行政院國家科學委員會專題研究計畫　成果報告

子計畫二：無線感測網路之系統評估模擬平台建置與基頻電路實現

計畫類別：整合型計畫
計畫編號：NSC93-2213-E-032-023-
執行期間：93 年 08 月 01 日至 94 年 07 月 31 日
執行單位：淡江大學電機工程學系

計畫主持人：詹益光
共同主持人：李揚漢
計畫參與人員：莊明學、曾憲威、林政曜

報告類型：精簡報告
報告附件：出席國際會議研究心得報告及發表論文
處理方式：本計畫可公開查詢

中　華　民　國 94 年 9 月 13 日

行政院國家科學委員會補助專題研究計畫 ☑ 成果報告 □期中進度報告

自主性分散式無線感測網路嵌入系統研製

計畫類別：□ 個別型計畫　☑ 整合型計畫
計畫編號：**NSC 93-2213-E-032-023-**
執行期間：93 年 8 月 1 日至 94 年 7 月 31 日

計畫主持人：詹益光　淡江大學電機工程學系
共同主持人：李揚漢　淡江大學電機工程學系
計畫參與人員：莊明學　淡江大學電機工程學系
曾憲威　淡江大學電機工程學系
林政曜　淡江大學電機工程學系

成果報告類型(依經費核定清單規定繳交)：☑精簡報告　□完整報告

本成果報告包括以下應繳交之附件：
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□赴大陸地區出差或研習心得報告一份
□出席國際學術會議心得報告及發表之論文各一份
□國際合作研究計畫國外研究報告書一份

處理方式：除產學合作研究計畫、提升產業技術及人才培育研究計畫、列管計畫及下列情形者外，得立即公開查詢
□涉及專利或其他智慧財產權，□一年□二年後可公開查詢

執行單位：

中　華　民　國　94　年　9　月　13　日

行政院國家科學委員會專題研究計畫成果報告

自主性分散式無線感測網路嵌入系統研製

子計畫二：無線感測網路之系統評估模擬平台建置與基頻電路實現(1/3)

計畫編號：NSC 93-2213-E-032-023-

執行期限：93 年 8 月 1 日至 94 年 7 月 31 日

主持人： 詹益光 淡江大學電機工程學系
共同主持人： 李揚漢 淡江大學電機工程學系

一、 中文摘要

本計劃為總計劃「自主性無線感測網路嵌入系統研製」之子計劃二。本計劃提出「無線感測網路之系統評估模擬平台建置與基頻電路實現」為三年之研究計劃。本計劃之目的是依照 IEEE 802.15.4 規格設而建立完整的實體層模擬測試平台與基頻電路之硬體實現。

本計劃利用 Top-down 的設計方法。依照 IEEE 802.15.4 的應用與規格與對於各種演算法及架構的了解，利用 ADS 與 Matlab 來建立完整的測試平台，包括了基頻電路與射頻電路的建立，對於實體電路無法模擬之無線通道的各種效應，經由通道模型的建立且加入系統平台的模擬，可得到實體電路無法預測之通道對系統之影響對於設計有極大的幫助。針對系統模擬平台所得到的數據與架構可供基頻電路硬體設計之參考，基頻電路硬體設計是利用 Verilog 來完成硬體的設計且利用 FPGA 的平台來作為硬體設計的平台與硬體測試。由 FPGA 所得到的硬體設計規格，作為 ASIC 下線的設計與未來測試的參考，最後完成整體系統的整合。

Abstract

This project is the sub-project II of the main project ’The Design and Implementation of the Distributed Autonomous Embedded System in Wireless Sensor Networks.’ This is a three years research and development project to develop ‘The Set Up of Simulation Platform for the System Performance Evaluation of the Wireless Sensor Network and the Implementation of Baseband Circuits’. The development of this project follows the Protocol of IEEE802.15.4 to set up a complete simulation test platform for the Physical Layer and the implementation of baseband circuits.

