



UNIVERSITI PUTRA MALAYSIA

**PERSONAL DIGITAL ASSISTANT (PDA) BASED CLIENT/SERVER DATA
COLLECTION SYSTEM**

NAGALETCHUMI BALASUBRAMANIAM

T FK 2004 106



**PERSONAL DIGITAL ASSISTANT (PDA) BASED CLIENT/SERVER DATA
COLLECTION SYSTEM**

By

NAGALETCHUMI BALASUBRAMANIAM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Partial Fulfilment of the Requirements for the Degree of Master of Science**

October 2004



Abstract of thesis presented to Senate of Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

**PERSONAL DIGITAL ASSISTANT (PDA) BASED CLIENT/SERVER
DATA COLLECTION SYSTEM**

By

NAGALETCHUMI BALASUBRAMANIAM

Chairman : Associate Professor Abd Rahman Ramli, PhD

Faculty : Engineering

Nowadays, in the competitive world, mobility plays an important role in the business and daily lives. Personal Digital Assistant (PDA) is one of the most actively developing areas in computer systems technology. PDAs start replacing PCs especially where PCs and Internet/Network technology do not reach. PDAs are being used to access, monitor, and control database management systems of organizations. This work investigates the issues involved in designing and developing a PDA based client/server data collection system for an inventory control of a hypermarket. This thesis also provides a comprehensive discussion on the software and hardware aspects of the data collection system. Personal Digital Assistant (PDA) module is used as a base unit in this research. Application software has been developed for the PDA and PC. Interfacing the software provides the system to function in a client server environment. The performance of the system in terms of memory usage by the PDA and synchronization time has



been studied, as these are important parameters from user point of view. Further integration of PDA with wireless technologies and other peripheral devices are discussed as future work of the research.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**SISTEM PENGUMPULAN DATA BERASASKAN KONSEP
PELANGGAN/PELAYAN**

Oleh

NAGALETCHUMI BALASUBRAMANIAM

Pengerusi : Professor Madya Abd Rahman Ramli, PhD

Fakulti : Kejuruteraan

Kini, keupayaan mudah alih memainkan peranan yang penting dalam dunia perniagaan dan kehidupan seharian. Pembantu Peribadi Digital (PDA) merupakan bidang yang membangun pesat dalam arena teknologi sistem perkomputeran. PDA mula menggantikan keperluan komputer, di mana komputer, Internet and sistem rangkaian tidak didapati. Penggunaan PDA kian menyerlah dalam sistem pengurusan data/maklumat organisasi. PDA digunakan sebagai alat untuk menyimpan dan mengawal pengurusan data organisasi. Kajian ini bertujuan untuk mereka bentuk rangka kerja dalam membangunkan sistem pengumpulan data berasaskan konsep pelanggan/pelayan. Sistem ini telah diaplikasikan untuk mengumpul data inventori di sebuah pusat perniagaan. Kajian ini juga akan membincangkan secara terperinci tentang keperluan perkakasan dan perisian untuk membangunkan sistem ini. Kajian ini berasaskan PDA sebagai modul utama. Perisian telah direkabentuk untuk keperluan pengumpulan data pada PDA



dan untuk keperluan penyimpanan data pada komputer. Integrasi kedua-dua komponen ini membolehkan sistem berfungsi berasaskan konsep pelanggan/pelayar. Kemampuan sistem yang direkabentuk dikaji dari aspek penggunaan ingatan pada PDA dan juga masa yang diperlukan untuk mensegerak data dari PDA ke komputer memandangkan ia merupakan parameter yang penting pada sudut pengguna. Sistem pengumpulan data ini boleh dipelopori untuk keperluan lain dengan penggunaan konsep dan teknologi yang sama. Penggunaan teknologi wayarles dan penggabungan perkakasan lain ke sistem turut dibincangkan untuk keperluan masa hadapan.

ACKNOWLEDGEMENTS

First of all, I would like to express my utmost gratitude thanks to my supervisor Assoc. Prof. Dr. Abdul Rahman Ramli, for his constant guidance and encouragement throughout the study. Thanks followed to Mr. Syed Abd Rahman Al-Hadad Syed Mohamed and Mrs. Wan Azizun Wan Adnan for their invaluable suggestions and guidance.

I owe a special thanks to my family and friends for their invaluable help, encouragement and support in completing this thesis successfully.

Special thanks to all my course mates and colleagues for their support and encouragement.

Finally, my appreciation to all those who in one way or another help me to complete this thesis.



