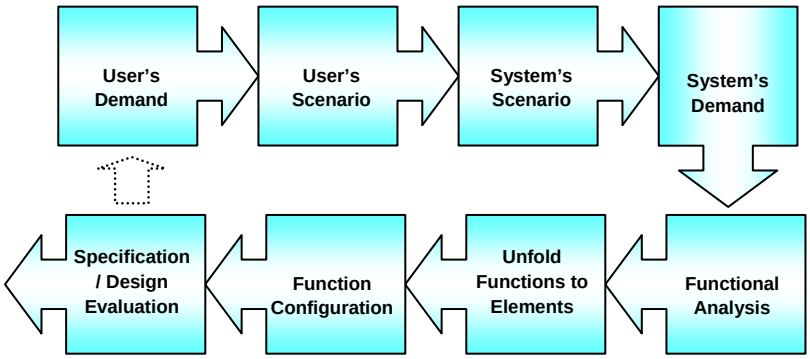


Figure 2 Transformation of system demands and formation of system specification

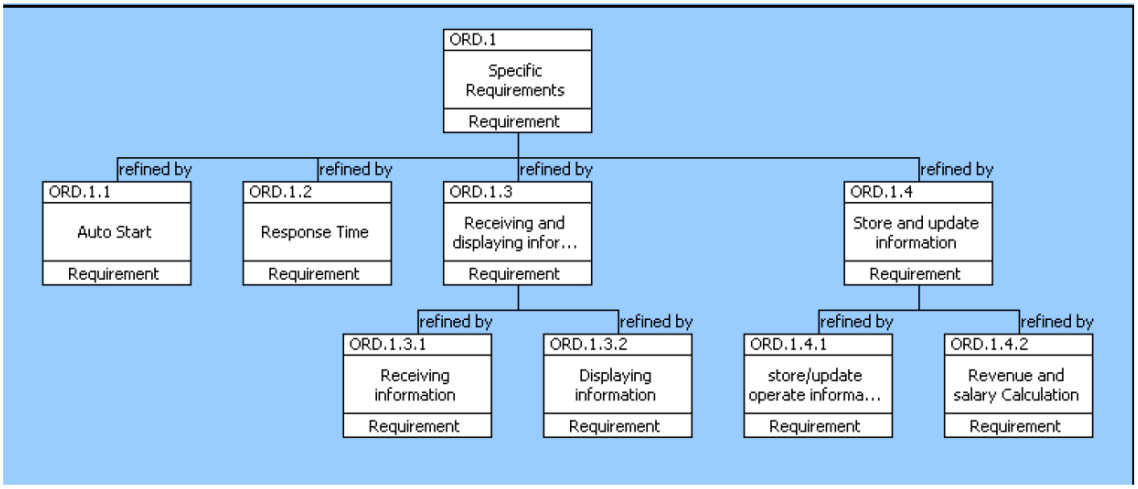


Figure 3 System Demand Layer Tree

Figure 4 presents system's first layer Function Flow Block Diagram (FFBD). Under normal situation, RS232 Network Converter and Digital Counter should keep in turn-on status, and turn on HealthCare Management package. Four major functions mentioned above should also be started. Figure 5 presents system's second layer FFBD (serial number 5), which performs the function that after receiving the service orders from client (non-member) or member, the system will designate an employee and calculate account receivables and service time according to the service type. The system will perform the service time countdown function when employee's proprietary tag is read by the RFID reader when he starts to provide service. The system will also automatically file this employee's working record. When service is over, system will input cash amount paid by client, whereas deduct charge from member's RFID stored value card by RFID reader. CORE provide N2 diagram to illustrate data flow between functions. Figure 6 is the N2 diagram corresponding to systems presented in Figure 5.

