A FINAL REPORT ON:
SMART CARD TECHNOLOGY

AUTHORED BY:

AREERAN PANYAPHOL
9620297
DEPARTMENT OF INFORMATION SYSTEMS

SUPERVISED BY:

DR. AHMAD FAROOQ
DEPARTMENT OF INFORMATION SYSTEMS

" IN PARTIAL FULFILLMENT OF THE DEGREE OF BACHELOR OF MANAGEMENT INFORMATION SYSTEMS "

KULLIYYAH OF ECONOMICS AND MANAGEMENT SCIENCES
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA.
53100 JALAN GOMBAK
SELANGOR DARUL EHSAN, MALAYSIA.

الجامعة الاسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيورسيتي إسلام انتارابغسا ملايسيا

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2001

"in partial fulfillment of the degree of Bachelor of Management Information Systems"

Kulliyyah of Economics and Management Sciences
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53100 Jalan Gombak
Selangor Darul Ehsan, Malaysia.

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ACKNOWLEDGMENTS

All praise is due to Allah (SWT), His beloved prophet Muhammad (SAAS) and his faithful companions (RAA). With the help and guidance endowed by Allah (SWT), I was able to finish this final year project report.

I would like to express my sincere gratitude and respect towards my supervisor, Dr Farooq Ahmad, for his fatherly guidance, kind encouragement, constructive comments and suggestions. May Allah (SWT) blesses and rewards him for his sincere endeavor and contribution in the way of knowledge.

My thanks and appreciation are also upon all lecturers of Information Systems Department IIUM. I would also like to express my heartfelt love towards my beloved parents; Ismail Panyaphol and Nafeesha Panyaphol, my younger brothers and sisters, and my future wife Fara Wahida Mod Rifat for her supports. I also would like to express my gratefulness to all who directly and indirectly involved in the production of this report

Last but not least, I hope this report would bring great benefits to all citizens of International Islamic University Malaysia (IIUM) especially administrators and system developers towards improving the effective and up-to-date of using student card, *Insyaallah.*

Project Introduction

Project Title: Smart Card Technology

Project Start Date: Semester I, 2000/2001

Project Finish Date: Semester II, 2000/2001

Project Supervisor: Dr. Farooq Ahmad

Project Objective:

- To conceptually, logically and physically analyze the design of smart card database system to be used within International Islamic University campus.
- To provide an informal environment to introduce and explain smart card technologies, applications and smart card scheme implementations
- To provide in-depth, practical understanding of smart cards and an insight into future possibilities
- To provide guidance and practical help in the planning, development and management of a smart card implementation

The smart card will assist in improving university performance and create a convenient and easy way for both staff and students to deal with any functions of university. Importantly, this project will partially fulfill my degree in Bachelor of Management Information Systems.

Approach:

- Research on smart card technology
- Design interface on smart card usages
- Design local and global database systems
- Use of Microsoft Visual Basic, Microsoft Access and other necessary tools in designing

Scope of the project: This final year project deals with the fundamental concepts of smart card technology. For the advancement in new era, many universities have been implementing the idea of smart card to replace a student card. A smart card is therefore a new innovation emerging to link a wide variety of university services through a single identification card. Thus, my project will mainly focus on designing and analyzing the databases to be used by the smart card within the university campus. The project will span over two consecutive semesters and will be covering mainly the following areas:

Progress Reports

1. Overview of Smart Card

- What is a smart card?
- What is the smart card architecture?
- What are the difference types of smart card?
- What are their capabilities?
- What are other comparisons?