I certify that an Examination Committee met on _____to conduct final examination of Nagaletchumi Balasubramaniam on her Master of Science thesis entitled “Personal Digital Assistant (PDA) Based Client/Server Data Collection System ” in accordance with Universiti Pertanian Malaysia (higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Sudhanshu Shekar Jamuar, PhD

Professor
Faculty of Graduates Studies
Universiti Putra Malaysia
(Chairman)

Elsadig Ahmed Mohamed Babiker, PhD

Lecturer
Faculty of Graduates Studies
Universiti Putra Malaysia
(Internal Examiner)

Khairi Yusuf

Lecturer
Faculty of Graduates Studies
Universiti Putra Malaysia
(Internal Examiner)

Khairuddin Omar, PhD

Associate Professor
Faculty of Information Science and Technology
Universiti Kebangsaan Malaysia
(External Examiner)

GULAM RUSUL RAHMAT ALI, PhD

Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date :



This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Abdul Rahman Ramli, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Syed Abd Rahman Al-Hadad Syed Mohamed

Faculty of Engineering
Universiti Putra Malaysia
(Member)

Wan Azizun Wan Adnan

Faculty of Engineering
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date :



DECLARATION

I here declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

NAGALETCHUMI BALASUBRAMANIAM

Date :



TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APROVAL	vii
DECLARATION	ix
LIST OF TABLES	xiii
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvii

CHAPTER

1. INTRODUCTION	
1.1 General Overview	1
1.2 Personal Digital Assistant (PDA)	2
1.3 Electronic Data Collection System	4
1.4 Problem Statement	5
1.5 Objective	7
1.6 Scope of the Thesis	7
1.7 Methodology	8
1.8 Thesis Organization	9
2. LITERATURE REVIEW	
2.1 Introduction	11
2.2 Previous Work on PDA	13
2.3 PDA Architecture and Features	33
2.3.1 Processing Unit	35
2.3.2 Operating System	35
2.3.3 Memory	36
2.3.4 Batteries	37
2.3.5 LCD Display	38
2.3.6 Input Device	38
2.3.7 Input/Output Devices	39
2.4 PDA Operating System	40
2.4.1 Palm Operating System	41
2.4.2 Windows CE	47
2.4.3 EPOC	51



2.5	PDA Connectivity	55
2.5.1	Protocols	56
2.5.2	Wireless Protocols	57
2.6	PDA Security	61
2.6.1	Identification	62
2.6.2	Authentication	62
2.6.3	Authorization	63
2.6.4	Device Security	64
2.7	PDA Synchronization	66
2.7.1	Palm HotSync Protocol	67
2.7.2	Intellisync	70
2.7.3	SyncML	72
2.7.4	CPISync	73
2.7.5	Scalability	75
2.8	Client/Server Model	78
2.8.1	Two-tier Client-Server Architecture	80
2.8.2	Three-tier Client-Server Architecture	82
2.9	Summary	86
3.	RESEARCH METHODOLOGY	
3.1	Introduction	89
3.2	Overview of System Concept	90
3.3	System Analysis	91
3.3.1	System Engineering Approach	91
3.3.2	Identifying Users of the System	92
3.4	System Design	92
3.4.1	Hardware Selection	93
3.4.2	Software Selection	96
3.5	Structure of the System	101
3.5.1	Architecture of the System	101
3.5.2	Software Design of the System	104
3.6	Development and Implementation of the System	105
3.6.1	PDA Application Software Design and Development	105
3.6.2	Designing and Developing the Database and User Interfaces for Local Server/Terminal and Central Server	111
3.6.3	Integrating Sub-Components into One System	112
3.7	Application Interaction	113
3.8	Testing and Evaluation Method	114
3.8.1	Memory Usage Experimental Studies	115
3.8.2	Synchronization Time Experimental Studies	116
3.9	Summary	117



4. RESULTS AND DISCUSSION	
4.1 Introduction	119
4.2 System Operation	119
4.2.1 Data Collection on PDA	120
4.2.2 Transferring Collected Data to Terminal/PCs	127
4.2.3 PC Application	128
4.3 System Evaluations Results	136
4.3.1 Memory Usage	136
4.3.2 Synchronization Time	142
4.4 Conclusion	146
5. CONCLUSION AND FUTURE WORK	
5.1 Conclusion	147
5.2 Future Work	149
5.3 Summary	151
REFERENCES	152
APPENDICES	156
BIODATA OF THE AUTHOR	164



LIST OF TABLES

Table		Page
3.1	Comparison of Palm and Pocket PC Operating System	94
3.2	Comparison of PDA data Collection Software	97