In this project it uses the Top-down design methodology. By utilizing ADS and Matlab it follows the applications and specifications of IEEE 802.15.4 and uses the knowledge of the algorithms and architectures to set up a complete test platform. The test platform includes the implementation of baseband and RF circuits, channel model set up when various channel effects can not be simulated by the physical circuits and also to include the system simulation platform to simulate various channel effects These results will be benefited and widely used in the system design and development. The data and system architecture obtained from the system simulation platform will be used as the reference in the hardware design of baseband circuits. It will use Verilog to complete the hardware design of the baseband circuits and it will use the FPGA platform to do the hardware deign and testing. It will use the hardware design data and specifications through running the

FPGA as the reference of design and future testing for lower level ASIC circuit. It finally completes the integration of the whole system.

二、計畫緣由與目的

由於無線網路的快速發展，因而許多新的規格與應用在最近與未來幾年將會不斷的蓬勃發展。就如現在當紅的無線網路產品 IEEE 802.11g 除了使用正交分頻多工(OFDM)調變方式提供高速的傳輸速度 (54Mbps)由於工作頻帶也在2.4GHz且包括IEEE 802.11b 所用的 CCK 調變，所以可以與在市面上流通廣範的 IEEE 802.11b 相互相容使用[1]-[19]。雖然 IEEE 802.11g 的高速度能夠符合我們使用的需求，但要用於 Notebook 等無線產品，能源上的損耗考量就變的格外的重要，基於這點考量 Zigbee 與 IEEE 就訂定了 IEEE 802.15.4 的規格，強調極低耗電的短距無線網路技術，傳輸速度為 20k-250k bps，以一般電池電力而言可使用數月至數年之久，其應用如圖 1 所示。

在 IEEE 802.15.4 的規格中可以了解到如圖 2,3,4 所示，MAC 的資料傳輸的格式與資料交換的動作原理以及 Baseband 的基本調變方法，可由此規格中訂定 MAC 與 Baseband 的介面。另一方面對於通道中傳輸常會遇到的問題有訊號經過通道所造成的傳遞損失（Propagation Loss）、訊號經由不同路徑到達接收端由多重路徑所造成的多重路徑衰弱（Multipath Fading）、統計衰弱特性的分佈(Fading Characteristics And its Statistical Distribution)、利用路徑損耗的計算得到經驗公式 (Empirical Formula for Path Loss Calculation)、還有由多重路徑衰弱所引起的符際間的干擾（Intersymbol Interference）、利用通道等化（Channel Equalization）的技術將受干擾的訊號還原[20]-[23]。

通常在系統模擬的階段會利用輔助軟體來幫助系統的設計架設模擬平台，如利用 ADS 與 Matlab 架設的系統模擬平台可以幫助設計以及得到最佳化的設計，可以利用所建立好的平台對於 low power 的基頻電路進行各種演算法與架構的考量，以符合 IEEE 802.15.4 low power 的設計。

另一方面，當某些應用如影像傳輸，需要利用 MPEG-4 來傳送影像，MPEG-4 需要用約 750Kbps 的速率來傳送資料，而 IEEE 802.15.4 最高的傳送速率為 250Kbps 是不足以傳送 MPEG-4 的資料，為了讓 IEEE 802.15.4 的應用能夠傳送 MPEG-4 的影像資料，可利用 MIMO(Multiple Input Multiple Output)的架構來解決這問題[24]-[33]。

三、研究方法與成果

研究方法：

完成 IEEE 802.15.4 與 IEEE802.15.4a 規格書研讀，分別將規格充分了解，進而規劃系統的架構，且定義系統的規格。且對於相關通道演算法之推導與分析並建立通到模型，利用 ADS 或 Matlab 的輔助軟體，分別對不同的系統架構做模擬以及將系統方塊圖重新規劃，再將所有的系統做整合模擬，與通道模擬，且定義好子方塊圖規格與各子方塊界面規格。

(A) IEEE 802.15.4 規格書的研讀，媒介截取控制層與實體層之間的介面。
(B) IEEE 802.15.4a 規格書的研讀，實體層與 UWB 之研究。
(C) 傳送端與接收端實體層規劃與設計並探討相關之演算法與架構。
(D) IEEE 802.15.4 系統架構圖規劃以及系統規格的訂定包括子方塊之間的介面規格。
(E) 通道的研究，包括相關之演算法之推導及分析，與通道模型之建置。