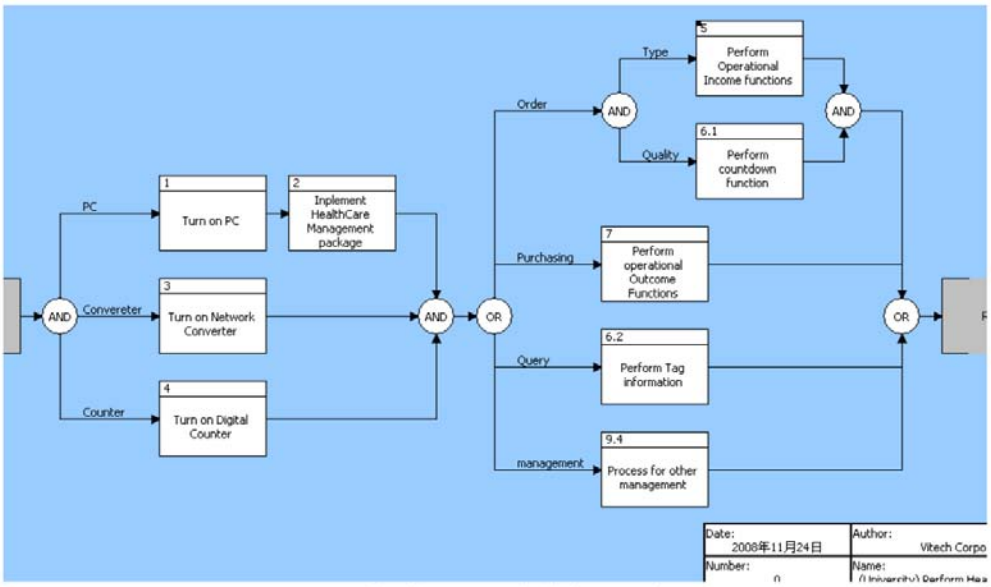


Figure 4 System's first layer FFBD

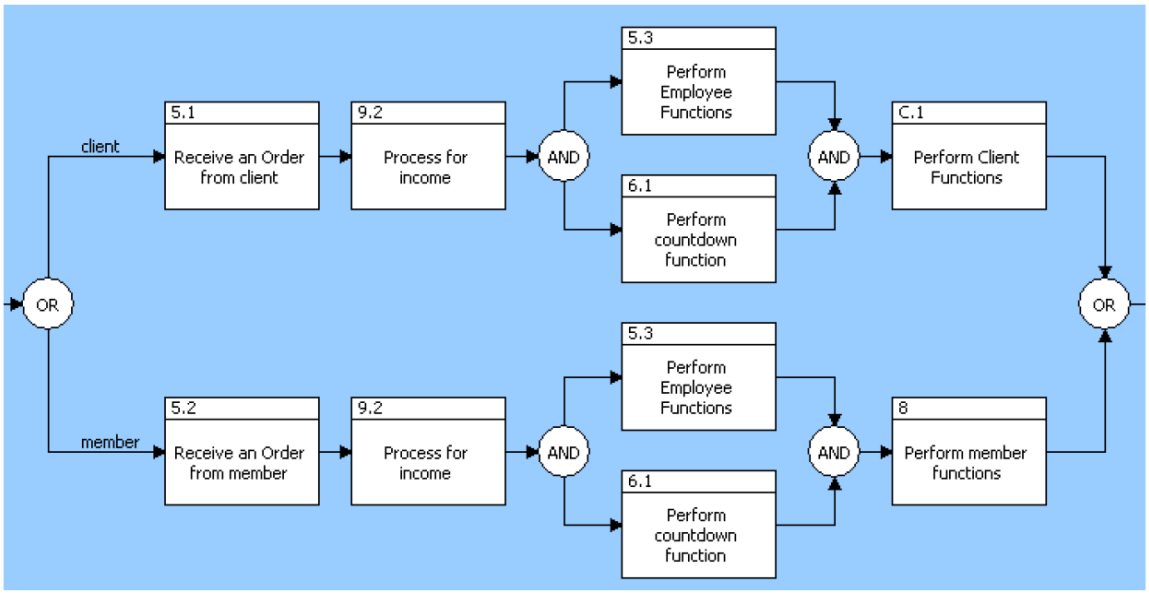


Figure 5 System's second layer FFBD

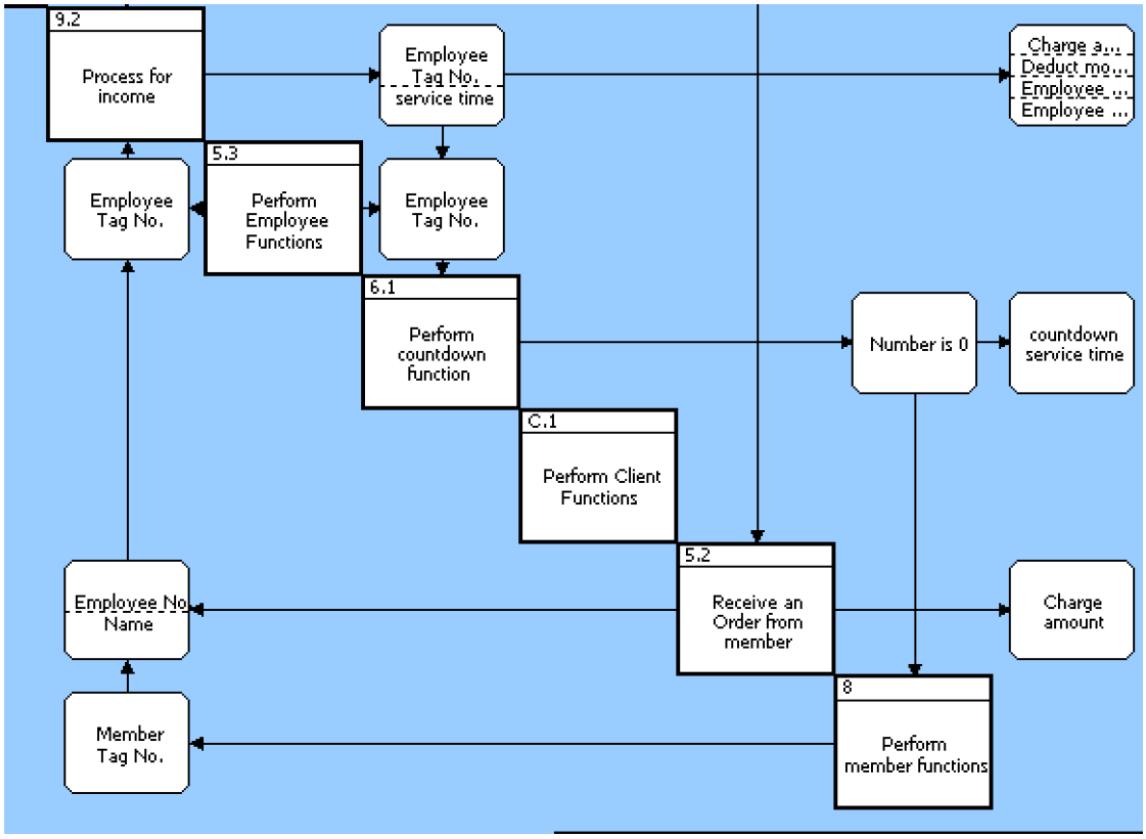


Figure 6 N2 diagram corresponding to systems presented in Figure 5

Systems engineering technology should also be applied to evaluate its working environment, besides analyzing the system functions designed. The elements beyond the system includes

non-member client, buildings, mobile phone base, local area network (which can link to internet). The decomposed functions illustrated in the figures are compiled according to National Institute of Standards and Technology (NIST) and Federal Information Processing Standards Publication 183 (FIPS PUB 183). Hence the figures could clearly display the function decomposition and various functions' ICOM (Inputs, Controls, Outputs, Mechanisms).

Building System's Physical Model

After finishing the demand analysis and functional analysis, CORE is used to build Demand vs. Function Tree to ensure that each demand would be satisfied by corresponding function. Figure 7-series present the System Hardware Tree, in which Figure 7-1 unfolds the first layer with second layer SYS 1.3, and Figure 7-2 unfolds the first layer with second layer SYS 1.2. Figure 8 presents the Physical Block Diagram. To ensure the system keeps the linkage among preliminary file, system demand, system functions, and hardware, CORE is utilized to draw the tracing diagram illustrated in Figure 9. Figure 10 is system entities installation illustration.

