SMART CARD APPLICATION DESIGN

by

John Smeh, B.Bus(Hons) VUT, BSci VUT, Dip.Sci. VUT

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ABSTRACT OF THE THESIS

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This study investigated sociotechnical criteria in the design and specification processes of smart card based projects through a case study. The adoption of the innovations in the case study was investigated.

The study consisted of three phases: analysis, design and implementation. These were in relation to sociotechnical design criteria and its incorporation into a design methodology.

Results from this study indicated that the adoption of the innovations was largely based on the design and specification processes. A formal model for these processes was constructed based on the case study.

A recommendation for ongoing research into the refinement of the model presented is suggested. An extended research project may focus on the model, or on one specific component.

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PREFACE

The primary purposes of this study were to provide a basis for the generation of a model of the smart card design process incorporating sociotechnical design criteria.

The development of a design methodology is an essential step to increase business acceptance and understanding of the technology.

The study is reported in five chapters. Chapter 1 presents an introduction to the problem, beginning with an analysis of the past and current states of smart card and related technologies. The problem is stated in general and then in specific terms.

Chapter 2 is a formal review of the literature of smart card technology and sociotechnical methodologies.

Chapter 3 describes the research design, which included the use of case study with a group of collaborating organisations. The case study consisted of several smart card based projects and their design and specification processes.

Chapter 4 presents analysis of the data obtained through the case study. Analysis addressed the identification of phases of the concept and specification processes. Descriptive analysis of the sociotechnical objectives and the innovation adoption perceptions, and appropriate inferential analyses are presented.

Chapter 5 presents conclusions and recommendations for further research. References, and a bibliography follow.

CHAPTER 1 INTRODUCTION

A smart card is a credit card sized plastic card that contains memory and a microprocessor beneath (typically) contact pads. This circuit stores information in an electronic structure that can easily, securely and accurately be retrieved by smart card equipped terminals. Following the introduction of smart cards in banking and telecommunications, further development has been ongoing in public transport, medical services and retail shopping.

The growth in smart cards for financial transactions is being coupled by the use of the memory capabilities of the cards for data storage in areas such as the health sector (Zoreda, J.L. & Otón, J.M. 1994, p.145).

The state of smart card development would indicate a technology looking for a purpose. It is a product that needs diffusion into a larger market. A single purpose smart card has very little attraction to a user.

A single card may hold several functions with different purposes, protection stipulations, and complexity. It is mentioned by Zoreda et al.(1994, p130) that the multipurpose smart card faces several impediments before it achieves common use:

'Unless we issue as many cards as applications that our user requires (thus producing packs of cards like the current ones), we must agree with other personalizers on crucial details concerning data handling and storage. Even worse, the applications need not materialize at the same time or in the same place; in a multipurpose card, the eventual presence of unknown applications must be foreseen from the very first issue of the card containing perhaps just one application.'

The multipurpose smart card can also be described as a universal smart card. The only difference is that the term universal implies a much wider use than a few applications.

A universal smart card can be in theory used on any smart card equipped device with a reasonable expectation of successful interaction.

Smart card (intelligent card) systems evolved in the 1970s and progressed through the 1980s, however, their globalisation and potential has not yet been achieved. In some countries, France for example, they have been accepted and implemented to a very high degree, while in others the technology is just emerging. Research into the sociotechnical and proprietary issues has highlighted some of the relevant factors that account for the slow proliferation of such systems.

The research question investigated was: **How has the design of smart card based systems influenced their adoption?**

The null hypothesis that was tested: $\mathbf{H_0}$: **There is no impact to the adoption of smart cards by the design process.**

An innovation can be an idea, practice or object that is perceived as new (Rogers, E.M. 1995 p.11). For this research the innovation considered is the smart card. Adoption is a decision to make full use of an innovation as the best course of action available (Rogers, E.M. 1995 p.21). Diffusion is the method by which an innovation is conveyed over time among the members of a social system (Rogers, E.M. 1995 p.5). The rate of adoption is typically measured by the length of time required for a social system to adopt an innovation (Rogers, E.M. 1995 p.23).

Rogers (1995 p.7) makes an important comment regarding innovation diffusion, which is very much valid in the case of smart cards:

> *'Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realized by potential adopters, and that the innovation will therefore diffuse rapidly. Seldom is this the case. Most innovations, in fact, diffuse at a disappointingly slow rate.'*

To understand the innovation, the smart card, and its adoption, this research sought to understand the design issues and innovation systems involved.

Sociotechnical Systems Theory (STS) is an open systems approach that endeavours to optimise the association between the social and technical elements of a system (Beekun, 1989 p.877). The present research analyses these underlying principles from a business perspective and proposes a set of procedures (a model) for the design of smart card applications. These procedures are based on the integration of a sociotechnical design model with the various design stages of a smart card application.

This research presents a modelling approach, the waterfall model, which was applied to smart card systems in a case study. The major design phases adapted from the waterfall model include concept, specification, design and implementation.

The case study used in this research is Australian based. This geographic limitation does not preclude its validity worldwide due to the globalisation of business and technology. The innovation is actually limited largely by overseas conditions as the smart card chips are all manufactured outside of Australia. So the same relative technical issues are valid worldwide as for Australia.

The size of the case study with the participating organisations does limit result analysis and possible conclusions. The size of the case study was limited due to the number of organisations in the smart card industry in Australia at the time that were willing to participate. Thus any statistical significance is negated and the results should be viewed with a potential towards a form of future research and theory generation.

The unit of research for the case study was a group of Australian small and medium sized enterprises (SMEs) involved in the smart card industry and covered a two year period (1996 – 1998). Some of the organisations were Australian based divisions of large multinational organisations that operated independently and were thus considered in the SME category. This research presents a framework for the design of smart card applications from a SME perspective. It provides a straightforward approach to the application design that a SME type of business can follow.

CHAPTER 2 LITERATURE REVIEW

The smart card revolution has been underway in France and other European countries for more than 10 years (Fancher, 1996 p.25). The U.S. along with the rest of the world has been lagging. One of the major instigators of the deployment of smart cards has been telecommunications policy as suggested by Fancher (1996 p.25):

> *'In the U.S., where telephone calls are cheap and it is a simple matter to attach a magnetic-stripe reader to a telephone line, the fraud-reduction aspects of smart cards are not necessarily worth the extra expense. Instead merchants can dial up a central database to make sure a card is valid before completing a transaction. In Europe, where calls are generally more expensive and connecting modem-equipped devices to phone lines is more difficult, security was a significant driving force behind smart card introduction.'*

This security requirement is a major benefit in favour of the smart card. Smart cards contain a number of hardware and software security features (Zoreda et al. 1994 p.39). These features are based on data access control and the use of encryption techniques for software, and by the IC (Integrated Circuit) during manufacture for hardware.

Since smart cards provide both software and hardware security their use is set to rise with the evolution of new IC technology being able to create smaller and faster circuitry.

Another motivation 'for smart-card introduction in the U.S. today is the possibility of multiple uses for the same card' (Fancher, 1996 p.25). It is possible, so far only in theory, to have a smart card that can be used for personal identification, a credit card, a medical record carrier and as a cash substitute. The possibilities are only really limited by industry and end user acceptance for these electronic media.

The development of smart card applications has traditionally been a lengthy and difficult process (Chen, Z. 2000 p.7). The smart cards are standardised in size, shape and communications protocols. The internal workings and software interfaces however have not been standardised.

The Card Standards

The standardisation of plastic cards is handled by the International Organisation for Standardisation (ISO). The various ISO standards relating to plastic cards cover everything from the placement of contacts on the face of a smart card (ISO 7816-2) so that any card and reader will be able to interface, to the placement of embossed characters on plastic cards (ISO 7811-1 1995).

Unfortunately, 'standardisation in the card world was a consequence of market trends rather than a previously agreed-on framework' (Zoreda et al. 1994 p.3). The ISO 7816 series of standards, which are constantly in a state of flux, are devoted to chip cards. It is rare to find cards and applications that completely comply with the ISO standards. Presently several consortiums are developing sub-standards, for example the EMV standard from Europay, Visa, and MasterCard which extends parts of the ISO 7816 standards.

The following sections review the basic concepts and main features of the current plastic card technologies - magnetic stripe cards, optical cards and chip cards. All these card technologies share the same plastic substrate. The only difference is the way the information is stored and retrieved. It is an interesting feature that often plastic cards will share the same features, for instance a smart card may also contain a magnetic stripe (Zoreda et al. 1994 p.3).

Magnetic Stripe Cards

ISO 7811 contains a description of the position, size and other characteristics 'of a 0.5-inch magnetic stripe located either in the front or rear surface of the card' (Zoreda et al. 1994 p.3).

A magnetic stripe in cards is divided into three longitudinal parallel tracks (Figure 2.1). The first and second tracks hold read-only information and the third track may be written to.

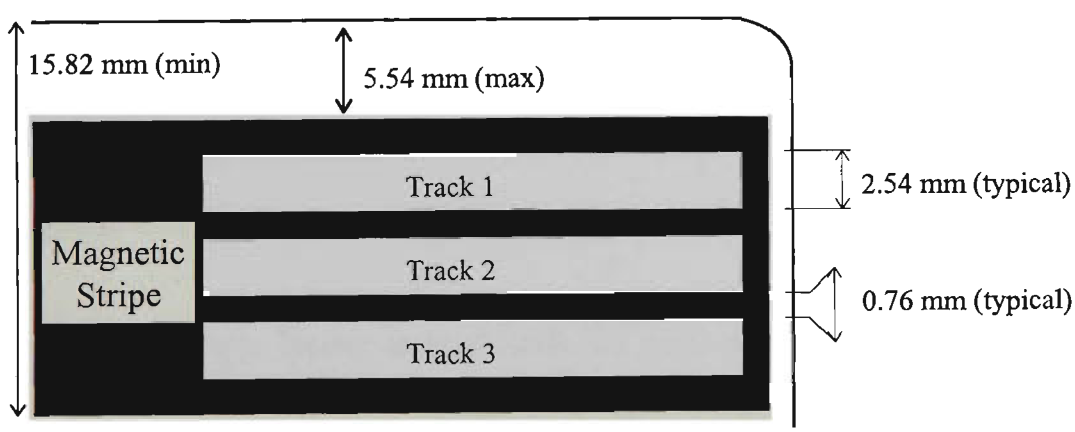

Figure 2.1 Location and dimensions of magnetic stripe track.

Source: Zoreda et al. 1994, p.4.

It is relatively easy to read and alter a magnetic stripe (Zoreda et al. 1994 p.4).

Track one of the magnetic stripe is reserved for the International Air Transportation Association (IATA) for automating ticketing applications. It has a 210-bpi (bits per inch) storage density, which makes room for 79 alphanumeric characters (Zoreda et al. 1994 p.3).

Track two was proposed by the American Bankers Association (ABA) to permit on-line financial transactions. It has a storage density of 75-bpi, which results in a 40 numeric characters capacity (Zoreda et al. 1994 p.4).

Track three is used for financial transactions. It has a storage density of 210-bpi, and may only contain up to 107 digits. It is rewritten every time the track is used (Zoreda et al. 1994 p.4).

Optical Cards

Optical cards, also known as laser cards, are made of 'two layers: one very thin, highly reflective layer covering a second, nonreflective layer (or the other way round: a nonreflective layer on a highly reflective one)' (Zoreda et al 1994 p.4). These layers are then covered by transparent protective plastic layers.