2. Possible usage of smart card within university (Mainly focus on interface)

- Academic (Examination and Registration)
- Clinic
- Library
- Student Attendance
- Canteen / Cafeteria
- E-purse / transaction
- Lab Entrance (Access Control)
- Bus Fare

3. Identification function to be dealt with by smart card

- Data requirement of each function
- User's view of each function
- Local database design
- Global database design

4. Summary of the project and recommendation for future research

Semester I (2000/2001)

- Overview of Smart Card
- Possible usage of smart card within university
- First progressive report
- First Work Assessment 50% completed

Semester II (2000/2001)

- Identification function to be dealt with by smart card
- Summary and future research
- Project final report
- Final Work Assessment 100% completed

Description

The main descriptions of project work are attached with this report in the following page

CHAPTER ONE

OVERVIEW TO A SMART CARD

1.1 What is a Smart Card?

Smart Card is a small electronic device about the size of a credit card that contains electronic memory, and possibly an embedded integrated circuit (IC). The chip allows the card to carry a much greater amount of information than a standard magnetic-stripe card. It is also the source of the card's smartness allowing it to process as well as store information.

There are three types of integrated circuit cards: simple memory card, hardwired logic card and microprocessor card. The term smart card is used in different ways by different organizations, but the International Standard Organization defines a smart card as a card with a chip.

1.2 Technology of Smart Card

In this section we will see how does a smart card look like. The card provides student ID and contains a student's colorful photo, student's name, card expired date, and electronic chip that contains information of the cardholders as in the figure 1.1.

Figure 1.1: A Smart Card

The above university card contains three different types of technology: the University Library Barcode, an infrared barcode strip and a smart chip. Not all cards will have all of the technology.

1.2.1 Barcodes

The barcode is the same version as the barcode that appears on the library card and will be used in the same way. The aim is to eventually phase out the barcode when the University Library no longer requires it.

1.2.2 Infrared Strip

The infrared strip appears along the bottom edge of the card. This is used for building access and the black strip is swiped through a reader. Where the card is compatible, the University Card Services can supply the manager of a department or college door access system with the information regarding the cards and the infrared barcode number. This information would then be inputted into the appropriate door access database and assigned a level of access for that card in the usual way. This will enable one card to be used in a number of different department/college door access systems, where compatible.

1.2.3 Smart Chip

The inclusion of the smart chip will enable future developments to be devised without the need to update cards and new hardware.

1.3 Smart Card Architectures

In this part we will analyze the overall architecture of the smart card, terminals and card readers that make up the system.

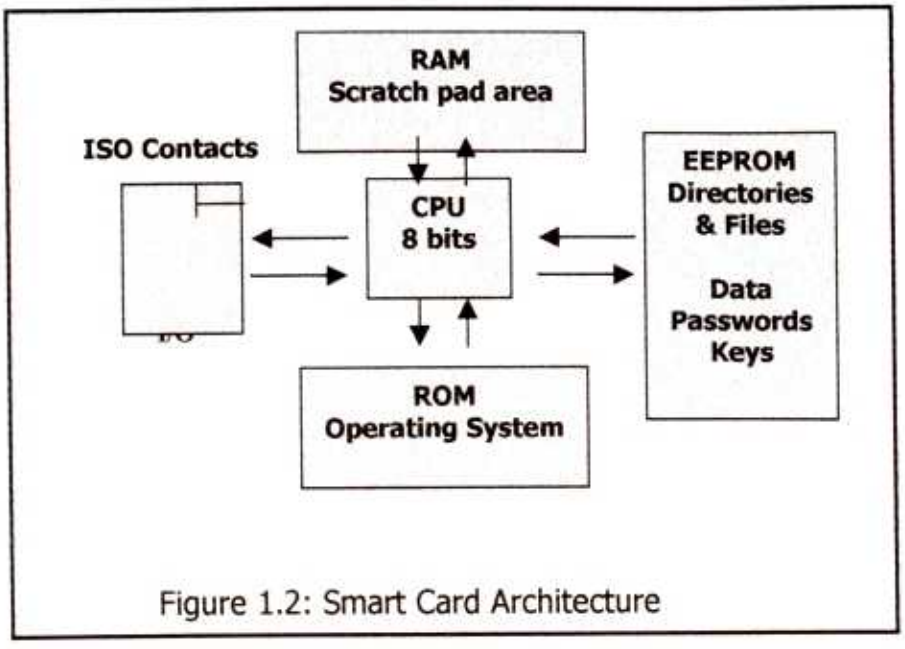

Figure 1.2: Smart Card Architecture

Figure 1.2 illustrates the typical layout of a chip and the amount of space required for each of the different types of storage and processing elements. As you can see, the largest area on a per-bit basis is the RAM, followed by EEPROM. The smallest area is the PROM or ROM produces during manufacturing.