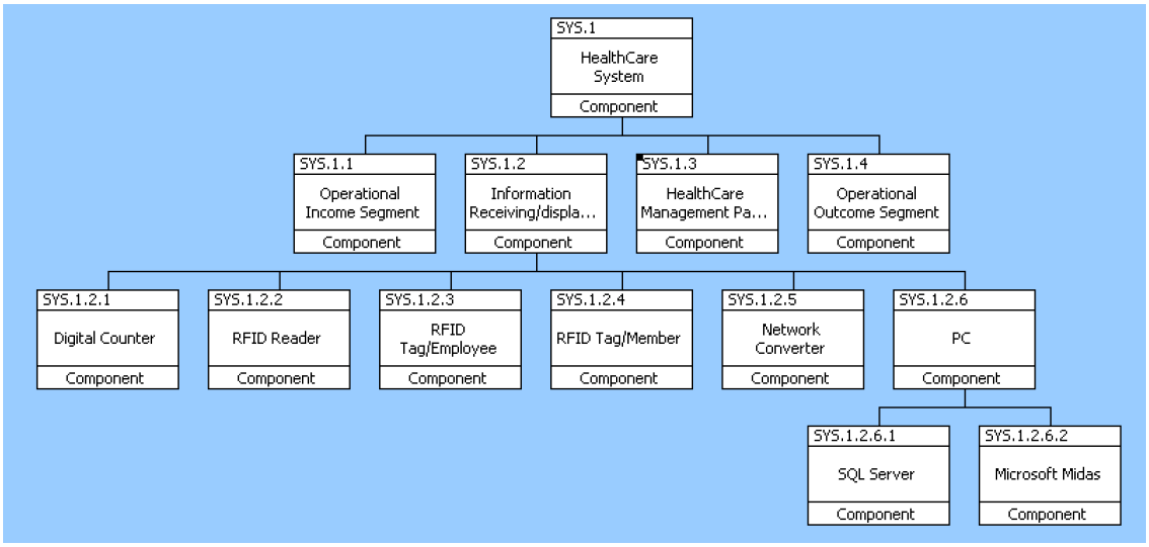


Figure 7-1 System Hardware Tree (First layer with second layer SYS 1.3)

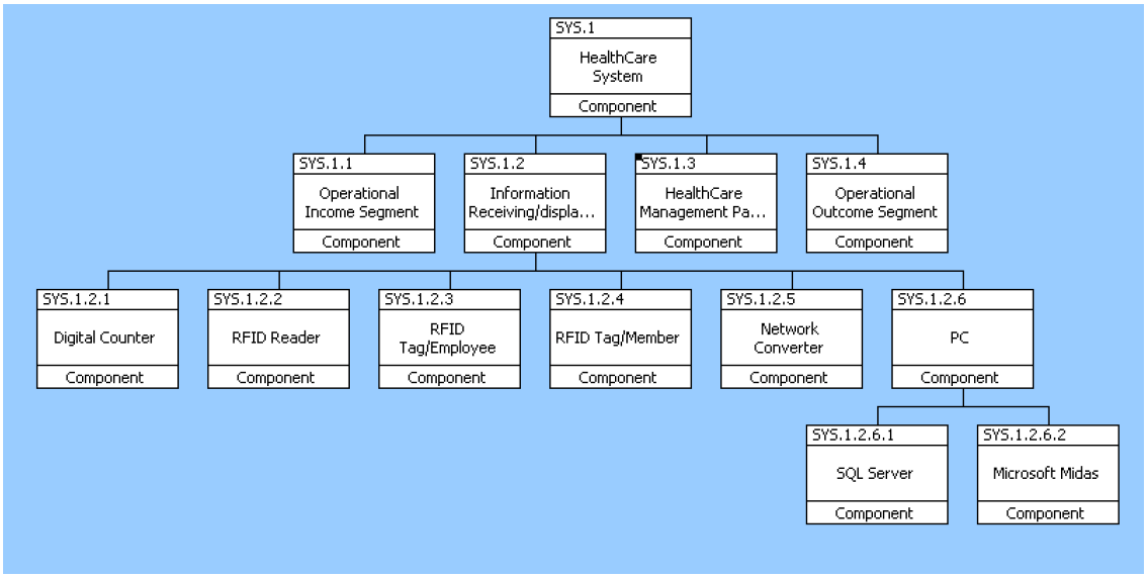


Figure 7-2 System Hardware Tree (First layer with second layer SYS 1.2)