Optical cards are not erasable. They work on the same principle as a CD-ROM - write once, read many times (WORM). The main advantage of this technique is the large capacity - a typical optical card can store over 4 MB of data.

Chip Cards

The term chip card is often used to describe a circuit containing card. This type of card always contains some amount of erasable or nonerasable memory, and possibly a microprocessor (Zoreda et al. 1994 p.5).

There exist two families amongst the chip cards:

- Memory Cards Without A Microprocessor.

Typically they hold less than 1 Kilobyte of nonrewritable memory. They cannot be reprogrammed and execute preprogrammed instructions. A typical application would be prepaid phone cards.

- Smart Cards With A Microprocessor.

In practice a smart card is a microcomputer lacking a power supply, display and keyboard. The card typically has several kilobytes of memory (usually RAM, ROM and EEPROM). All data access is via the microprocessor. Some modern cards have maths coprocessors to handle cryptographic algorithms.

The main advantage of a smart card is its security. Their microprocessors are very useful (Rhee, M.Y. 1994 p.449):

> *'... not only for data storage, but for information processing as well. They store, process, and control internal cryptographic algorithms, and are thus eminently suitable for establishing identity, and enhancing logical security.'*

The security aspect can be a major emphasis in the selling of smart card technology. Cards used for security and financial purposes incorporate many very different security measures, each of which adds to the difficulty of using a card fraudulently or producing a counterfeit card (Hendry, M. 1997 p.9).

Design Criteria – Standards

During the evolution of smart cards a number of standards and specifications have been defined to ensure that the cards, card acceptance devices, and applications can work together (Chen, Z. 2000 p.24). The following section lists some of the prominent standards and specifications.

ISO 7816 Standards

Published by the International Organization for Standardization (ISO), ISO 7816 Integrated Circuit Cards with Contacts, describes 'the locations of the contacts' (Dreifus, H. & Monk, J.T. 1998 p.32) and more. It comprises a number of sections that define the physical characteristics, layout, data access techniques, data storage techniques, numbering systems, and registration procedures (Dreifus, H. et al 1998 p.32).

- Part 1 – physical characteristics
- Part 2 – dimension and location of contacts
- Part 3 – electronic signals and transmission protocols
- Part 4 – interindustry commands for interchange
- Part 5 – application identifiers

- Part 6 – interindustry data elements

- Part 7 – interindustry commands for SCQL

GSM

The telecommunications industry currently deploys the majority of smart cards for use in GSM (Global System for Mobile Communications) (Dreifus, H. et al 1998 p.5). A GSM phone has a subscriber identity module (SIM), which is a smart card.

The GSM as defined by the European Telecommunications Standards Institute (ETSI) is a specification for a an international terrestrial mobile telephone system (Chen, Z. 2000 p.25). There are several relevant GSM standards:

- GSM 11.11 - specification of the SIM-mobile equipment interface

- GSM 11.14 – specification of the SIM application toolkit for the SIM-mobile equipment interface

- GSM 03.48 – security mechanisms for the SIM application toolkit

- GSM 03.19 – SIM API (Application Programming Interface) for the Java Card Platform

EMV

Europay, MasterCard and Visa defined a specification based on ISO 7816 with proprietary features to meet the needs of the financial industry:

- EMV '96 Integrated Circuit Card Specification

- EMV '96 Integrated Circuit Card Terminal Specification
- EMV '96 Integrated Circuit Card Application Specification

Open Platform

The Open Platform defines card and terminal specifications as well as development tools. It works across different cards and operating systems but standardises the process for back-end systems such as personalisation, key management and application loading. It allows smart card issuers to select between operating systems and application development tools while making available a core security and card management technology. The Open Platform specifications are owned and managed by the GlobalPlatform organisation.

The Open Platform specifications were initially developed by Visa and now have been transferred to GlobalPlatform (Chen, Z. 2000 p.26).

OpenCard Framework

The OpenCard Framework (OCF) architectural model 'makes a distinction between applications and service developers on one hand and card and terminal providers on the other' (Hansmann, U., Nicklous, M.S., Schack, T. & Seliger, F. 2000 p.84). The aim 'is to reduce dependence on each of these parties as well as dependence on the platform providers' (Chen, Z. 2000 p.26).

Since the first Network Computers had smart card readers, 'the idea of a Java framework for smart card access was born.' (Hansmann, U. et al 2000 p.81). It seeks to provide a standard interface for interacting with smart card readers and applications in the card.

PC/SC

The PC/SC Workgroup is an industry consortium to define a general purpose architecture for smart cards on personal computers.

OCF and PC/SC are similar in concept. OCF can access a card reader device on a Windows platform through a PC/SC resource manager (Chen, Z. 2000 p.26).

The ISO 7816 group of standards provide a framework for the other standards. For example, how the data is arranged and how a file is retrieved. The other standards are at the application level. For example, what format the data is in or which application the data belongs to. It is at this application level that a consensus must occur to have any true interoperability.

New Technologies

There are several new developments that are steadily growing in popularity in the smart card industry – Multos and Java Card.

They are not smart card operating systems, but are application programming interfaces (API). They define software program calling conventions with which an application accesses the operating system and other services.

Essentially they are an attempt to put a standardised interface between the smart card operating system and the application. Some of the benefits of this approach are:

- Application development will be easier.
- Security will be improved with an extra layer of protection.
- Hardware independence will be increased.
- Multiple applications will be possible with the extra security features.
- Backward compatibility with ISO 7816 standards.

The expectations of these new innovations have increased with each new iteration of the API. For instance the Java Card API 1.0 was introduced in November 1996. The latest version was Java Card version 2.1.1.

Expectations

The expectations for the smart card were most likely set high by the industry. In a networked world, the mass media and the smart card industry has increased the knowledge of the technology amongst society.

The progress 'toward worldwide interoperability lay in the establishment of international standards' (Guthery, S.B. & Jugensen, T.M. 1998 p.34). The optimism of the smart card industry seemed to have been based on technological issues. Yet numerous products ended in failure (Rogers, E.M. 1995 p.79).

In 1997, Hendry (p.6) listed several reasons why smart cards might be about to enter a period of rapid growth:

- The main patents have expired and the field is therefore free for many more players, possibly including some smaller and more innovative companies, to enter the market.

- Concerns about the security of the main competing technology, the magnetic stripe, have increased, and it may now be cheaper to replace the technology than to continue to upgrade the security of magnetic stripe cards.

- Several applications that are strongly linked to smart cards (such as health cards, digital mobile telephony, electronic purses, and satellite television decoding) are themselves growing rapidly in almost every country.

- The potential market for electronic purses and telephone cards in the former planned economies and the developing world is estimated at over a billion cards a year.

This potential growth was also illustrated in 1998 (Dreifus, H. et al. pp.4-14) with a worldwide market growth of smart card systems in many different industries, the declining cost of smart cards, and emerging electronic commerce systems.

The optimism of the industry was evident still in 1999:

'Finally, 1999 will be the year of the smartcard in Australia. After years of talk and trials and fiddling at the margins, smartcards will play a significant part in Australian commercial life over the next 12 months and beyond.' (Phillipson, G. 1999 p.35)

The smart card might be recognised by some as the next generation financial transaction card (Hansmann, U. et al 2000 p.15). Despite this it has not been adopted into everyday life in Australia.

Freedman, G. (2000 p.1, 7) discusses the 'fading of many blue-sky speculations about a smart card in every hand has not weakened industry faith in the productive future of the technology'. The reality behind the marketing of the technology shows that 'while suitable technology standards and real shipping product have been available for years, the adoption of smart cards has still fallen far short of even the most cautious early predictions' (Braue, D. & Groves, B. 2000 p.41).

Smart cards do have many advantages, yet there is no clear design or implementation path visible for smart card implementation in a practical business environment other than general design descriptions found in various literature (Kaplan, J.M. 1996, Hendry, M. 1997, Rankl, W. & Effing, W. 1997, Dreifus et al. 1998, Guthery, S.B. et al. 1998).

Sociotechnical Design Principles

Sociotechnical Systems Theory is an open systems approach that seeks to optimise the association between the social and technical systems of an organisation (Beekun, 1989 p.877).

It is simply a system design methodology that incorporates social considerations (Cooper, J., Gencturk, N. & Lindley, R. 1996 p.3).

Purser (1992, pp.383-384) describes the general principles of sociotechnical design according to the principles stated below.

Principle 1: Compatibility of the design process.

> *'This principle simply states that the process by which technology and organizational structure is designed and implemented must be compatible with the needs of multiple and diverse users.'*

Principle 2: Variance control.

> *'Sociotechnical design of an organisation should result in the control of 'variances' at their source. What this means is that the social system of organization should be designed and equipped to detect, correct, and eliminate technical errors, defects, or problem states before they become transmitted to other locations or departments downstream.'*

Principle 3: Boundary location.

> *'According to this principle, boundaries in the organization should not be drawn where task interdependencies require close coordination, and the sharing of information, knowledge and learning.'*

Principle 4: Deliberation legitimisation.

'Decisions in a non-routine, highly integrated technical environment require well designed social deliberations (ie. Meeting, teams, committees, etc.) to support and coordinate integrated activities. The process by which key technical decisions are made in tightly integrated systems is a crucial determinant of organizational effectiveness. Thus, specific attention must be focussed in the topology of the decision-making process.'

Principle 5: Redundancy of functions (the multi-functional principle).

'Sociotechnical theory is built upon the principle that organizations are open systems which must continually adapt to their environments if they are to ensure their own survival. The open systems view maintains that the organization must obtain and transform inputs to valued outputs. This transformation, or technical conversion process, consists of a series of interrelated steps. ... Traditionally, organizations have viewed people who perform technical tasks as redundant parts. While highly specialized and narrow jobs may afford the organization some degree of flexibility (because the cost of replacing these parts is minimal), this flexibility is limited to the short-term. ... The contribution of sociotechnical theory has been to offer an alternative, variety increasing form of work organization, based on a key design principle of building redundant functions. With this type of design, variety and flexibility is gained through multi-functional skilling and combining disciplines into integrated work teams.'

A Sociotechnical Approach To Smart Card Systems Design

Presently there is only a limited amount of research available involving sociotechnical systems and smart cards. The majority of the available research originated in Australia from Cooper et al. (1996).

Cooper et al. (1996) reported a case study, in which the collective smart card experiences of Australian firms known to be adopting smart card technology was analysed. They also presented a way of incorporating a sociotechnical strategy appropriate to the introduction of a smart card technology system.

Cooper et al. (1996 p.6) provided the following illustration of their interpretation of a model for a sociotechnical design system.

For completeness, the model is reproduced here (Figure 2.2). The reader may find it helpful to refer to Cooper et al. (1996) for a complete discussion on their interpretation and application of a suitable model.

It should be noted here that an exhaustive search has resulted in Cooper et al. (1996) as being the principle instigators for research in the field of smart card design.

This investigation also drew on the innovation adoption and diffusion work by Rogers (1995). In particular it looked at Rogers criteria for successful diffusion with respect to adoption in the Cooper et al. model for a sociotechnical design system.

Therefore, the work of the thesis adapted the Cooper et al. (1996) results into the various phases of the development of a model. It must be noted that it is not possible to create a single model of a sociotechnical system (Lindley, R. 1997 p.167). Each sociotechnical model draws on experience obtained elsewhere. Consequently each sociotechnical model is different.