Semiconductor manufacturers and smart card produces have a number of possible options available to them in designing the sizes of the various elements. Most chip card applications today require a minimum of 8K of program memory to support an application. Many advanced applications such as GSM cards often require additional ROM sizes. EEPROM memory areas provide space for data storage ranging form ½ K to 8K or 16K. These large memory sizes come at a tremendous cost, through, since the physical area of EEPROM memory increase by a factor of 4 over that of ROM.

Comparing with the traditional 125 bytes magnetic stripe, smart card provides larger storage capacity ranging from 1K bytes to 64 K bytes. It comprises of a microprocessor (CPU), ROM, RAM, EEPROM and a serial communication interface, which will be elaborated in later.

Smart card systems have typically been implemented using assembly-level or another low-level language to program the applications that are loaded inside the cards and terminal readers. These programs allow the card and the reader to communicate with programs written with higher-level software, such as COBOL or C, on host computers.

Improvement in software technology and in the smart cards themselves should encourage the development of more effective ways of creating smart card programs by using interpreter, applets (such as Java).

1.3.1 Memory

Memory cards, and all smart cards for that matter, have some from of memory storage. Memory cards are primarily designed for storing information or values and are commonly used for applications such as disposable prepaid telephone cards used in public telephones. Memory cards have product options such as register size and memory access time that need to be considered when developing smart card applications. Larger registers allow more data to be accessed or processed at one time. There are two types of memory cards: EEPROM (storage-only) memory cards and memory cards with registers.

1.3.2 EEPROM (Storage-Only)

An EEPROM memory card is a storage card with rewritable memory. These cards are used to store information such as a buyer profile for loyalty card programs or database information that might be carried from one application to another. EEPROM memory card can be designed as free memory in any format since no standard regulate the allocation of data space inside the card. You can access memory in this kind of card via either a pointer increment processes controlling access to specific information or by reading memory in one continuous stream.

1.3.3 Register

These second and third generation cards, with very limited memory sizes, use an abacus-style counting method. The abacus method uses a limited-intelligence-register approach. The registers use hard-wired logic to decrement a large number through a series of counter stages with decreasing values. When all the counter stages have been exhausted, there is no money or value left on the card. Since these cards are not rewritable, they are discarded.

1.3.4 Microcontroller

Microcontroller-based cards are truly smart card. They contain a microprocessor unit, RAM, ROM, mass storage (usually EEPROM), input/output hardware, and an operating system. The micro processing unit uses a set of instructions that gives it the ability to process mathematical operations such as addition, subtraction, multiplication, and division. It also has the logic to control the various element of the device. The chip contains a random access memory (RAM) that may vary in size from a low of about 128 bytes to a high of 256 bytes. RAM memory will increase over time as applications require more short-term storage space because of their complexity. Read-only memory (ROM), which stores the fixed programs, is also included in this fixed allocation of the physical space on the silicon chip. The last memory area to be included is a mass storage area, which ranges from 1 kilobyte to approximately 64 kilobytes. Mass storage smart card is the same as in a PC disk drive, only much more limited, and it ise used for storing the results of an operation. The information can then be used again in subsequent processing steps. This rewritable memory area will also increase over time as multi-application systems are implemented and increased amount of information must be managed by the smart card.

The input/output hardware is called the universal asynchronous receiver/transmitter (UART). All of the components of the card are connected to the UART, which is in turn connected to the pins that provide physical access to external peripherals such as terminals, printers, and PIN pads. Most cards today require 5 volts to operate. Power for the card is received from the terminal. It is expected that the next generation will require only 3 volts.