(F) 模擬平台之建立，包括 RF 端與基頻之模擬平台建立，利用 ADS 與 Matlab。

(G) Low power 之設計與考量。

(H) 提出 MIMO 的設計，以增加傳送的速率。

<u>研究成果：</u>

已完成論文投稿數，共四篇

已收錄論文，共二篇

1) 李揚漢, <u>**詹益光**</u>, 莊明學, 曾憲威, 林宗祺, 張志聿, 錢柏君, ”軟式決策之迴旋碼編碼器與腓特比解碼器之硬體實現於正交分頻多工系統,” *2004 年網際網路暨通訊科技研討會, NWIC’04 Taiwan, November 11, 2004.*

2) Yang-Han Lee, Rong-Hou Wu, Ming-Hsueh Chuang, <u>**Yih-Guang Jan**</u>, Liang-Lin Jau, Kung-Chen Mei, and Shian-Wei Tzeng, “Application of RSSI on indoor security wireless network,” *The Fifth IASTED International Multi-Conference on Wireless and Optical Communications (WOC 2005) Wireless Networks and Emerging Technologies (WNET 2005).* (Acceptance at March 24, 2005)

已接受論文，共一篇

1) Yang-Han Lee, <u>**Yih-Guang Jan**</u>, Ming-Hsueh Chuang, Shian-Wei Tzeng, Liang-Lin Jau, Min-Ru Wen, Wei-Chen Li, and Sheng-Kai Yu, “Co-Emulation Design for OFDM Baseband Transceiver,” *Tamkang Journal of Science and Engineering* . (Submission at May 4, 2005)

已投稿論文，共兩篇

1) Yang-Han Lee, <u>**Yih-Guang Jan**</u>, Ming-Hsueh Chuang, Shian-Wei Tzeng, and Chiung-Hsuan Peng, “A Novel Architecture for High Speed Viterbi Decoder,” *Tamkang Journal of Science and Engineering* . (Submission at May 5, 2005)

四、 結論與討論

本計劃利用 Top-down 的設計方法。依照 IEEE 802.15.4 的應用與規格與對於各種演算法及架構的了解，利用 ADS 與 Matlab 來建立完整的測試平台，包括了基頻電路與射頻電路的建立，對於實體電路無法模擬之無線通道的各種效應，經由通道模型的建立且加入系統平台的模擬，可得到實體電路無法預測之通道對系統之影響對於設計有極大的幫助。針對系統模擬平台所得到的數據與架構可供基頻電路硬體設計之參考，基頻電路硬體設計是利用 Verilog 來完成硬體的設計且利用 FPGA 的平台來作為硬體設計的平台與硬體測試。由 FPGA 所得到的硬體設計規格，作為 ASIC 下線的設計與未來測試的參考，最後完成整體系統的整合。

今年計畫之進度，按照原本預計之進度：

1. IEEE802.15.4 之系統架構之規格及各子方塊間之介面規格設計(已完成)
2. UWB 基本原理之研究與探討(已完成)
3. MIMO 架構之演算法與架構之研究(已完成)
4. 通道傳送損失特性之分析與研究(已完成)
5. 利用 ADS 程式建立基頻及 RF 端之模擬平台(已完成)
6. 利用 Matlab 程式建立基頻及 RF 端之模擬平台(已完成)

未來二、三年之進度：

1. 完成低功率 IEEE 802.15.4 系統的製作，以銜接無線感測網路中媒介擷取控

制層，以達到無線感測網路中用戶基頻傳達速率的需求。同時在此計劃中我們將利用 MIMO 架構於所設計的 IEEE 802.15.4 系統中以達到用戶對於高速傳送如 MPEG-4 傳送的需求。

2. 完成 IEEE 802.15.4a 系統中 UWB 基本方塊圖規格的訂定，同時也將推導出一精確的定位演算法以縮小現今文獻中所提供之定位演算法的誤差。

3. 本計劃將提供一完整的無線網路中頻道的特性及頻道的模型可提供日後無線網路中探測信號傳送衰減時之基本數據。

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MIMO

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六、 圖表

圖 1 IEEE 802.15.4 之應用

PHY (MHz)	Frequency band (MHz)	Spreading parameters		Data parameters		
		Chip rate (kchip/s)	Modulation	Bit rate (kchip/s)	Symbol rate (ksymbol/s)	Symbols
868/915	868-868.6	300	BPSK	20	20	Binary
	902-928	600	BPSK	40	40	Binary
2450	2400-2483.5	2000	O-QPSK	250	62.5	16-ary Orthogonal