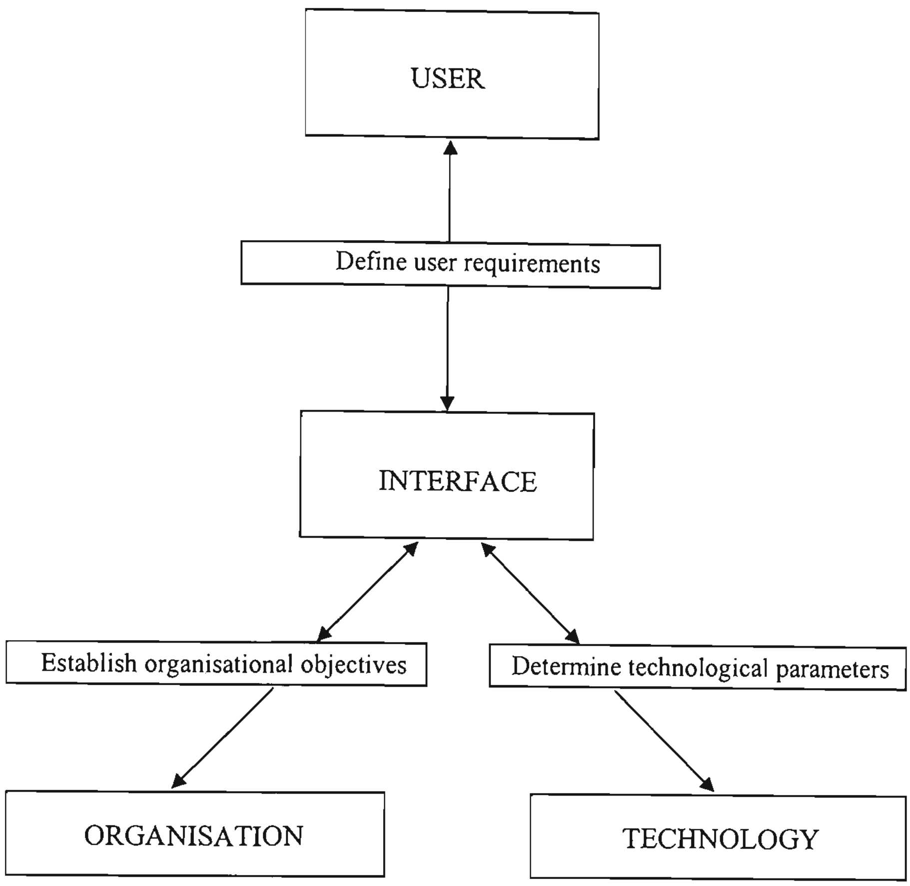

Figure 2.2 Model of a sociotechnical design system

Source: Cooper et al. 1996, p.6.

This model attempts the '... joint optimisations of the technical and social aspects [which is] not easy unless social scientists take the time to learn enough about the technology to understand the kinds of options that the technology can offer.' (Cooper et al. 1996 p.6)

Cooper et al. adopted this model as a basis for their case study. This meant that the examination of the systems design strategy implemented by each project included the operational objectives listed in Table 2.1.

Key sociotechnical objectives for smart card systems design
• Establish an appropriate user awareness effort $_{S1}$
• Conduct pre-design user consultation $_{S2}$
• Conduct design stage user consultation $_{S3}$
• Conduct implementation stage user consultation $_{S4}$
• Develop an on-going user consultation plan $_{S5}$
• Maintain existing or alternative means to access the service provided $_{S6}$
• Make the design provide an improved quality of life $_{S7}$
• Produce a design compatible with both user and organizational goals, and within the predetermined technological parameters $_{S8}$
• Ensure that the system has ongoing design flexibility $_{S9}$

Table 2.1 Identified key sociotechnical objectives.

Source: Cooper et al. 1996, p.7.

The reader should note that Table 2.1 shows how each objective is tagged by a reference numbered from S1 – S9 (Smeh, J. & Adam, T. 1998 p.417). These references are applied later in this research to the respective phases of a design process, in a model adopted and expanded from Rankl, W. & Effing, W. (1997 p.284).

Cooper et al. concluded on the basis of their case studies that '... there is a high level of use of sociotechnical principles across the various projects and that this high level is maintained at an operational level through all stages of design from planning through to implementation' (1996, p.9).

While this may be true for the organisations that were surveyed by Cooper et al., it only serves to show an appendage to a completed smart card project. It would be more beneficial to analyse and apply their 'key sociotechnical objectives' in a live project or case study.

Lindley (1997 p. 219), a co-author in the Cooper study, continued with an analysis of four distinct stages of smart card innovation:

1. Feasibility Trials 1974-1985

2. Single Applications 1985-1995

3. Multiple Applications 1995-2005

   'Over the past two years, a number of projects involving multiple applications and operating on a national or global scale were announced and associated trials began. This period of development can be associated with the potential use of multiple applications, the increased scale of projects and involving the need for several organisations to cooperate.'

4. Market Maturity and Standardisation 2005-

This research is placed in Stage 3: Multiple Applications. This is considered in the analysis of the case study and is a consideration in the design of the resulting smart card systems.

CHAPTER 3 METHODOLOGY AND METHODS

This undertaking is an applied research endeavour. A descriptive research methodology is most appropriate as it allowed the researcher to actively participate in the project rather than being an observer. This allowed the researcher to directly observe Cooper et al's sociotechnical objectives.

According to Hedrick, T.E., Bickman, L. & Rog, D.J. (1993), the overall purpose of descriptive research is to provide a picture of a phenomenon as it naturally occurs, as opposed to studying the impacts of the phenomenon or intervention. Descriptive research can be designed to answer questions of a univariate, normative, or correlative nature (i.e., describing only one variable, comparing the variable to a particular standard, or summarizing the relationship between two or more variables).

Resulting data consisted of:

- self-reports (eg., attitudes and circumstances of individuals),
- observations (eg., events or actions), and
- various kinds of documentary evidence (eg., letters, meeting minutes, plans, reports).

A case study was conducted with the assistance of several collaborating organisations. The case study incorporated several smart card projects which involved the same collaborators (SMEs). This case study provided the data referred to above. The data was used to validate a range of criteria.

The collaborators in the case study were used to refine a smart card design methodology (Figure 3.2) and to test the null hypothesis (H_0).

Figure 3.1 shows the various components of the research process and its links to Cooper et al's sociotechnical design model.

The case study followed Cooper et al's sociotechnical objectives format. This involves three parts: analysis, design and implementation. These parts are intertwined under the sociotechnical design system (Figure 2.1) with the result being the 'interface' as seen in the figure.

More specifically, this involved discussions with users and collaborators, and considerations of the impact of the technology.

The research draws on experience with the collaborators at all levels of their organisational structures where available. Information from point of sale terminals was sought to obtain behavioural patterns; other considerations, for example, standards, were dealt with through the technical collaborators.

The design methodology that was used for building the procedural model was developed from the analysis of interviews, administrative records, observations and documentary evidence from the above mentioned analysis, design and implementation phases.

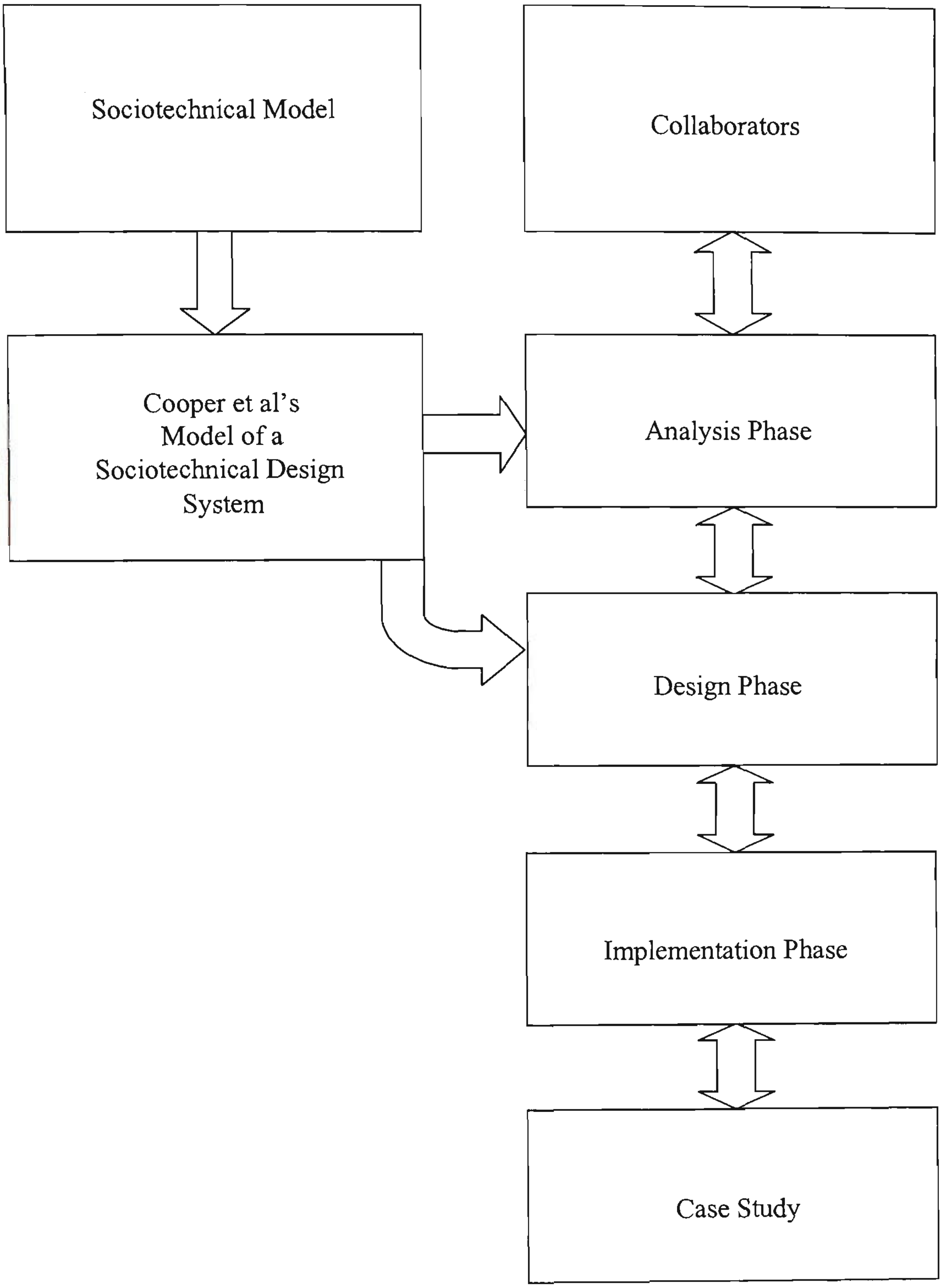

Figure 3.1 Research Process.

The implementation of the key sociotechnical objectives assisted in developing a systematic design - implementation methodology for smart cards in the business world.

The criteria for this design methodology are:

- Smart Card Standards (ISO 7816)
- Range of Applications (Banking/Financial, Medical Services, Telecommunications, Transport, Retail Shopping, Customer Loyalty Scheme)
- Sociotechnical Issues (Organisational Objectives, User Requirements, Technical Requirements)
- Security Features

In the design of a system where the ownership of information gives the system value, security concerns must be addressed for both economic as well as sociotechnical reasons.