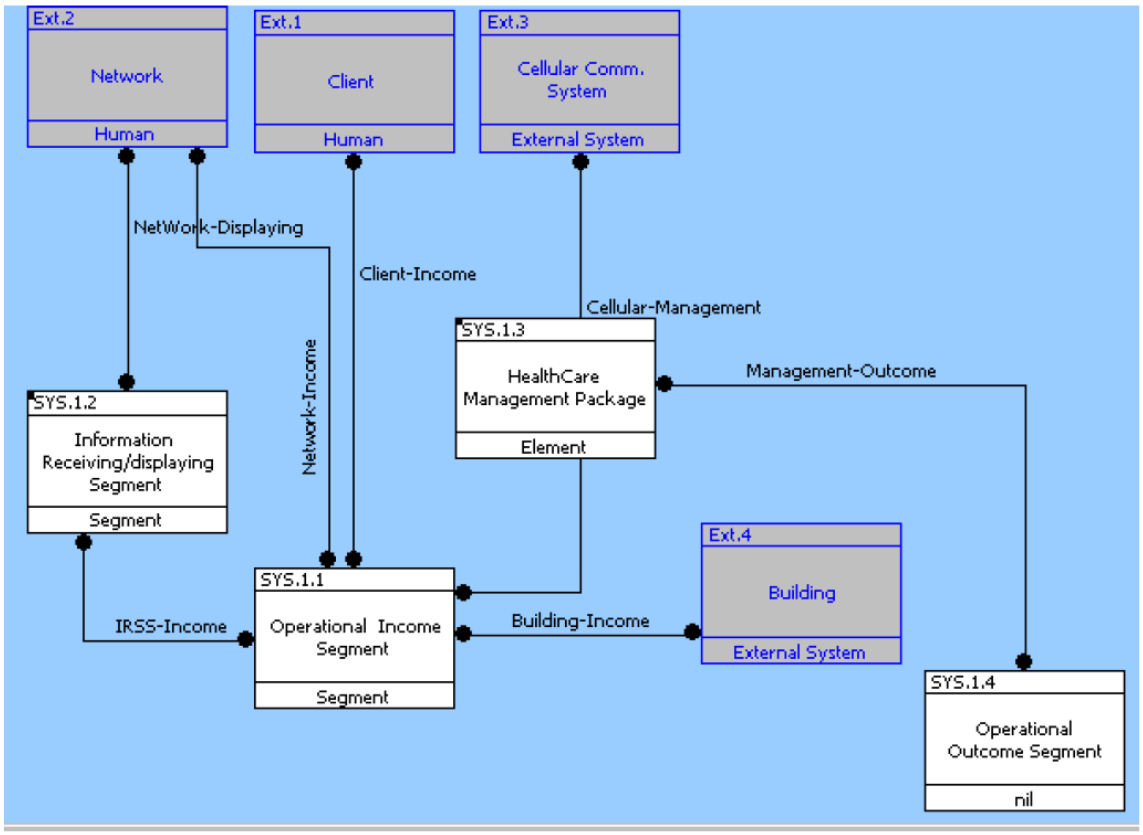


Figure 8 System Linkage between Hardware (First layer Physical Block Diagram)