圖 2 IEEE 802.15.4 之頻帶與調變之關係對應表

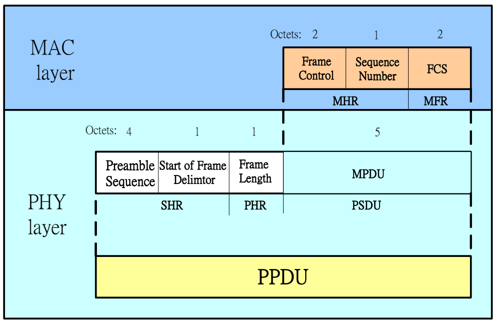

圖 3 MAC 與 PHY 之資料封包與格式

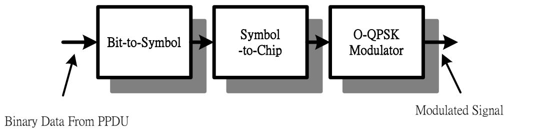

圖 4　2.4GHz 之 PHY 調變方塊圖

行政院國家科學委員會補助國內專家學者出席國際學術會議報告

附件三

94 年 9 月 13 日

報告人姓名	詹益光	服務機構及職稱	淡江大學電機工程學系
時間 會議地點	2005.07.19 ~ 21 加拿大，班夫	本會核定補助文號	NSC 93-2213-E-032-023-
會議名稱	(中文)國際無線網路和新興科技會議(WNET 2005) (英文)IASTED International Conference on Wireless Network and Emerging Technologies (WNET 2005)		
發表論文題目	(中文)安全無線網路在 RSSI 上之應用 (英文)Application of RSSI on Indoor Security Wireless Network		

報告內容應包括下列各項：

一、參加會議經過

本次參加的國際會議名稱為“IASTED International Conference on Wireless Networks and Emerging Technologies (WNET 2005)”，以下簡稱 “WNET 2005”。此次 WNET 2005 的舉辦地點是位於加拿大(Canada)的班夫鎮(Banff)，時間為 7/19 至 7/21 為期三天的會議。

而我本人由於家在美國鳳凰城，故是由鳳凰城飛往溫哥華，則因考量與會的便利性而選擇投宿在與會場相隔約 15 分鐘路程的飯店。由於此次行程本是定於 7/19 日的飛機，本人的論文報告是在 7/20 日的下午兩點，時間上還是很充裕，且當地太陽下山的時間非常的晚，所以還可以去週遭的景點看看，所以就去了硫磺山搭纜車上山，上到山頂感覺到大自然的吸引力，映入眼簾的美景雖在電視上看過，但當親身體驗實有種說不出的感動及很深的體會，下山後又到了硃砂湖，此湖因為當夕陽西下時，會將湖面染成硃紅色而命名，但當本人到達時看佈道夕陽，有的是湖面上有著山的倒影，這個畫面，又讓本人再次有了不同的感動。

隔天 7/20 日到達會場先辦理註冊手續，本會議贈送了一個簡易背包，並可以在會場進行三頓中餐及一頓晚餐以及一個晚宴，註冊手續辦完後我們跟著老師前往強士頓峽谷，去感受大自然神奇的力量，走到峽谷的盡頭看到的是一個瀑布，雖然不大，但也可說是壯觀，之後再趕回會場，因為我們所報告的場次時間是下午 2:00 到 5:00，所以趕回現場實際演練一次，以求報告時能力求完整。由於之前報告的經驗告訴我，報告時不應對著稿唸，也不應硬去記誦講稿，最好能夠以即興演說的方式，所以這次的報告在於訓練自己能夠更迅速地以英文思考。報告的過程雖不盡理想卻也還能勉強讓底下的聽眾瞭解我的論文內容，唯一不足的是英文訓練仍嫌不足，必須在多加強。報告結束後，因當地日落時間較晚，所以我們又到了夢連湖景點，此湖所映出的顏色勢必綠色的，第一次看過湖的顏色可以如此的漂亮，真是讓人有點捨不得離開這個地方。