The previously mentioned collaborators provided access to their resources so that information could be collected to analyse, design and implement this model.

This undertaking was an applied research endeavour. As formerly stated a descriptive research methodology was the most appropriate as this allowed the researcher to actively participate in the project rather than being an observer. This allowed the researcher to directly implement Cooper et al's sociotechnical objectives.

The material presented in this research results partly from a comparative study of innovation management practises in the case study. It draws on interviews, meetings and project participation with the case study collaborators. It was not possible to collect project level data from all the collaborators. This was due to the size of some of the corporations, the geographic location of some of the projects and the ever changing business world.

Interviews with collaborators lasted a number of hours. Each interview began with a series of open ended questions. These questions were aimed at furthering an understanding of the organisational functions, scope, size and methods. Often these interviews also continued in the form of formal and informal meetings and telephone conversations.

Open ended introductory questions were intended to allow respondents the chance to explain the company's smart card design processes and management practises. This however did not always work as intended. Often the collaborators were cautious and wary of potentially giving away latent competitive information to an outsider. This resulted in frequent return site visits, confidence and trust building periods. This situation prolonged the research process.

The result was a view from an internal perspective of several smart card based projects. The questions asked were complex and technical enough that no one person in any of the organisations was able to answer. Although this also increased the frequency of contacts, it provided a enhanced view of internal procedures as a denizen.

Figure 3.2 illustrates the research process undertaken with respect to the case study and the research question. The models and processes presented are the result of iterations into the case study projects. The models and processes presented incorporate step by step procedures that are designed for a business to follow.

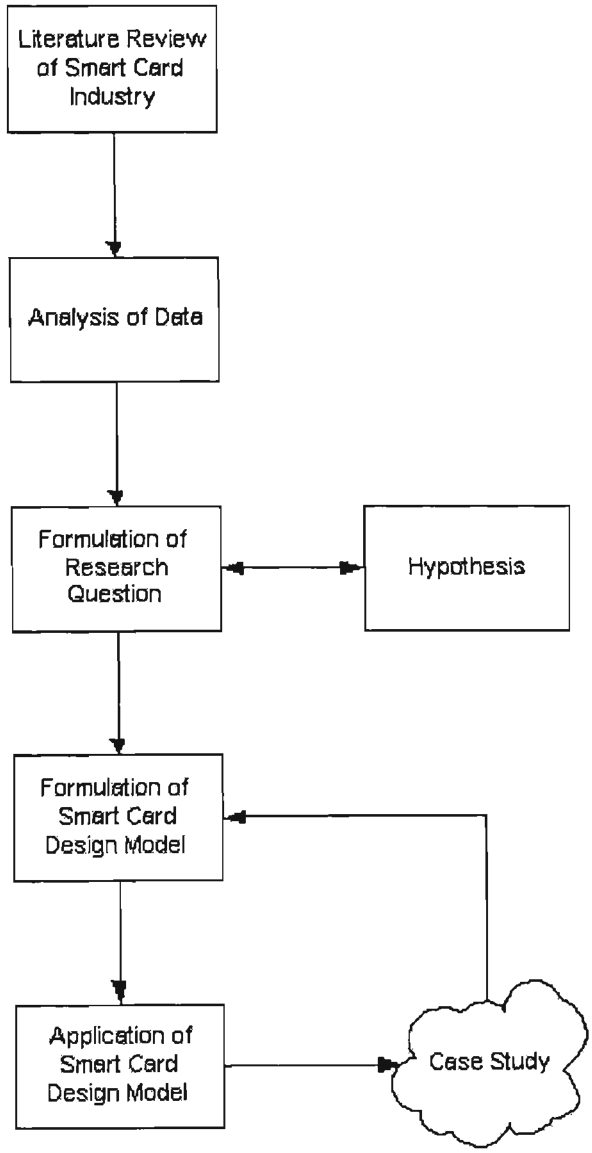

Figure 3.2 The research process and the iteration of the design model.

CHAPTER 4 DATA PRESENTATION AND ANALYSIS

Presently there is only a limited amount of research available involving sociotechnical systems and smart cards. The majority of the available research originates in Australia from Cooper et al. (1996) and Lindley (1997).

Cooper et al. (1996) describe a case study, in which the combined smart card practice of Australian firms that had implemented smart card technology were examined. They also present a way of incorporating a sociotechnical strategy appropriate to the introduction of a smart card technology system. This study describes the design procedures and issues, and how these incorporate the various sociotechnical criteria in the design phase of smart card applications.

Although these sociotechnical objectives are identified for smart card systems, they are actually general sociotechnical objectives that can be associated with any type of technology.

Several collaborators were involved in this research. These collaborators can be described by the initial criteria of location and industry involvement. The definition of the business size used in this research is as follows. Small businesses are classified as those having fewer than 20 employees, medium sized businesses are classified as those having 20 to 199 employees, and large businesses as those having 200 or more employees (Australian Bureau of Statistics 2000).

The collaborator criteria of location, whole business size, Australian smart card business size, and smart card industry activity are combined in Table 4.4. The reason for separating the two criteria, whole business size and Australian smart card business size, was due to some organisations having international operations. This provides a realist representation of the collaborators organisations. For example, Collaborator A has international operations, yet only has a sales division for smart cards in Australia.

The interplay of five forces that were also examined: commerce and competitive issues, financial issues, technology issues, labour force issues, and the demographics will be discussed with reference to each collaborator later.

Location
1. Australia
2. Europe
3. North America
4. South America
5. Asia
6. Africa

Table 4.1 Location criteria.

Smart Card Industry Activity
1. Manufacturer
2. Integrator/Reseller

Table 4.2 Smart card industry activity criteria.

Number of Employees	**Business Size**
< 20	Small
20 – 199	Medium
> 200	Large

Table 4.3 Business size defined by number of employees.

Data source: Australian Bureau of Statistics (2000)

Collaborator	Location	Whole Business Size	Australian Smart Card Business Size	Smart Card Industry Activity
A	1, 2, 3, 4, 5, 6	Large	Small	Manufacturer
B	1, 2, 3, 4, 5, 6	Large	Small	Manufacturer, Integrator/Reseller
C	1	Small	Small	Integrator/Reseller
D	1	Medium	Small	Integrator/Reseller

Table 4.4 Collaborator criteria combined.

Collaborator Descriptions

Collaborator A (ColA)

This organization is a large multinational that manufactures smart card chips and other technical products, and sells to other manufacturers and integrators. There is a sales division in Australia for smart cards. ColA also has a division that sells Point of Sale (POS) solutions.

Collaborator B (ColB)

This organization manufacturers smart card capable POS (Point of Sale) devices and other associated equipment internationally. They sell directly to both integrators and the final customers. ColB has developers in Australia and hence can customise POS solutions to sell to their customers.

Collaborator C (ColC)

This organization customises POS devices. They have been investigating the possibilities of smart card systems replacing their traditional magnetic stripe based systems as used in their customer loyalty applications. Their other products are promotional schemes for the purposes of brand loyalty such as scratch tickets and the marketing that surrounds such promotions.

Collaborator D (ColD)

This organization is both a customer of Collaborator C and a reseller of other related products. They add their own hardware and software to other products to make customised solutions for the food, beverage and entertainment industries that appear at the point of sale.

The Case Study

The case study was not simple by any definition. It involved several organisations, each with a vested interest in gaining market share. The peculiar element of this study, and perhaps an indication of the industry, was that regardless of being competitors they were also each others customers.

To illustrate this, a situation in point. Collaborator D (ColD) would purchase a POS system from either Collaborator C (ColC) customised, or directly from Collaborator B un-customised. ColD could them purchase smart card chips directly from ColA and have another party embed them in plastic and program them or have ColB or ColC organise it.

Decisions such as these were made at a senior management level and often involved internal politics and business agreements. Unfortunately with the nature of business agreements being mainly confidential this information was not to be included in the results as agreed with the collaborators. It should be satisfactory to state that such decisions were intended to be for the financial benefit of the organisations involved.

The case study observed several smart card projects and their progress from the concept stage through to implementation or abandonment over a three year period. Out of all the projects at concept stage, only one reached the implementation phase. The research did not follow that project as closely as the others due to geographic constraints.

None of the collaborators had implemented any evident project design or management methodologies. Each project was seen as a short term event that should proceed as previous efforts had. Despite the technology change involved in all the projects, there was no radical change either in management or innovation observed in the companies. This caused difficulty for any outside observer in understanding what processes, if any, were in place. Fortunately, each organisation did unintentionally follow a waterfall model approach to project workflow as suggested by Rankl et al. (1997 p.284). It was discovered that previously this workflow pattern had been repeated to the extent that it became an unwritten procedure in each organisation and was hence incorporated into the research. A waterfall model was adopted for the research due to the lack of any other observable methodologies amongst the collaborators or the smart card industry at the time. A waterfall model provided an extension of existing familiar methodologies that would be readily comprehended by the collaborators.

Figure 4.1 illustrates the steps of the adapted Waterfall model for the manufacture of software for smart cards.

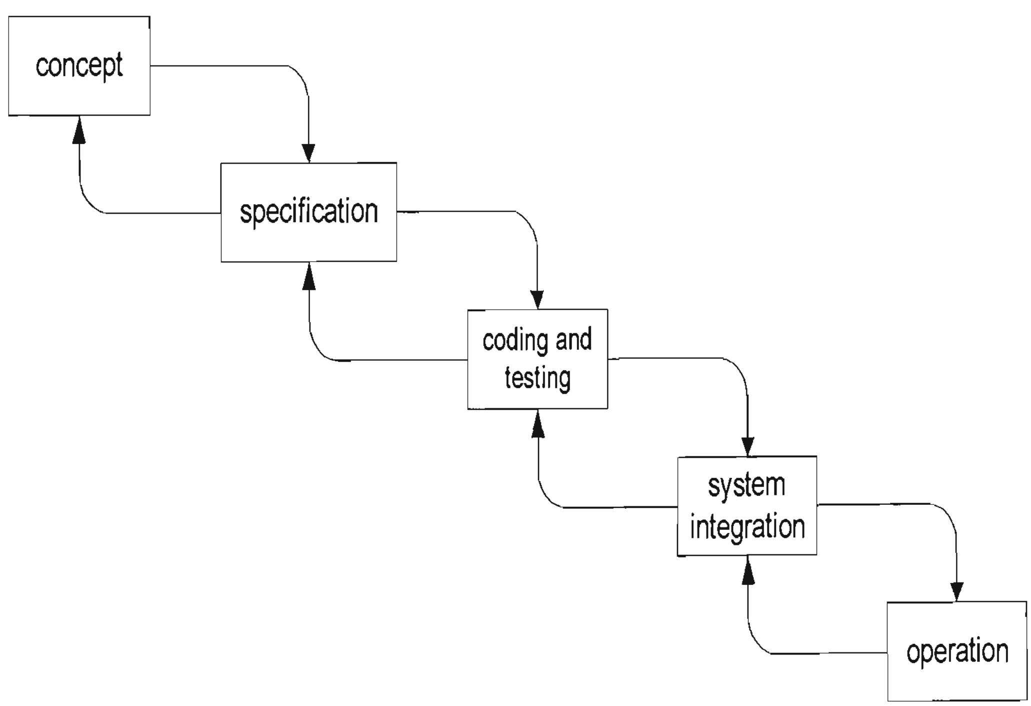

Figure 4.1 Waterfall model.
Source: Rankl et al. 1997 p.284

The five steps or stages of the adapted waterfall model are typically performed consecutively. The waterfall model allows for the backtracking of steps. This is useful because in the development of a product or solution circumstances and problem definitions can unavoidably change. Rankl et al. (1997 p.284) discuss the need to often overlap the steps, a method known as simultaneous engineering.