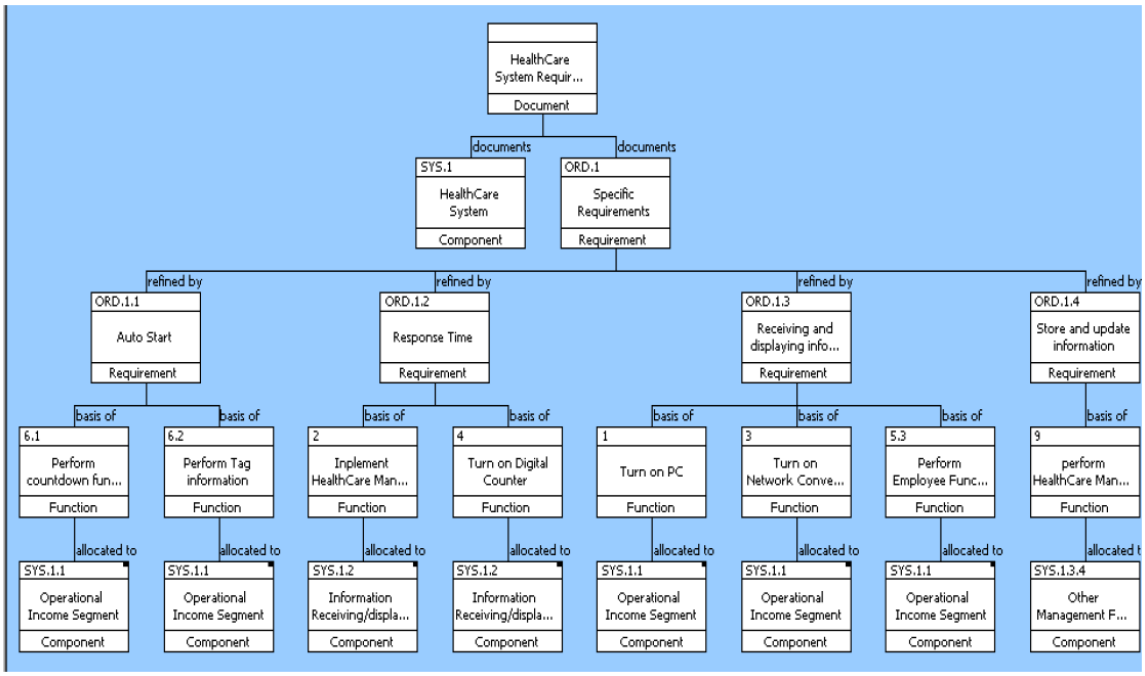


Figure 9 Tracing Diagram from preliminary file to hardware constructing

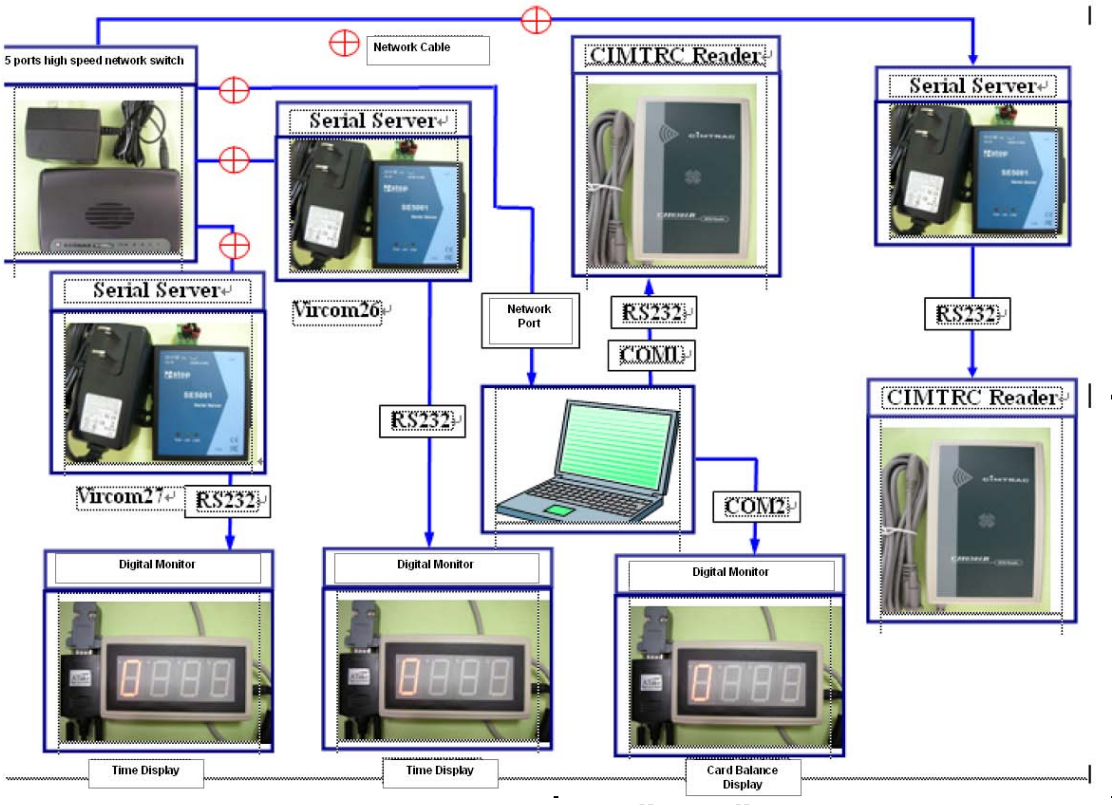


Figure 10 System Entities Installation Illustration

Conclusion

This paper combines systems engineering techniques with CORE developed by Vitech Coporation, which saves 50% working hours. System analysis is also completed, which includes 13 operation requirements and 24 key functions derived from these requirements. In addition, information needed in the system function configuration and detailed design is also fully collected. The research shows that:

(1) When analyzing a new system, systems engineering process, which starts from conceptual design related to environment, external system and internal system, to further division of demands and functions, then to developing system's software and hardware by function configuration method, can successfully satisfy customer's optimization requirement.

(2) Vitech's CORE facilitates to keep the wholesome between system demands and functions match. In addition, when designer is considering of the function flow, CORE can help add, amend the FFBD at any moment. Hence designer can quickly perform the analysis, and keep good communication with user.

(3) The results of the research can be integrated with the application of object-oriented software. So when carrying out the function program planning, designer can consider combining appropriate forms and components (in the component tray) with the unfolding and configuration of functions.

(4) The research successfully finishes certain diagrams, including System Demands Layer Tree, FFBD, N2 Diagram (which is unfolded to the third layer). These diagrams can be used as important foundation in system development.

According to customer's requirements, this research fulfill the development of service management system in two separate stages. Based on the demands of the service management system and systems engineering technology, coding is completed for several modules, including basis information, daily operation, operation information analysis, and so on. Basic information module consists of 6 forms; daily operation module has 7; and operation information analysis module has 6. Other achievements include SQL database installation, management