1.4 Selecting the right Smart card options

As a system is built, whether is be for library, health care, finanacial services, a specific set of options must be chosen and trade-offs made to maximize the avialble memory and limited processing abilities fof the smart card. Memory can be used for specific, relatively simple, prepaid applications like bus tokens. When the application is more complex, a microcontroller-based card system should be considered. The following options should be considered in the decision-making process:

1.4.1 Dedicated Coprocessors

Dedicated coprocessor can be incorporated on microcontroller cards to perform more complex functions – for example, fast, dynamic authentication of a security key that nominally should be accomplished in less than 1 to 2 second. This hardware is similar in designing to floating-point processors and consists of a large parallel set of registers used to perform specific mathematical operations. In a microcontroller, a dedicated coprocessor that is designed to process 64 – or 128-bit word sizes requires only a limited number of instructions. These instructions are typically arithmetic instructions such as long multiply, long divide, long compare, and various remainder provisions.

1.4.2 Silicon Size

There is a practical limit to the size of the silicon that can be successfully and reliably embedded in a plastic card. Current technology sets this boundary at about 25 square millimeters. There are additional factors, including the complexity of the software and the mask hardware, that require trade-offs in the size of the ROM (fixed program) versus the variable-program RAM or EEPROM locations. ROM and RAM are relatively inexpensive when compared to EEPROM.

1.4.3 Operating System

The interface between the smart card and the terminal provides the physical and logical access to the data on the card. The application code for this interface resides in both the card and the terminal under the control of the respective operating systems. As applications grow in complexity, the physical space in ROM on the card side of the interface will prohibit further operating system functionality unless new approaches are created to implement the interface.

1.4.4 Security

A major consideration is the method in which the security will be designed into the product. This should include the method for conducting a secure session between a card and a terminal. Security choices must be made concerning whether to require authentication before a transfer of information can occur or to allow some parts of the

cards to stay open while other remain closed until they are successfully unlocked using a key-based challenge and response.

1.4.5 Card Reader

A smart card Reader is an electronic device about the size of a deck of cards that you attach to your PC (the attachment works similar to your mouse hook-up). The Reader acts as the interface between your computer and the chip in the Smart card, allowing them to communicate with each other. Once attached, the Reader actually "reads" your chip, allowing you to view the information stored there and to securely pass that information when you choose.

1.5 The role of "Standards" in Smart Card

What are standards? According to international Standards Organization (ISO), " Standards are documented agreement containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose." Standards are required to ensure that cards and card-accepting devices are built to uniform specifications. This ensures that cards manufactured and issued by one industry sector in one part of the world can be accepted by a device in another part of the world. These cards and devices may support many different types of industries so that, for example, payment cards may be accepted in card-accepting devices at gas stations. This is possible because there are international standards in place. The International Organization for Standardization (ISO) has developed standards for smart cards. These standards were developed for use by multiple industries. Individual industries are now developing proprietary versions of these ISO standards to support their own specific smart card applications. These are designed to conform to the standards issued by ISO. The goal is to ensure uniform standards for smart cards that will allow interoperability of cards among a wide array of industries. There are numerous standards developed by members of the Forum (ISO), and others, to support and promote smart card standards.

1.6 Types of Smart Cards

Smart cards are defined according to the type of chip implanted in the card and its capabilities.

1.6.1 Plastic Card Standard The early application developers adopted the existing standards for cards with magnetic stripes and embossing as their reference points. These standards established the physical characteristics of plastic cards and fixed the location of the magnetic stripe on the back and the embossing on the front of the cards. The chip and module can be positioned on the card without violating exiting standards, thus allowing a migration from magnetic stripe card to chip card. Existing magnetic stripe cards have limited capacities to carry information. A smart card carries more information than can be accommodated on a magnetic stripe card. It can make a decision, as it has relatively powerful processing capabilities that allow it to do more than a magnetic stripe card (e.g., data encryption).