第三天早上一大早又去了會場，因為我們同行中有位老師所報告的場次時間是早上8:30 到 11:00，雖為會議的最後一天，但今日與會的人數缺絲毫未減。報告結束後即與同行的老師一起進行深度觀光旅遊並繼續各類型的話題。此行最大的收穫，是讓自己有了更廣的國際觀，清楚知道自己本身的不足，以加強自己本身的本質學能。

二、與會心得

此次的與會讓我又學習到了許多的東西，這不僅是專業領域方面的技術與知識，最大的收穫則是對一個各國人文的認識。電視上所看到的往往與親自去體驗的會有大大的不同。本次研討會有形形色色來自各國出色的教師及學生參加，但他們著重的方向、做事的態度以及如何表現一件他們欲表達的事這些都不同，或許這些就是他們能如此傑出的原因所在。

再來另個收穫就是驗證了自己在學界所研究的努力，專業知識的充實、想像力的培養以及對系統架構的思考周密度。學習及吸收他們所提的研究理論，更可以找出他們方法的缺點，以及還有哪些地方可以加以改善等…，並且跟他們研究及討論，以及未來的研究方向。

在此次會議，透過大會安排的討論更了解世界各國在光纖傳輸方面的研究現況，會後並與國外學者交換意見及研究心得，充分達到學術交流的目的。出國參加此類的學術會議，不但可以增廣見聞，亦可增加國際觀，此行對本人可以說是獲益良多。

三、考察參觀活動(無是項活動者省略)

四、建議

最後建議，本校也可爭取舉辦類似的大型會議，一方面可以增進各國彼此的交流，另一方面亦可提升本校在先進科技上的國際地位。

五、攜回資料名稱及內容

論文集：本次研討會所接受發表之論文內容。
研討會註冊收據。
研討會議程表一張。
印有研討會圖案之背袋一個。
印有研討會圖案之原子筆一支。

六、其他

APPLICATION OF RSSI ON INDOOR SECURITY WIRELESS NETWORK

Yang-Han Lee[1], Rong-Hou Wu[2], Ming-Hsueh Chuang[1], Yih-Guang Jan[1], Liang-Lin Jau[2], Shian-Wei Tzeng[1], and Kung-Chen Mei[1]

[1]Department of Electrical Engineering
Tamkang University
Tamsui,Taipei Hsien, Taiwan 251, R.O.C.
E-mail: 692351157@s92.tku.edu.tw

[2]Dept. of Computer & Communication Eng.
St. John's & St. Mary's Institute of Technology
Tamsui,Taipei Hsien, Taiwan 251, R.O.C.
E-mail: rhwu@mail.sjsmit.edu.tw

ABSTRACT
A smart security system in indoor environment using the Received Signal Strength Index (RSSI) is proposed in this paper. RSSI shows irregular wave pattern with low variance in common closed field. If dramatic RSSI signals happen in a closed environment, it means that someone may have entered the field or something has moved its position. Furthermore, this new technology can simply be used as a wireless security system without the necessity of preparing any special experiment equipment, all that is required is a normal labtop and wireless LAN cards.

KEY WORDS
Wireless security system, RSSI, wireless LAN card

1. Introduction

In wireless communication systems, the most important consideration is the multipath fading effect [1] between the transmitter and the receiver. Due to multiple reflections from various objects, the electromagnetic waves travel along different paths of various lengths. The interaction between these waves causes multipath fading at a specific location, and the strengths of the waves decrease as the distance between the transmitter and receiver increases. The mechanisms behined electromagnetic wave propagation are diverse, but can generally be attributed to reflection, diffraction, and scattering. Fading is often studied by separating the variation into two separate effects of long-term fading [2] and short-term fading [3]. Long-term fading is typically caused by relatively small-scale variations in topography along the propagation path. Short-term fading is typically caused by the reflectivity of various types of signal scatterers, both stationary and moving. The Doppler effect [4] and various man-made noises [5] also affects the multipath fading. Moreover, the multiple signal paths that arrive at the receiving end, displaced with respect to each other in time, is referred to as delay spread [6]. The arrival of two closely spaced frequencies with different time-delay spreads, having a strong potential for correlation, is referred as the coherence bandwidth [7-8], and RSSI signals are usually used to represent the multifading effect sensored.