LIST OF FIGURES

Figure		Page
2.1	A supporting flowchart made by GUNGEN using GMemo on a PDA	14
2.2	System setup of 'ALWAYS' home-visiting nurse station support system	18
2.3:	Distribution of agents and agencies in intelligent monitoring system of elderly	20
2.4	System Configuration for an ATOS-PDA System	22
2.5	Example of PDA-based I2C bus analysis system with multiple masters and four slave devices	24
2.6	The framework of mobile surveillance services	25
2.7	The IPMS System	27
2.8	The overall scheme of the experiments done with the CPIsync algorithm	29
2.9	Basic InfoFlo Infrastructure architecture diagram.	32
2.10	Basic components of a PDA	34
2.11	Palm OS Architecture	42
2.12	Windows CE Architecture	48
2.13	EPOC OS Architecture	52
2.14	An appointment schedule modified on different devices: a home machine, an office machine, and a PDA	68
2.15	A comparison between the two modes of Hotsync-Slow Sync and Fast Sync.	70
2.16	An Intellisync Anywhere server installed on accompany network	72



2.17	Scalability strength and weaknesses of the different synchronization protocols.	75
2.18	Two-tier Client/Server architecture design	81
2.19	Three Tier Distributed Client/Server architecture depiction	84
3.1	High level structure	92
3.2	Architecture of PDA based data collection system	103
3.3	Software interrelationship of the PDA based data collection system	104
3.4	The main part of the prototype software	107
3.5	The flow of the prototype software to input new inventory data	108
3.6	The flow of the prototype software to edit the existing inventory data	109
3.7	The flow of the prototype software to delete the existing inventory data	109
3.8	Application interaction of the system	114
4.1	The main form of the database designed on PDA	122
4.2	Second form designed of the PDA	123
4.3	Third form designed on PDA	124
4.4	Fourth forms designed on PDA to input new inventory counts	125
4.5	Fifth form designed on PDA to edit inventory data	126
4.6	Sixth form designed on the PDA which pop up as items are selected to be edited from the fifth form	126
4.7	Seventh form designed on the PDA to delete inventory record	127
4.8	User Login Form	129



4.9	Main Screen Form	130
4.10	Item Master Form	131
4.11	Staff Master Form	132
4.12	Vendor Master Form	133
4.13	Purchase Form	134
4.14	Database Backup Form	135
4.15	Database Recovery Form	135
4.16	Memory taken by the application software versus the number of inventory record on PDA	139
4.17	Memory Taken by the Application Software Versus Number of Preliminary Information Downloaded to the PDA and Number of Inventory Records Collected of PDA	140
4.18	Synchronization time required to synchronize a fixed numbers on inventory data collected (50 records) on a PDA to varying size of database on PC	143
4.19	Synchronization time required to synchronize a varying numbers on inventory data collected on a PDA to a fixed size of database on PC (3500 record)	145



LIST OF ABBREVIATIONS

API	Application Programming Interface
CAPI	Cryptographic Application Programming Interface
CGI	Common Gateway Interface
DAO	Data Access Object
DBMS	Database Management System
ECG	Electrocardiogram
EEPROM	Electrically Erasable and Programmable read Only Memory
GNU	GNU's not Unix
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IrDA	Infrared Data Association
IrMC	Infrared Mobile Communication
JDBC	Java Database Connectivity
JVM	Java Virtual Machine
LAN	Local Area Network
LCD	Liquid Crystal Display
MIPS	Multipurpose without Interlocked Pipeline
ODBC	Open Database Connectivity



OLE	Object Linking and Embedding
PDA	Personal Digital Assistant
PKI	Public Key Infrastructure
RAM	Random Access Memory
RMI	Remote Method Invocation
ROM	Read Only Memory
RTOS	Real Time Operating System
SSL	Secure Sockets Layer
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol/Internet Protocol
USB	Universal Serial Bus
VM	Virtual Machine
WAP	Wireless Application Protocol
WIM	Wireless Identification Module
WML	Wireless Markup Language
WTLS	Wireless Transport Layer Security
WWW	World Wide Web
XML	Extensible Markup Language



CHAPTER 1

INTRODUCTION

1.1 General Overview

The ever-fast innovation and diversification of development in the computer systems and mobile technology have brought significant impacts to our daily lives. One of the most active areas of computer system development today is Personal Digital Assistant or PDA.

PDA is replacing PC especially where PC and Internet/Network Technologies do not reach. This is true as today's world demand the necessity of miniaturization and its thirst to execute the latest technology is escalating.

Mobile and wireless devices such as cellular phones, pager, and PDAs are widely used to get information. People want to send and get information freely, that is, at anytime any locations. So it is practical for people to have a handheld computer in a pocket rather than a desktop or laptop and to have access to information whenever and wherever they need it.