1.6.2 Contact Card Standard A contact smart card requires insertion into a smart card reader with a direct connection to a conductive micro module on the surface of the card. It is via these physical contact points, that transmission of commands, data, and card status takes place. It is the most commonly used smart card among the four. It can be easily distinguished by the sharp gold plate chip on the card as show in figure 1.3.

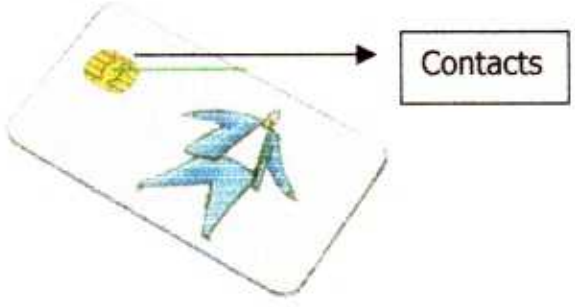

Figure 1.3: Contact Smart Card

In figure 1.4 shows the micromodule embedded into the plastic substrate or card. Prior to embedding, a cavity is formed or milled into the plastic card. Then either a cold or hot glue process bonds the micormodule to the card.

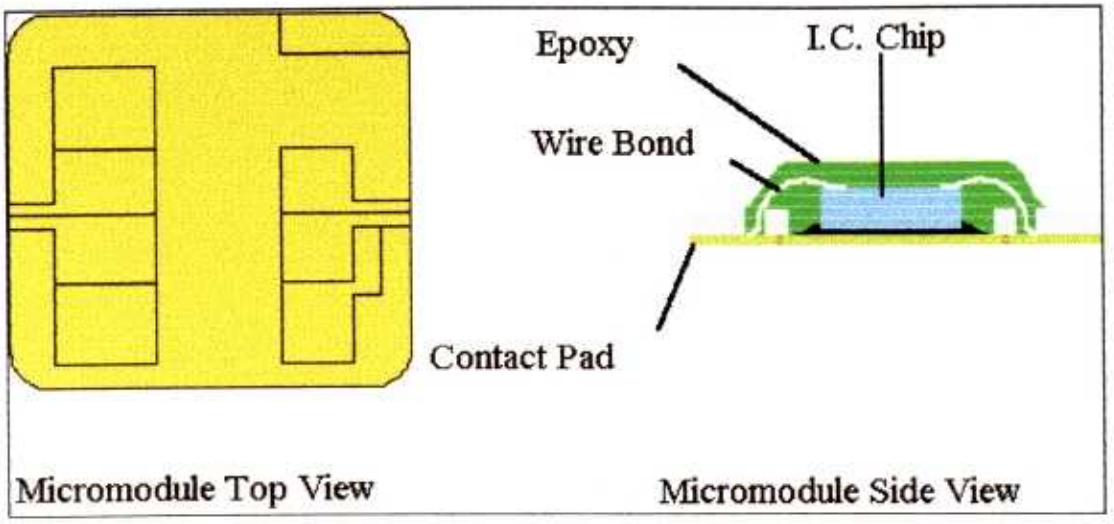

Figure 1.4: Contact Chip Diagram

1.6.3 Contactless Card Standards A Contactless card requires only close proximity to a reader. Both the reader and the card have antenna and it is via this contactless link that the two communicate. The range is typically two or three inches for non-battery powered cards, and this is ideal for applications such as mass transit that require very fast card interface. There are two types of contactless cards. The first is a contactless proximity card in which the card is read by inserting it in a special reader. The second is a remote contactless card in which the card can be read from a distance, such as at a toll booth, airline "electronic tickets," and public transport.