Simultaneous engineering obscures an expansion of the model by creating a situation where steps overlap and jump between internal phases of the expanded model.

This research studied the design stages in detail of the various smart card projects in the case study. The design stage covers the Concept Process and the Specification Process.

Concept

Figure 4.2 shows a diagram of the concept process and what activities occurred in that stage of the waterfall model. What occurred in each project of the study differed greatly. This figure shows a compilation of concept events from the smart card projects.

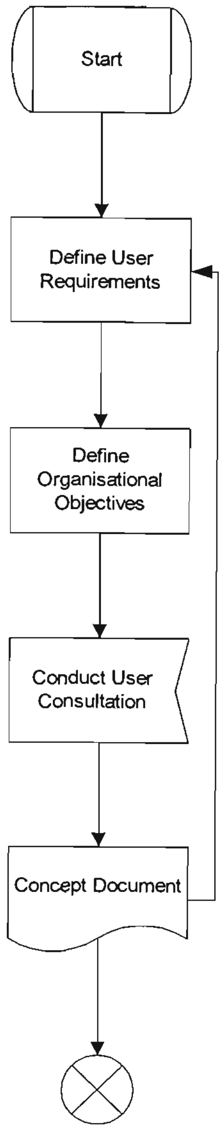

Figure 4.2 Concept Process.

Source: Smeh, J. & Adam, T. 1998 p.418

Rankl et al. (1997 p.284) describes the concept process as the step that determines "what" the finished software/system has to perform. This is an accurate description. It may seem obvious, yet in the course of the research it was observed that a key component was missing, namely the end user.

An example of this was evident when ColB was designing a smart card system for a customer loyalty application at car parks. The only consultation that occurred was between senior management of both the collaborator and the customer. These meetings were always regarding financial matters and contract approvals. The users were not consulted.

When the management at ColB were questioned regarding this, they referred to past POS implementations and avoided the issue. Despite the fact that a smart card based loyalty program has little to do with a large financial institution's EFTPOS system. This issue later returned to trouble them.

The end user was mostly overlooked in the concept stages of all the smart card projects observed. Instead the system provider and the organisation involved dictated the system design. ColC was the only organisation to consider the ability of the end user to use the POS equipment and change it accordingly.

In the Define User Requirements phase, the system designers endeavour to analyse and interpret the user requirements from the system. In this approach we can include S6 and S7 from the sociotechnical objectives from Table 2.1.

By maintaining existing or alternative means to access the service provided, the designers are attempting to maximise end user acceptance of new technology. Often however this would bring added expense in maintaining and duplicating services. For instance, a bank could maintain both a smart card and magnetic stripe EFTPOS network while phasing in the smart cards. While a small retailer could not probably afford the extra expense of the often numerous hardware options required to do so. Thus cost is a large issue in S6.

This point was illustrated when ColC was considering upgrading their magnetic stripe based loyalty systems to smart card based technology. The economics of the situation locked them into remaining with the magnetic stripe technology. To convert to the smart card system they had two options: purchase an add on card reader and invest in rewriting their POS software, or to convert to a single function smart card based POS device and invest in completely new POS software.

Sociotechnical objective S6: 'Maintain existing or alternative means to access the service provided' is assuming that there was a previous service and system that is being replaced by the smart card system. In the case study this situation only occurred once, with ColB and the previously described car park system. This system will be examined later in detail regarding its outcome and adoption of innovation.

In making the design provide an improved quality of life (S7), designers are again attempting to maximise end user acceptance of new technology. A new system does not always improve quality of life. A smart card based electronic purse system can appear to reduce the need to carry numerous coins. Whether this improves the quality of life for anyone other than the card issuer is questionable.

In the Define Organisational Objectives phase, the system designer identifies and defines what the organisation requires the system to do. This can be any business activity, for example, moving the organisation into the world of electronic commerce, or collecting data for loyalty marketing purposes.

In this phase of the concept stage sociotechnical objective S8 (Table 2.1), should be considered. This is an issue of trying to maximise end user acceptance of a technology or system. However at this early design stage the technological parameters are not yet precisely determined. So this would become a "what if" scenario being presented to the user in the Conduct User Consultation phase. The S8 sociotechnical objective does make a reappearance in the Specifications Process.

The system designers decide the Conduct User Consultation phase in detail. It could consist of user focus groups, user trials, questionnaires or surveys. As noted previously there was no user involvement in any of the smart card projects in the case study. Conduct User Consultation can be viewed in the concept stage as being the sociotechnical objective S2 'Conduct pre-design user consultation'.

Regardless of the method of user consultation followed, the end result is what is crucial. Most of the collaborators did not anticipate the end users of the systems being conceptualised. The user should have an input as to what the end product of the system design is. This user feedback is then iterated back into the Concept stage.

When the designers are positive that they have determined "what" the finished software/system performance targets are, they can then produce the Concept Document. The Concept Document should list in detail what is exactly expected from the system so that the design can be precisely defined in the Specification stage.

Specification

Rankl et al. (1997 p. 285) describes the specification step as establishing a "how to do it" process. The final result is a formal specification document which the application and system is based on. An expansion of the Rankl waterfall model specification stage is illustrated in Figure 4.3.

Regardless of design methodology or application level standard used in a smart card based project, the specification process in Figure 4.3 applies. This is because of the ISO

7816 standards which define some of the common elements of every smart card such as the file system.

Thus it is in the System Definition phase that the hardware and software platforms for the smart card system are selected. Figure 4.4 illustrates some of the many choices that have to be made in this process.

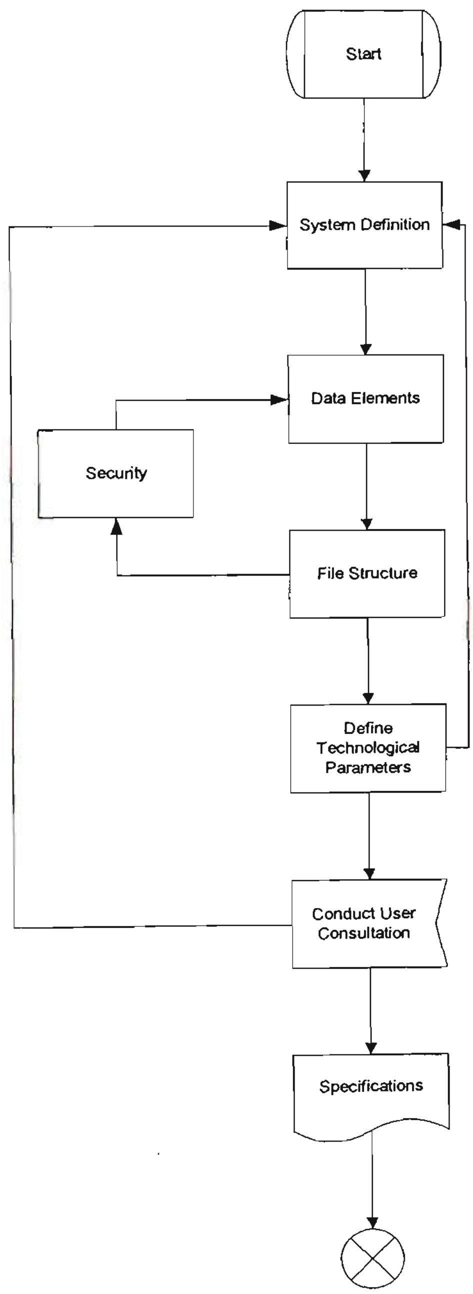

Figure 4.3 Specification Process.

Source: Smeh et al. 1998 p.419

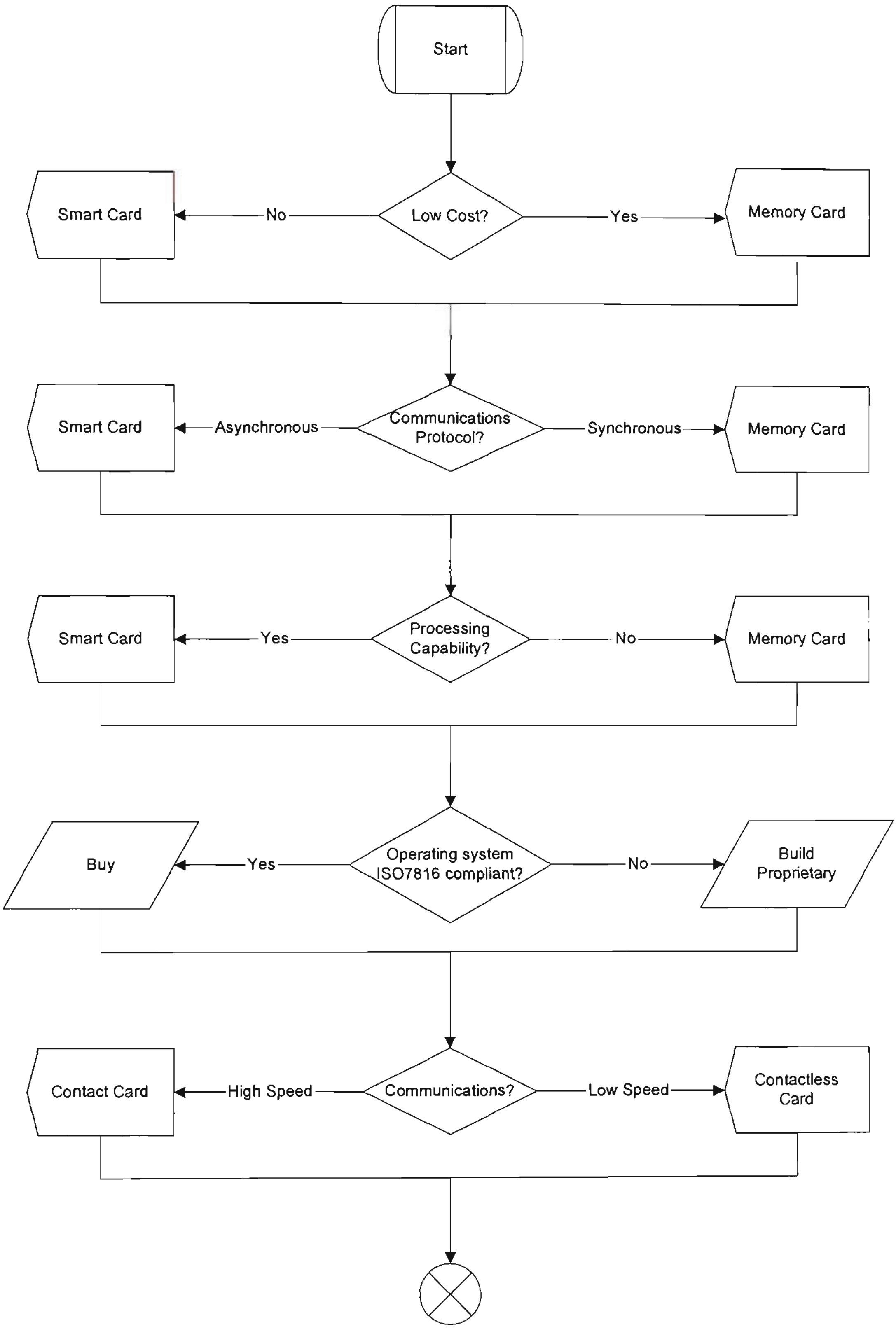

Figure 4.4 Decision Process.