From previous explanation, the sigals from RSSI can be unbalanced due to environment changes or multipath fading. If we offer a simple and stable environment, we will find the variation of RSSI is unclear, and the link quality values are centralized at some values. Knowing its unique characteristics, we can use RSSI as a motion detector under closed or stable environment. When violent changes occur, RSSI will create greater amplitudes and high variances. So if great changes of RSSI signals arise, it is positive that there are unusual movements around the surrounding, achieving the goal of wireless security system.

2. Changes of RSSI Signals due to Interference

The interference of environment variation of RSSI signal in a closed field is studied in this section. The scheme of RSSI measurement is shown in Fig. 1, and the measurement strengths of RSSI is shown in Fig. 2(a) and Fig. 2(b). At the beginning, the RSSI has huge unstable variations caused by humans operation inside the room, and later opening the door to leave. Between 670 ~ 700 seconds, we have another huge unstable variation of RSSI,

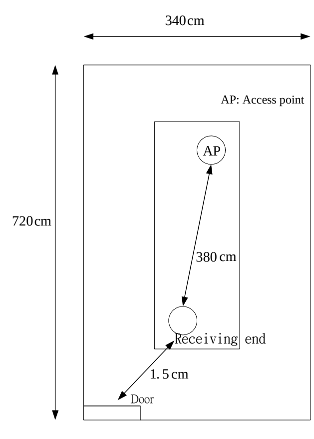

Figure 1: The scheme of RSSI measurement.

this time caused by suddenly opening and closing of the door from outside of the room. Soon, it will return to its original stable status. Also we take successive 5 points of RSSI signal to calculate the standard deviation of RSSI as shown in Fig. 3(a) and Fig. 3(b). We can see that the locations of huge RSSI variation in Fig. 3(a) and Fig. 3(b) corresponds with that of Fig. 2(a) and Fig. 2(b). Therefore, it indicates that there are environment changes when the standard of RSSI is between 2 and 5.

3. Distant of Detection

This section describes the variation of RSSI in relations to the distance between the source of interference (door) and the receiver (labtop). If the distance between the receivor and the source of intereferece is too great, it is possible that the changes in the surrounding cannot be detected. This idea is shown in Fig. 4, and the computations of interference reaction between distance and access points (AP) are shown in Table 1, where the distance refers to the length between the receiving end (labtop) and the interference end (the door) From Table 1, we can see that the ideal reaction range is within a radius of two meters.

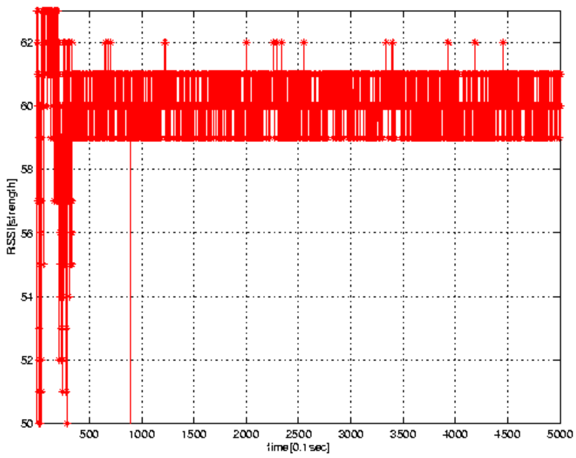

Figure 2(a): The strength of RSSI signal (0-500sec).

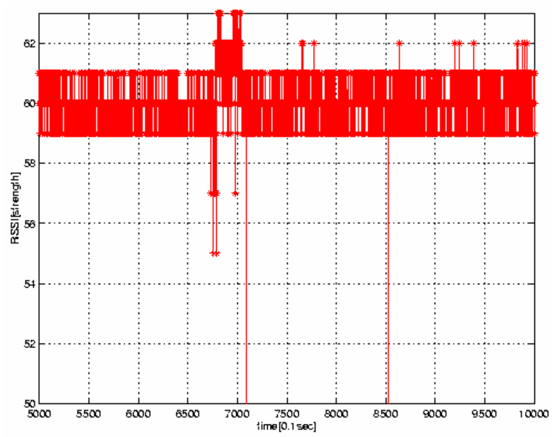

Figure 2(b): The strength of RSSI signal (500-1000sec).