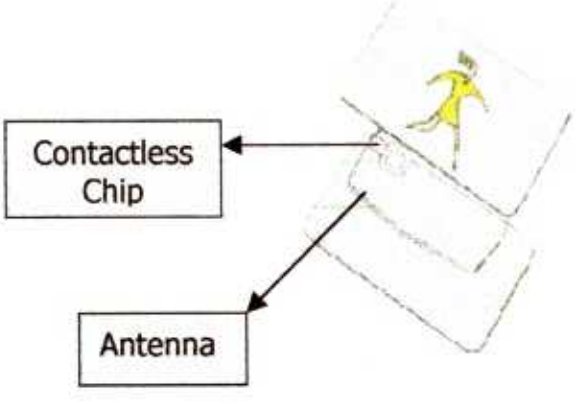

Figure 1.5: Contactless Smart Card

Figure 1.5 shows the top and bottom card layers which sandwich the antenna/chip module. The antenna is typically 3 – 5 turns of very thin wire (or conductive link), connected to the contactless chip.

1.6.4 Combi and Hybrid Card Standard Two additional categories derived from the contact and contactless cards are Combi cards and Hybrid cards. A hybrid card has two chips, each with its respective contact and contactless interface. The two chips are not connected, but for many applications, this Hybrid serves the needs of consumers and card insurers. Just emerging is the Combi card which in a single chip card with both a contact and contactless interface, with a very high level of security. The mass transportation and baking industries are expected to be the first to take advantage of this technology.

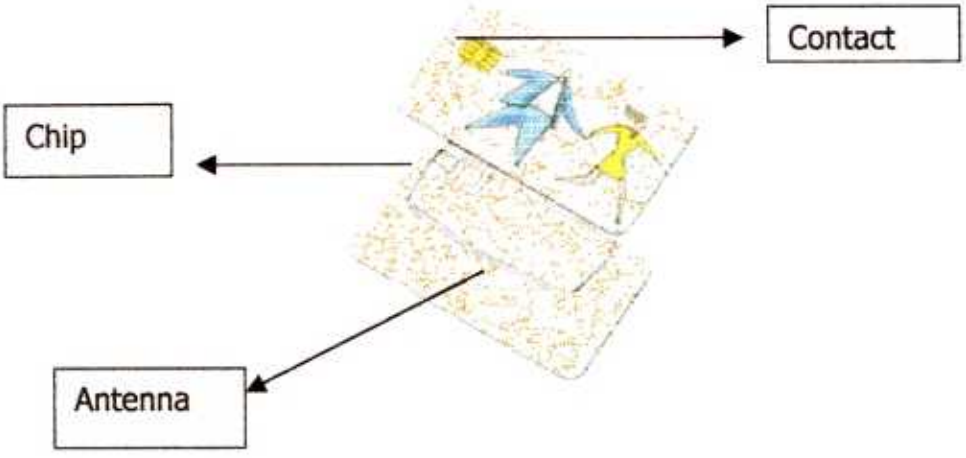

Figure 1.6: Combi and Hybrid Card

Figure 1.6 shows both the contact and contactless elements of the card. A Combi has only one chip while a Hybrid card has two.

1.7 Smart Card's Capabilities

1.7.1 Provide increased utility Your financial institution could expand your access to the information, products, and services they provide. Smart cards can communicate with a wide variety of devices that provide account access such as point-of-sale terminals, ATMs, personal computers, mobile phones, telephones, and many others. Smart cards can also be used to conduct secure transactions over the Internet. Smart cards will give financial institutions the power to offer you more convenience. Smart cards will provide acceptance at merchants who now only accept cash, such as newsstands, vending machines, and laundromats. As the "access key" to many accounts, the chip reduces the number of cards that must be carried. In fact, smart cards can be used to access all of a customer's accounts, since they are able to store information about multiple financial applications.

1.7.2 Handle multiple applications A smart card has the capability of carrying multiple applications. A multiple application card can support different types of applications (e.g., healthcare, financial services, travel, and loyalty programs) on the card itself thereby reducing the number of cards in the wallet. Smart card can solve a multitude of problems – from a simple identification system, to providing a highly secured and convenient automated currency option. The multi-application card features personal identification and dormitory security, banking, and a wide range of stored value functions for the purchase of food, books, photocopying and vending services.