Source: adapted from Dreifus, H. & Monk, J.T 1998 p.231-233

The diagram in Figure 4.4 shows some of the possible System Definition issues faced by a designer in the Specification Process. At this stage the design focuses on the specifics of the system. This stage relies on the input of the Concept Document which is required in some form. It is in the System Definition where the concept is translated to the individual components of a smart card system – software and hardware.

The initial decisions are based on cost and function. Usually a memory card is half the cost of a smart card. The management who made such decisions in the case study did not distinguish the difference between the two technologies. They saw no difference on the outside because the contacts are the same for both. There was a need for the designers to highlight the security, communication and processor differences.

The management at Collaborator B in the car park project knew about the differences. They felt that the cost difference was the more important issue. This issue will be discussed later regarding this project.

With the high cost of custom writing a smart card operating system (OS), what remains is a choice of the remaining operating systems. Until recently this choice had depended on the smart card integrated circuit because each manufacturer had a few OS choices for their chips. In the early years of smart cards, the designer only had one choice of an OS – the one from the manufacturer. Each manufacturer would customise the OS so no two different cards would have the same OS functions. For instance, one might have mathematical function extensions, and the other might have very limited functionality.

The designer now has a choice of API. As previously mentioned there are Multos and Java Card API platforms available.

The use of proprietary functions in the OS places a limitation on the likelihood of worldwide interoperability. If the cards operated differently, there was no chance of interoperability.

A most important design decision is that of the internal file system specification layout. A smart card is simply a storage device with limited processing power. The developer must base the file system layout decision on what scheme is being used, for example EMV, GSM or any other proprietary scheme.

A constant in all smart card OS designs that are based on the ISO 7816 standards are the definitions for the types of files: MF, DF and EF.

The MF is the master file. It is the root directory and contains all other directories and files. The DF is the dedicated file. These are directories that contain further files. They can be though of as a subdirectory. The EF is called the elementary file. It contains the user data, and can have several internal data structures – linear files, cyclic files, purse files, and transparent files (Guthery, S.B. et al. 1998 p.73).

The files on a smart card contain data to regulate secure access within the file system. The access rights are resolved when a file is created. The scope of possible file access conditions varies between each smart card OS. Thus a complete smart card OS specification is necessary to design a secure system.

Data Elements are where the information to be stored on the smart card resides. They depend on the purpose of the smart card in the overall design. The Data Elements are then put into a File Structure. Next some decisions regarding security are required. For instance, should there be any security at all? What level of security is required at the MF, DF, and EF levels?

When the designer has completed the Security iteration the result should be a file system plan with the appropriate security. This should also include the size of the data to be stored. This is another reason why the concept phase is critical.

The next step is to Define Technological Parameters. This is a broad area, which can include hardware constraints on memory usage, smart card scheme standards and OS limitations and functions. For example, if the GSM or EMV standards were to be included in the system, they should be listed in the Define Technological Parameters phase.

The Define Technological Parameters phase contains the sociotechnical issue, S8. The associations between the social and technical elements of the system need to be optimised, they effectively constrain and become parameters of each other. An example is a smart card scheme not requiring extensive security, and the end user requesting to use PIN numbers. If the user and organisational goals are not compatible the user will go elsewhere.

The phase, Conduct User Consultation, is similar to the one in the Concept Process stage. The only real difference is that the user is given the full details for the design rather than the theoretical concept design. This phase could consist of user focus groups, user trials, questionnaires or surveys. It is not important how this is achieved. The user should have input as to what the end product of the system design is.

This Conduct User Consultation phase fulfils the S3 sociotechnical objective, 'Conduct design stage user consultation'.

The user could be involved in feasibility trials to produce cost-benefit analysis for the organisations involved at this stage. This would contribute to the final Specifications for the system.

Ensuring the sociotechnical objective of ongoing design flexibility of the system, S9, can be achieved in several phases. It is appropriate for the System Definition phase; the Define Technological Parameters phase; and the Conduct User Consultation phase. The specification of design flexibility in this context is not an easy task. It may enter into consideration of the social or technical aspects of the design. For instance, is there enough memory on the smart card for multiple applications? Design flexibility can encompass several processes and phases.

Several of the key sociotechnical issues have not been listed in the Concept and Specification stages because they are more suited to the other stages of the waterfall model. Namely these are sociotechnical objectives S1, S4 and S5.

Sociotechnical objective S1, 'Establish an appropriate user awareness effort', would be a part of the Systems Integration and Operation stages of the Rankl waterfall model (Figure 4.1).

Sociotechnical objective S4, 'Conduct implementation stage user consultation', would also be a part of the System Integration and Operation stages of the Rankl waterfall model.

Sociotechnical objective S5, 'Develop an on-going user consultation plan', does not really fit into the Rankl waterfall model. This is because there is user consultation throughout the model, so the planning for this consultation should have occurred previously. This would have been a management and design guideline to emphasize the user consultation in the design methodology.

The design methodology presented offers an adaptable smart card application design system that is readily comprehended by people in the business community.

This model is adaptable and scalable due to the relevant ISO standards in place in the smart card industry. Most smart card schemes support more than the bare minimum standards of the file system. This leaves for a lot of flexibility in underlying phases of the processes discussed.

With the proliferation of design tools, the design of smart card applications could be facilitated through other software technologies, for example, Rapid Application Development (RAD). Rapid Application Development is a development approach that makes use of teams using joint application development and iterative-prototyping techniques to create systems within several months. (Gemplus 2001) Rapid Application Development is a development life-cycle designed to give much faster development and higher-quality results than those achieved with the traditional life-cycle. (Martin, J. 1991)

Case Study Projects

Car Park Loyalty System

As mentioned previously, Collaborator B (ColB) was to design and implement a smart card based car park user loyalty scheme. This was planned to involve several car parks, major retailers near the car parks and at a later stage there was the future possibility of using car parking meters and a stored value system. The ultimate goal was to create a cashless central business district car parking scheme.

At the stage when the researcher joined this project it was already six months behind schedule. Management gave those involved the ambitious task of designing and implementing the system within another six months.

This was to be this organisation's first major smart card based rollout in Australia. They had previously participated in some banking trials as POS providers.

They found themselves in an unusual position, they were their own client for a change. They could not rely on someone else dictating the design criteria and specifications. Thus it was left to management to make the decisions. Unfortunately their decisions were not technology focused but profit and cost focused.

Thus another separate company was formed with a controlling interest coming from a Middle Eastern financier. So in the interests of profit, the management has effectively handed control of the project to someone else.

The design and specification processes were completed and the final specifications were ready to be given to a programming team. The managers decided to focus on profit again. The designs were rewritten to use the cheaper memory cards instead of smart cards.

This was a serious change in the view of the designers, as the loyalty scheme would provide car park discounts and substantial prizes as a reward for customer loyalty. This change would make it easier for the security to be compromised.

By this stage six months had passed. The main reason for the slow progress was managements continuing negotiations with the relevant car park owners and the city authorities.

When the design was again finalised another problem occurred. This time the financial backer had grown impatient and it was decided that a group of overseas programmers would complete the project. There seemed nothing wrong with this decision at first since the designers were also busy working on other projects simultaneously and would enjoy the reduced workload.

However a problem soon appeared – language. Very few of the overseas programmers could understand the specifications as they were written in English. Thus they decided to work to their own verbal specifications and ignored the written English version.

It was at this stage that the research involvement with this Collaborator ended. Further contact was maintained through occasional telephone calls to discover any developments. It was discovered six months later that they were set to go into a rollout of the project into the car parks.

During the deployment an interesting consequence of using the overseas programmers was discovered. At that time the y2k, or millennium bug, problem was known worldwide. The overseas developed code did not have this problem but a more unusual one – the October bug. The programmers had used their own specifications and had used only one digit to represent the month field. Hence the month could only be January (1) to September (9). The way this problem was discovered was due to some of the systems being installed in a production environment in October.

It then took them roughly a month to rectify this problem. By this stage an Internet and print media campaign had been launched to promote the system, its benefits and incentives.

The system soon failed with very few participating end users and mounting debt. The company running the scheme became insolvent with over one million dollars in debt. They left some of the employees unpaid and some very unhappy financiers.

Entertainment Loyalty Smart Card Project

Both Collaborators C and D were interested in using smart card technology in a variety of venues for customer loyalty purposes. The difference in the project was that they had previously used magnetic stripe technology to implement such systems.

At the time of the research, the magnetic stripe based systems were successfully in use at venues such as bars and hotels. They were interested in the ability of the smart cards to be used for multiple applications such as stored value, customer loyalty and advertising.

They saw the added possibility of using the surface printing on the plastic card as an advertising opportunity on a multipurpose card.

As mentioned previously this project was discontinued due to the high cost of smart cards. Magnetic stripe technology was mainstream, cheap and readily available. Another factor was the lack of electronic purse or stored value smart card standards at the time. Also at the time there were only proprietary multi-application smart card schemes available that had been unproven in an Australian market. Thus this project did not pass the Concept and Specification Process stages.

Other Smart Card Projects

For this research another two companies involved in the smart card industry were contacted and interviewed. The other participants were not involved to the extent of the Collaborators previously discussed.

These two organisations were by the Australian Bureau of Statistics definition, classified as small and large businesses. The smart card systems involved were single application only at that stage. The large business was about to run a trial pilot multi-application stored value smart card system. Subsequent to the research that trial took place, and later their multi-application effort was abandoned.

Both organisations used proprietary smart card operating systems. The small business displayed no interest in moving to multipurpose smart card technology. They were established in the niche market of hotel room lock security and did not see any added benefit to innovating further.

Innovation In The Case Study

The majority of business ideas are beyond the power of one person to pursue (Christiansen, J.A. 2000 p.73). This was evident in the research case study. Many people contributed to each project. In each project profit was the aim of the innovation. However one project stood out for its profit focus. In all the interviews with ColB management, cost and profit were always of the primary concern.

The smart card designers involved with Collaborator B held the view that the design – innovation process was obstructed by input from management. This was significant and it should be noted as some of the key activities during the project life-cycle include idea generation, funding, development and implementation (Christiansen, J.A. 2000 p.72).

Every project starts with an idea for an innovation. The people with the idea then go looking for funding. Nothing in business occurs without funding. Depending on the organisation this can be a simple or a long process. As previously illustrated funding and profit can cloud perception of innovation issues. The development and implementation activities mainly are the same with any project life-cycle. They vary depending on the technology and size of the organisational infrastructure.

A summary of the goals, decisions and results of the project undertaken by Collaborator B are listed in Table 4.5.

Seeking better funding via an external source in itself is not an imperfect goal. It was the extent to which the managers agreed to hand over control where the initial designers saw a flaw. The reduction of project control to an unseen overseas entity who's only obvious interest was their return on investment. This influenced the decisions of the managers who had to report on the state of the project regularly. The pressure to create profit increased severely after any decision was made.

Management Goals	Decision	Result
Better funding	External funding	Reduced project control
Better development	Faster development	More bugs in the system
Faster development	Overseas developers	Ignore specifications
Reducing costs	Reduce specifications	Demoralise staff

Table 4.5 Collaborator B Management Decisions.