The characteristics and advantages of a PDA have been exploited for well-beings of mankind. PDA based systems are used in government sectors such as education, healthcare, rural development, transport system, social marketing, and agriculture. On the other hand, PDA based systems are used in private sectors such as pharmaceuticals, healthcare, wholesale, retail, distribution, telecom, communications, banking, and insurance.

PDA based systems are used vastly due to its benefits and the device characteristics. The device attracts the end users by being user friendly and providing portable technology. The electronic data collection systems develop based on PDA are an effective reach system, while eliminating redundancy of data, paperwork, and swift in implementation of various management activities.

1.2 Personal Digital Assistant (PDA)

PDAs have recently become a popular organizing and planning tool as they serve the function of cumbersome pen-and-paper day timers, address books, and to do lists in a compact, user-friendly electronic format. PDAs are not bigger than an average sized calculator. There are wide varieties of PDAs available for both business and personal market. Some PDAs also support other functions, such as video playback and voice recording.



PDA is a portable device that can receive, manipulate, and send information. With the functions the device can provide, it increases the flexibility for users. Furthermore, it has large range of applications on it. These applications can be manipulated to increase the productivity and mobility of business, ease our livings and others. Moreover PDAs are compatible with a variety of operating systems and has low maintenance cost. Generally PDA encompasses most of the flexibility and power of a laptop and personal computer but in a pocket-sized form.

PDAs do not develop their full potential unless they are connected to applications and services through the Internet. There are a number of ways how a PDA can be connected to the desktop data. They are direct serial connection which most of the current users are familiar with, dial-up connection, and network connection.

Wireless technology gives an important breakthrough for PDA users and software development organizations to develop applications and services based on PDAs. Several wireless protocols for PDA already exist and most are evolving rapidly.



1.3 Electronic Data Collection System

Data collection technology has taken giant leaps forward over the last 30 to 40 years. Earlier days, pencil and paper approach were widely used but today, numerous devices and options are available for gathering data. The optimal choice depends on several factors, including the complexity of the task, the speed, accuracy, and documentation required. Data collection systems range from the simple to the complex, with a range of performance and functionality.

Electronic data collections become popular as it provides several advantages over the conventional data collection methods. Elimination of clipboards, paper maps, handwritten worksheets, and the collection of more data in less time are a few basic advantages over the conventional paper based data collection methods.

Other advantages includes the elimination of data re-entry, branching, real-time error checking, an integrated Global Positioning System (GPS) interface, and enhanced data integrity. Collecting data using pen and paper eliminates the task of transferring data into electronic format. Post-processing of data into electronic media often involves manual data entry, which susceptible to error. This process is often time-intensive and costly.



Furthermore, electronic data collection is an efficient and effective mean of collecting data. The capabilities of this system are only limited by the ability of the mind to find new applications for the technology.

1.4 Problem Statement

Nowadays, mobility has become an important factor in determining the productivity and enhancement of a business. On the other hand, PDA, are no longer seen as an executive toy but an important business and consumer tool. The features of the device, which is small, portable and light, increase the flexibility for the users. Moreover, PDA can be used as a powerful electronic data collection device. With that, PDA based handheld system is proliferated across many areas both in the government and non-government sectors.

As the business world is getting more and more complicated, many governmental and non-government organizations are facing problem in data management system. Data management system ranks from data collection, monitoring, and analysis as well. A flexible, electronic and mobile data collection system is needed to overcome the obstacles in today's competitive business world. The system must be able to receive, manipulate, and send data to the main server to be updated and allow the end users to exchange data among them.



PDA is a flexible, electronic, and mobile device. It is also capable of acting as a temporary storage of data. It minimizes the time and effort spent in the conventional method. Integration of the handheld system into the current heterogeneous system will provide a significant competitive advantage to forward-thinking organizations by extending the functionality of mission-critical applications to internal users wherever and whenever they need it. The return in both financial term and in organizational efficiency and effectiveness is compelling.

Even though, many systems exist for PDAs, systems designed to work in an integrated client/server environment will serve better the need of the users, (Carroll, 2001). Developing a data collection system which has the ability to link the data collected on PDA (client) to a central database (server) will provide the users of the system with unlimited advantages. Data synchronized from PDAs to terminals at different locations could be linked to the central database and any data updated on the central database could be distributed to the terminals and to the PDAs through the future synchronization.

This was the main motivation of this research, developing a data collection system in client/server environment. The system will offer the users an unlimited advantages and the system can be expanded to any other applications.