software installation and launch for use. As for basic information, besides employee information and customer information, the system is designed with the input interfaces to gather the basic information of service types, payment methods, and operation revenue according to customer's requirements; in addition, according to employee's habitual input manner and to the operation requirement during client service, the system includes the daily operation record and statistic function, which includes client's voucher consumption history, employee's service history, payment and gathering records in daily operation, and operation revenue and expenditure. Furthermore, in order to cater client relationship management requirements, the systems has the function to query the records of clients who come to the healthcare house and those who do not, and client's voucher consumption history. Finally, according to enterprise's accounting requirements, the system can provide employee wage report and monthly/annual operation reports. Presently the management system has been put into use according to the planning schedule. In addition, as requested by the enterprise's need to enhance client service quality, the system combines RFID technology with client's stored value card, and makes service time transparent, both of which help promote management efficiency and service quality.

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BIOGRAPHY

Jyh-Horng Kuan, born on May 9, 1955, graduated from Air Force Academy in 1976, and received Master of Science degree in Aerospace Engineering and majored in Fluid Mechanics from University of Texas at Austin in 1982. Then in 1982, he joined Chung Shan Institute of Science and Technology and participated in the research and development of IDF engine. In 1987, he achieved PhD in Aerospace from Colorado State University. In 1998, he was in charge of promoting the independent research and development of turbine engine, and successfully developed a downsized turbine engine. In 1999, he was appointed as vice president of the Aeronautical Engineering Division in Chung Shan Institute of Science and Technology. In 2003, he retired from army and pursued a education career, where he started to be actively engaged in the research of integration of systems engineering and RFID system.