The management goal of better development was based on the belief that it meant faster development. Funding was the primary criteria that led to the overseas developers, who then ignored the system specifications to the detriment of the final solution.

The demoralising of the staff that were involved in the initial design and specification processes was compounded at the installation stage. These were the staff that were then asked to deploy the system and maintain it. The effect was augmented when the total costs to the financier increased and the finances evaporated.

There was a hidden management reason for pursuing this project that took a long time to discover. This reason was revealed by a designer at the end of their involvement with the organisation. Each division of the organisation has an annual sales quota. Thus the pressure on the managers to meet a quota that previously they had not was colossal. This extended to the idea of creating a project to meet a quota – the Car Park Loyalty System.

Thus the flawed innovation in ColB can be seen to be the result of a series of managerial errors that compounded over time to produce a failed smart card system.

The management felt that they were not to blame for the failure. They thought it was a problem of lack of users. In a sense they were correct. So the question is raised, why didn't people use this smart card system? Why wasn't this innovation adopted?

Note that the term smart card system is still used to describe the system despite it being a memory card system. In the industry the terms are interchangeable due to the appearance of the two being identical to the ordinary consumer.

As stated previously, diffusion is the method by which an innovation is conveyed over time among the members of a social system. Innovations that are perceived as most economically rewarding and least risky are adopted more rapidly (Rogers, E.M. 1995 p.89).

The method used by ColB to sign up users to their loyalty scheme must be considered. A user would have to either make a phone call or use an Internet site to make an application. A form would then be sent by mail to the user. The user would then have to return by mail credit card details to join.

If a user were to read the conditions of the loyalty scheme they would discover that to receive any of the incentives (prizes) that were offered they would probably not join. There is no economical reward to joining a system that costs money only to never in reality receive a reward. The initial designers revealed that part of the deployed systems conditions for receiving a reward made it extremely unlikely that anyone would ever receive anything.

There existed another problem, the mail out to the user with a card. This would take at least a month. So the user saw nothing for their money for at least a month. In the meantime the card readers were idle.

The users did not gain any convenience from the system either. An example, when entering a car park they would first have to find their card, insert it into the card reader. This would put a time stamp in its memory. Then the user has to drive further to get a ticket from the car park ticketing machine.

On exiting the car park the user would give the card to an attendant who would insert the card into another reader and enter the amount spent at the card park. This would update a counter to an appropriate amount on the card. Then the user pays for the car park.

This scenario only adds an extra step to the users activities. It has no immediate benefit. It only adds another single function plastic card to their wallet or purse.

Tables 4.6 show some of Rogers (2000 p.207) identified variables determining the rate of adoption of innovations.

Perceived Attributes of Innovation	Car Park Loyalty System
Relative advantage	No
Compatibility	No
Complexity	Yes
Trialability	No
Observability	No

Table 4.6 Perceived attributes of the car park loyalty system.

Relative advantage is the degree to which an innovation is perceived as being better that the one that it replaces (Rogers, E.M. 1995 p.212). This loyalty scheme had no relative advantage because it was not replacing a previous system. As mentioned previously the user had little chance of benefiting from it.

Compatibility can be technical and social. This system was technically incompatible with any other card based system – proprietary. Socially, the more familiar a system or product is the more compatible it potentially is with the users needs. Since this was a first for Australia we can say that it was not familiar. The social aspect is examined later.

Complexity is the extent to which the innovation is perceived as difficult to understand and use (Rogers, E.M. 1995 p.242). This loyalty scheme was difficult to understand for those who designed it. The users often found it hard to understand how the rewards scheme functioned.

This system had not been tested in end user acceptance or in any limited basis. The car park owners just had a final system installed. The end user bought a card. There was no method for either the user or owner to try before they committed to the system – no trialability.

Due to the system being hardware based, everything happened in the software. There was no observable benefit at the car park for the user. There was no flashing computer graphics to catch the user's eye.

The extent of promotion of the scheme was a factor in the adoption. The media chosen by the managers were: an Internet web site, Point of Sale (in the car park) and in free teenage alternative music newspapers. This would suggest that they were targeting the youth market. In can be suggested that they were targeting the wrong market. The type of youths who read free alternative music newspapers are not likely to be car parks major clientele. A manager later revealed this newspaper media as being chosen purely based on cost. The incentives policy was aimed at a long term, constant and frequent user.

Thus the chance of a person who is interested in free offers, purchasing a card that had no visible advantage is small. This plus the nature of the social system that they were targeting explains the resulting small uptake of the car park loyalty scheme.

Table 4.6 illustrates why this particular instance of a smart card innovation adoption failed. The other smart card projects did not reach the implementation stage. They failed due to economic reasoning, and cost : benefit analysis. Collaborator B could have done the same analysis rather than trying to sell their hardware and software to meet a sales quota.

The entertainment loyalty smart card project did not progress beyond the concept and specification processes. From the design information presented in the meetings and interviews, it was possible to analyse the perceived attributes and possibility of adoption.

Perceived Attributes of Innovation	Entertainment Loyalty System
Relative advantage	Yes
Compatibility	Yes/No
Complexity	Yes/No
Trialability	Yes
Observability	Yes

Table 4.7 Perceived attributes of the entertainment loyalty system.

The proposed smart card based entertainment loyalty scheme was to provide a relative advantage over a previous magnetic stripe based scheme. The relative advantage visible most to the consumer was that the scheme's loyalty based rewards increased.

As mentioned, this scheme was previously magnetic stripe card based. This system allowed the consumer to user a kiosk type facility to instantly obtain a coupon that was used to obtain a reward of some type. This system was inherently insecure because the amount of awards collected was stored on the easily corruptible magnetic stripe.

The innovation came in the form of using a smart card to store this information. It could also store a certain amount of previous transactions made by the user. Thus the scheme was to be expanded so the retailer could differentiate a user who frequently purchased certain items. The plan was to use the marketing data gained from this scheme to improve individual product marketing.

This planned relative advantage would give the consumer reward 'points', and could be based of repeat purchases of items rather than on the previous scheme of total purchase 'points'.

As an example, if CustomerA purchased ProductA five times on the previous scheme. The points they might earn = (5 x ProductA's point value). On the new scheme they might earn = (5 x ProductA's point value x Repeat buyer bonus).

Another planned relative advantage was the linking of the POS devices to the cash registers. This would allow a consumer to immediately use their reward points at the time of purchase rather than going to a kiosk as previously mentioned. It would from the retailer's point of view, save time in keying customer transactions.

Compatibility with the previous system was a design issue that remained unresolved. From a technical outlook, if the system used an add-on smart card reader there would be backward compatibility. This would results is a three device configuration: a printer, a magnetic stripe device and a smart card device. As previously mentioned, ColC considered the ability of the consumer and retailer to use the POS equipment. It would have been simpler from the perspective of the retailer to replace the magnetic stripe reader with the smart card reader. The social compatibility aspect depended on the technical compatibility due to a previous system existing.

The complexity of the proposed solution to the user would be reduced compared to the previous magnetic stripe based system. There would have been less user intervention required in the use of the system. However, the increased complexity of the reward points calculation would have possibly increased consumer confusion. It is impossible to gauge the possible answer to the complexity perception for this proposed innovation due to an incomplete design.

The trialability aspect of this innovation is different from that of the car park loyalty system. The proposed solution allowed a user to use a test card at a kiosk to see an example of a transaction and a reward. This characteristic effectively allows the consumer to briefly trial the innovation to help to reduce any perceived complexity.

The observability of the system was increased by the kiosks and nature of the change. It was observable to other users at the venues. There would have been no radical change in physical appearance of any of the components in the system. The only real change was to the card and the reader. The system was to have been tested at a few selected venues with a planned gradual conversion of other locations.

This proposed innovation would have been an interesting test for smart cards in the Australian marketplace. It appeared to have had enough perceived innovation attributes to merit a successful implementation.

The two innovation projects discussed present two different design and management philosophies. The car park loyalty system was initiated purposely by management to artificially increase hardware sales to meet a quota. While the entertainment loyalty system was designed to increase the product's marketing data collection ability and consumer appeal.

The fact that one failed and the other never reached a production stage provides a view of the price sensitivity of the smart card industry. The car park system eventually used the cheaper memory card technology. The entertainment system previously used magnetic stripe based cards and found the costs of the smart cards to be too high for a small project.

During the period of the research, a magnetic stripe card would cost from $0.10 - $0.20 fully printed. While a smart card would cost from $5 to $15. The cost of a memory card started at $2. The cost on all would vary on the volume and features. With smart cards, the higher the security and features, the greater the cost.

When the price of a product decreases a rapid rate of adoption is encouraged (Rogers, E.M. 1995 p.213). Unfortunately the price of smart cards has not declined substantially. This would suggest that smart cards have not reached a critical mass for costs to be reduced. Despite industry predictions of the smart card reaching critical mass, the various trials worldwide have failed to gain public acceptance (Philipson, G. 1999 p.35).

The economies of scale observed in the research suggest that the use of smart cards would not be viable unless there were multiple applications involved. Collaborator C considered this possibility but concluded that it would be too complex to manage the contractual and financial conditions of such a system. For instance, how would the costs of the system be distributed between the parties?

If as previously mentioned, Lindley's (1997), prediction of distinct stages of smart card innovation were correct then the multi-application/multipurpose smart card would have been possible for Collaborator C. The reality was different however. It was in theory at the time to have such a card. It was too hard to commercially obtain them due their proprietary nature and a lack of production. Multi-application schemes in the period 1995-1998 were only short term trials by manufacturers to market a potential solution. There was no adherence to standards and specifications governing multipurpose smart cards at the time.

The comparison of these two projects reveals an aspect of innovation research – postdiction versus prediction (Rogers, E.M. 1995 p.210). Rogers states that the usefulness of research on the attributes of innovations is to predict their future rate of adoption. While the majority of research in the area has been postdiction, not prediction.

Predicting the future of an innovation based on a set of criteria such as relative advantage and compatibility is risky. They can be used to position an innovation so that it will be more acceptable to the intended consumer (Rogers, E.M. 1995 p.211).

The interaction with five forces were also examined: commerce and competitive issues, financial issues, technology issues, labour force issues, and the demographics were also factors considered by the designers and management in each project.

The commerce and competitive issues faced by each collaborator were essentially the same as any other business. These were trying to secure a continuing monetary profit for their business. Of interest in the industry generally, and in the case study is that the organisations are both competitors and each other's customers to varying degrees.

In the electronic commerce industry it has been noticed that companies try to overcome competitive issues by partnering with other suitable companies. This is done for mutual benefit. For instance, Collaborator B partnered with Collaborator C to resell their hardware.

The financial issues were as discussed previously the costs involved in smart card technology. Each collaborator found it difficult to justify the high costs versus benefits to their customers.

The labour forces issues manifested themselves in the form of the collaborators finding it difficult to locate the appropriate developers for the technology. The advent of a platform such as the Java Card API has made it possible to use the widely know programming language of Java to program a smart card. Previously a developer had to use assembly language, proprietary computer languages and tools to achieve the same task (Chen, Z. 2000 p.8). The problem however is currently that Java Card is not ready for commercial-strength applications (Hassler, V. & Fodor, O. 2000 p.75)

The demographics issues faced by the collaborators were mainly in the form of targeting the appropriate market for an innovation. For instance, Collaborator B as previously discussed targeted the wrong market for the service they were offering. While Collaborator C and Collaborator D knew from previous efforts and the marketing data gathered who their customers were.