1.7.3 Improve the Services Smart card could highly improve the service. Using smart card reduces the cost of cash handling and fraud and theft with the associated security.

1.7.3.1 Education

The smart card can be as a student matric card as well as library, access, e-purse, health, etc. it can be used to access information over the Internet for distant learning and also to access students' academic records. Universities and other institutions of higher learning can track their students progress inexpensively but efficiently via an off-line devices.

1.7.3.2 Government

Smart cards offer a number of opportunities to central and local governments seeking to find out more about individual citizens and their needs so that they can improve the services offered. Smart cards can be used to provide citizens with secure access to information and services over the Internet, as well as a convenient means of accessing physical rooms and buildings.

1.7.3.3 Financial Services

For retail banks and other financial organizations, smart cards provide a perfect way of reducing the chance of fraud and theft, while also providing clients with a more convenient, secure, multi-propose card which enhance their loyalty. The solution can be used by financial providers looking to offer their customers e-purse, credit card and debit card functionality on a single card which can also host a variety of applications from other industries.

1.7.3.4 Military Applications

Smart card is a multi-application management card and issuing system that allows you to create and operate a smart card scheme tailored precisely to your needs. The utilization of smart card have been proven in the field by US defence forces in application ranging from weapons, ammunition, medical, dental immunization and deployment management. Additionally, smart card can provide cashless environment on military bases and ships. Implementations of this type deliver substantial operational savings by eliminating the collection, management and handling of cash plus associated losses and risks.

1.7.4 Greater amount of information Details about student can be stored on the electric chip in the card as well as being printed on the face of the card. As smart card technology offers significant storage capacity, a greater amount of information can be stored on the chip (securely encrypted if necessary).

1.7.5 Integrate with current system Benefit from smart card technology while maintaining existing infrastructure. This flexibility allows the university to decide what needs to be maintained and those requiring upgrading. Smart card can integrate with the existing security, access system, library software and the university databases.

1.7.6 Offer higher security Smart cards actually offer more security and confidentiality than other financial information or transaction storage vehicles. A smart card is a safe place to store valuable information such as private keys, account numbers, passwords, or valuable personal information. It's also a secure place to perform processes that one doesn't want to expose to the world, for example, performing a public key or private key encryption. Chip cards have computational power to provide greater security, allowing verification of the cardholder. Entering a PIN is one method of verification. The benefit of the smart card is that you can verify the PIN securely, off-line.

1.7.7 Offer a number of important benefits Smart cards actually provide more benefits to both card issuers and their customers. For instance, for the card issuer:

- Lower cost of cash handling
- Improved security and reduced fraud
- Full audit trail and system integrity provided by a centralized management system
- Reduced administration cost in terms of mail shots
- A reduction in cost of delivering local services
- Personnel identification

1.7.8 Provide an extraordinary amount of expandability Instead of putting the university and other institution resources' into a programme that limit future possibilities, smart cards offer them the opportunity to invest in a programme that exceeds current needs and provide answers to questions yet to arise.

1.8 Comparison of Smart Cards

Amount of Chip

Contact	1 chip
Contactless	1 chip and 1 antenna
Hybrid & Combi	A Hybrid has 2 chips, while a Combi has 1 chip

Security

Contact	Significantly more secure
Contactless	Less secure than contact smart card at present
Hybrid & Combi	A very high level of security

For users with disabilities

Contact	Have few positive benefits for disable people
Contactless	Have considerable benefits and provide interesting application for navigation and identification of landmarks, technical installation Have many positive attributes of benefits to a wide range of disable people

Transportation Ticketing

Contact	Are used in convenience and significantly greater time taken
Contactless	Commonly used, take less time

Smart Card Standard

Contact	ISO 7816 series
Contactless	ISO 14443 standard