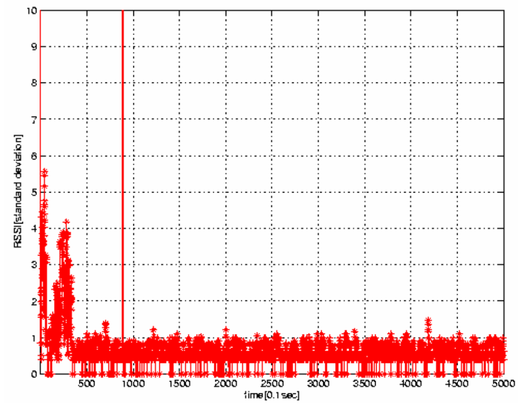

Figure 3(a): The standard deviation of RSSI signal (0-500sec).

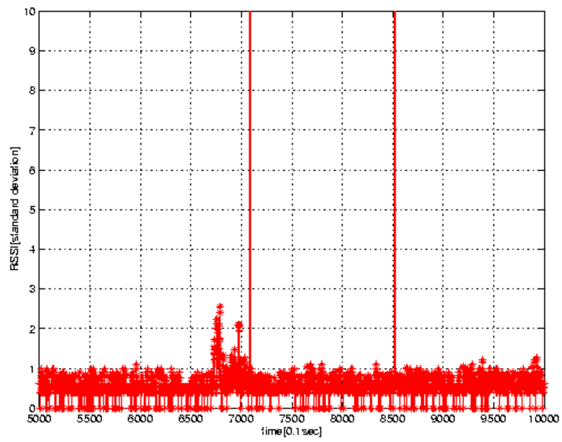

Figure 3(b): The standard deviation of RSSI signal (500-1000sec).

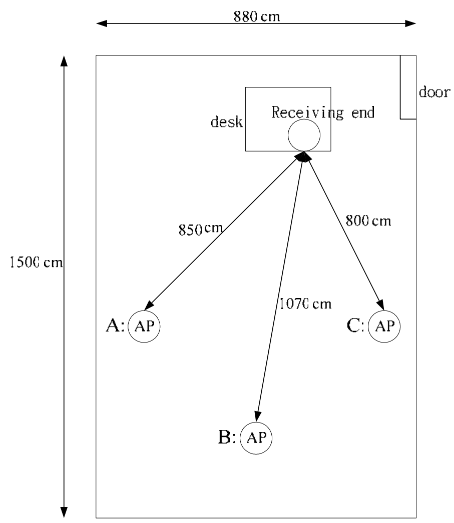

Figure 4: The scheme of distance reaction meansurement.

Table 1: The interfence reaction between distance and access points.

Distance(cm) / location	80	160	200	240	320	480
A	O	O	O	X	X	X
B	O	X	X	X	X	X
C	O	O	O	O	X	X

O: The reveiving end can detect interference variation.
X : The reveiving end cannot detect interference variation.

4. Similation Result

We use VC++ 5.0 software to create a program for detecting the RSSI signal, as shown in Fig. 5. Its function is to show the "***Time***" when unstable RSSI variation occurs.

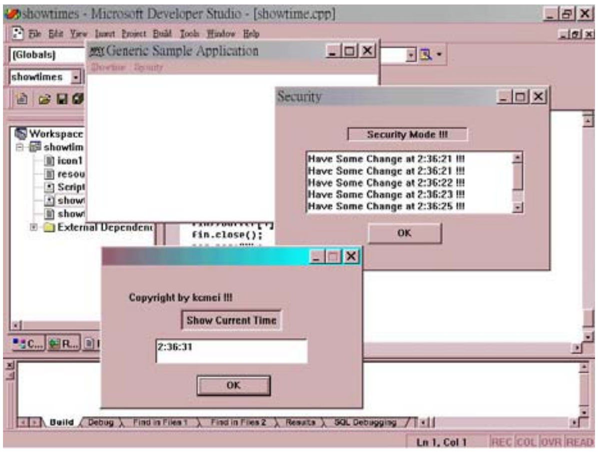

Figure 5: The detection time results of RSSI variation.

5. Conclusion

The equipment needed for this wireless security system using RSSI is very simple. It is so straightforward; even ordinary individuals or families can achieve this. Therefore, this method is being called the "simple and easy" wireless security system. The only drawback is the interference source has to be within the ideal "two-meter" radius in order for this technology to work properly.

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