The success or failure of the projects involved in the case study was a mixture of these issues and those previously discussed. However sociotechnical and innovation diffusion criteria alone do not decide the fate of an innovation.

Social Issues Observed

During the course of this research there were some social concerns raised by individuals in the majority of the interviews – privacy.

In relation to smart card based services, existing laws provide only incidental protection for consumers (Clarke, R. 1996).

Clarke suggests several dimensions to the term privacy:

- Privacy of person
- Privacy if personal behaviour
- Privacy of personal communication
- Privacy of personal data

The only privacy issue observed in this research was the requirement for privacy of personal data. In each of the projects observed, regardless of function, privacy was inherent in the designs. There was no observed attempt by any collaborator to buy or sell any individual's personal data.

Collaborator C considered the issue of privacy when they pondered the possibility of in the future adding a stored value scheme to the system they were designing. Principally, if the stored value scheme was anonymous, how would value be recovered from a lost or stolen card? It was concluded that the design would have to increase dramatically in complexity and cost, and was hence discarded.

Social compatibility with a value system should be considered in the design process of an innovation. This however did not occur in the car park loyalty system. They did not consider if people would accept the technology. They assumed that people would adopt a new technology and that they were correct.

Unfortunately the demographics of the people who participated in the car park loyalty system were not made available. Thus it is difficult to state what conditions in the social system prevented or hindered the diffusion process.

Some of the possible factors were: privacy, social status and compatibility with needs. Did the system increase a person's social status in any interpersonal network? Was the idea of a car park loyalty system needed at the time? These are the types of social issues that may be pursued by future research in the area.

Kaplan (1996, p.123) suggests some smart card marketing issues that are equally valid in the context of social issues: product, price, place and promotion. Product represents the relative advantage perceived criteria. Price relates both to social and business needs. Place represents how and where the card is marketed and to whom, which is a social issue. Promotion as used by Kaplan, refers to relevant advantage and the need for a product.

There is the business issue that most companies need to justify the migration to smart cards (Allen, C. & Barr, W.J. 1997 p.222). The manner in which this business issue if affected by social issues is a complex area which the business needs to consider carefully and is beyond the scope of this research.

The social and business issue of price was illustrated in September 1998 when the smart cards industry was faced with a global depression. In 1998, Russia defaulted on its debts and the Asian economic crisis appeared to deepen. Struggling Asian countries took strong economic measures to combat a regional meltdown (Frost & Sullivan 1999 Ch1.p.1).

The effects of the Asian economic crisis did indeed have effect on the car park loyalty system. One effect was observed in the overseas project funding. The overseas financier grew impatient with the project and terminated it. Another was possibly because of the worsening economic situation and a social group's willingness to join a new scheme. People were spending less just as the system was implemented.

These are some of the types of social issues that may be pursued by future research in the area.

The managers and designers of the smart card systems investigated did influence the final outcome of the products, both physical and economical. They influenced the adoption of these innovations by the decisions that were made through the product life-cycle. The perceived attributes of the designs provide an indication of the possibility of adoption. Since the managers and designers influenced the perceived attributes, the data provides strong evidence that the null hypothesis (H_0) is not valid and that there is an impact to the adoption of smart cards by the design process.

The null hypothesis can be rejected as invalid from the data gathered in the case study. The results of the perceived attributes analysis together with the observed failure of adoption clearly indicate that the design process did influence the adoption. The testing of the null hypothesis through the case study shows that a sample of smart card projects were influenced by their design processes.

The degree to which the design process affects the adoption of this particular innovation is debatable and beyond the scope of this research and is in the realm of adoption research. For example, did social conditions affect the design of the innovation or did the innovation cause changes in social conditions, and what impact did this have on the adoption? These are issues for potential future research.

Elliot (1998), discusses some specific Australian based smart card trials – MasterCard Cash and Visa Cash. Elliot applied potential generic cost : benefits analysis to the smart card trials. Those cost : benefits also apply to the smart card based loyalty systems described in this research due to the planned future use of the systems with a stored value application. Some of the potential benefits have already been discussed in terms of the Rogers perceived attributes of an innovation – relative advantage and compatibility.

The following tables (Table 4.8, Table 4.10) list the Elliot (1998 p.174) potential benefits and costs.

1. New source of income (manufacture, royalties, process/license fees, equipment rental)
2. Float - $ value in card can be used by the system until consumer redeems the full value
3. Multiple functionality – including: personal identification credit card, ATM card, telephone credit card, transit pass, medical records cash substitute
4. Reduced credit card fraud (card details may be encrypted and password protected)
5. Reduced load on EFTPOS network (& reduced transaction costs)
6. Reduced exposure to telecommunications failure resulting in loss of business
7. Reduced costs of handling cash – about 4% of the value of all bank transactions
8. Reduced security risk associated with handling money or in vending machines
9. Loyalty programs and customer profiling. Accumulation, analysis and possible sale of detailed customer information. Capability to increase customer service.
10. Speed up the consumer payment process – direct implications for staff costs etc
11. Ability to buy/sell goods from a distance
12. More hygienic than using money
13. Remove errors associated with incorrect change. Always have exact change.
14. Potential to carry fewer cards. Interoperability – support different currencies.
15. Consumers that fail to qualify for a credit card will be able to use smart cards.

Table 4.8 Examples of potential benefits.

Source: Elliot, S. 1998 p.174

The potential benefits listed in Table 4.8 are with respect to a generic implementation of smart card electronic payment systems (Elliot, S. 1998 p.173). The case study only observed one smart card based system proceeded to implementation - the car park loyalty system. As mentioned previously the entertainment loyalty system did not proceed past an informal cost : benefit analysis.

The benefits of each of the systems in the case study are listed below with respect their potential future implementation plans including stored value applications.

Benefi t	Car Park Loyalty System	Entertainment Loyalty System
1	✓	✓
2	✓	✓
3	✓	✓
4	✓	✓
5	✗	✗
6	✓	✓
7	✓	✓
8	✓	✓
9	✓	✓
10	✓	✓
11	✗	✗
12	✓	✓
13	✓	✓
14	✓	✓
15	✓	✓

Table 4.9 Benefit analysis of proposed case study systems issues.
✓=Yes, ✗=No

1. Risk – of negative impact on core business (different causes)
2. Infrastructure – software, hardware, process development, employee training, marketing.
3. Card costs – smart cards range in price from less than $1 to about $20, a magnetic-stripe card range between 10 and 50 cents. Average card costs are currently $2.50
4. Restriction in consumer choice due to lack of merchants accepting cards
5. Royalty, licensing, interchange fees
6. Lack of generally accepted design standards
7. Technology averse consumers
8. Tax liability – merchants who understate cash receipts to reduce tax are less able to do so.
9. Technology and card malfunction
10. Theft or loss of disposable cards
11. Disputes associated with consumer liability of unauthorised transactions
12. Wastage – small amounts leftover on cards won't be redeemable
13. Transaction fees – debit card transactions often don't attract fees
14. Privacy – including ability for various government agencies, law enforcement agencies, and private litigants to access records of smart card usage
15. Loss of anonymity

Table 4.10 Examples of potential costs.

Source: Elliot, S. 1998 p.174

Cost	Car Park Loyalty System	Entertainment Loyalty System
1	✓	✓
2	✓	✓
3	✓	✓
4	✓	✓
5	✓	✓
6	✓	✓
7	✓	✓
8	✓	✓
9	✓	✓
10	✓	✓
11	✓	✓
12	✓	✓
13	✓	✓
14	-	-
15	✓	✓

Table 4.11 Cost analysis of proposed case study systems issues.

✓=Yes, ✗=No

In the cost : benefit analysis of the systems in the case study it is more of interest to examine any differences and any negative answers due to the common objectives in the loyalty schemes. Despite the systems being from different vendors and for different industries (parking and entertainment) their cost : benefit characteristics are mainly the same using the Elliot (1998) examples.

This would suggest that a similar result negates the effect of the different industries and system operator industries. This however is a generalisation. A simple yes or no answer cannot convey the actual cost : benefit accurately as it is affected by the wording and interpretation. It merely provides an indication as to the need for further investigation.

As an example, the system owner and operator of the car park loyalty system was a terminal manufacturer. Thus the infrastructure costs (Cost 2) were reduced because they were effectively selling the hardware to themselves and then renting it to the location owners. Thus they were making a profit at each level of the supply chain.

Being a terminal manufacturer however was also a risk (Cost 1). The reason being that selling terminal hardware and software was their core business, not the complete ownership, design, rollout and operation of a system. A failure could have potentially had disastrous consequences on their other operations.

Privacy of user information and loss of anonymity was not decided in any formal design specifications for either of the systems. Thus it could not be included in the cost : benefit analysis issues.

Benefit 5 (Table 4.8) is answered as a 'no' because of the choice the managers and designers made when deciding on stored value reloading methods. It was decided that the systems would require a cash register operator to manually credit a value to a stored value card. Thus the systems would not have a link to any current banking EFTPOS network. Each would have been their own private stored value scheme with interlinks potentially to similar schemes. Thus there would have been no reduction of load on EFTPOS networks.

Benefit 11 (Table 4.8) is answered as a 'no' due to the requirement for the user to be on the vendor premises to use the smart card loyalty system. Thus they could not buy/sell goods from a distance.

The Elliot (1998 p.174) examples of potential costs and benefits are based on literature. It was found in the case study that actual cost : benefit analysis was an informal process in the collaborating organisations. This was a function of the both the size (SME) and management style of the collaborators.

The observed cost : benefit analysis did not ask as many questions or raise as many issues as listed in Tables 4.8 and 4.10. The questions were all monetary in nature:

1. What is the risk to the business?
2. What is the cost to the business?
3. What will the profit be to the business?

Table 4.12 Observed cost : benefit questions.

The results from the case study systems to these cost : benefit questions is in Table 4.13.

Cost : Benefit	Car Park Loyalty System	Entertainment Loyalty System
Risk	High	High
Cost	Very High	Very High
Profit	Low	Low

Table 4.13 Case study observed cost : benefit analysis.

For the car park loyalty system the risk was high as previously mentioned. Although they were effectively buying their own equipment, the development and rollout costs were constantly increasing as the project fell further behind schedule. Initially it was to be completed in six months – it took nearly two years. The profit, even when it was in the concept process, was predicted by those involved to be low. As mentioned previously the management ignored this issue to pursue their agenda of artificially meeting sales quotas.

The car park loyalty system from a business standpoint should not have proceeded beyond the concept process. It did however allow the researcher to view the failure of a smart card based system.

The entertainment loyalty system had the same answers to a cost : benefit analysis (Table 4.13). The difference was that the management decided not to proceed beyond the concept process. An interesting point of difference was that the car park loyalty system was funded by an overseas financier and a overseas parent company. While the entertainment industry loyalty system was funded by the owners – the managers. The adoption of the car park system was affected by the managerial directions and the organisational attitudes through the perceived attributes. This provides an example of how the organisation itself can influence the adoption of an innovation because the employees did not really care and sometimes that attitude showed to the customers.

Elliot (1998) explored the costs : benefits as critical drivers and inhibitors of adoption of smart card technology and proposed a theoretical framework for further research (Figure 4.5).

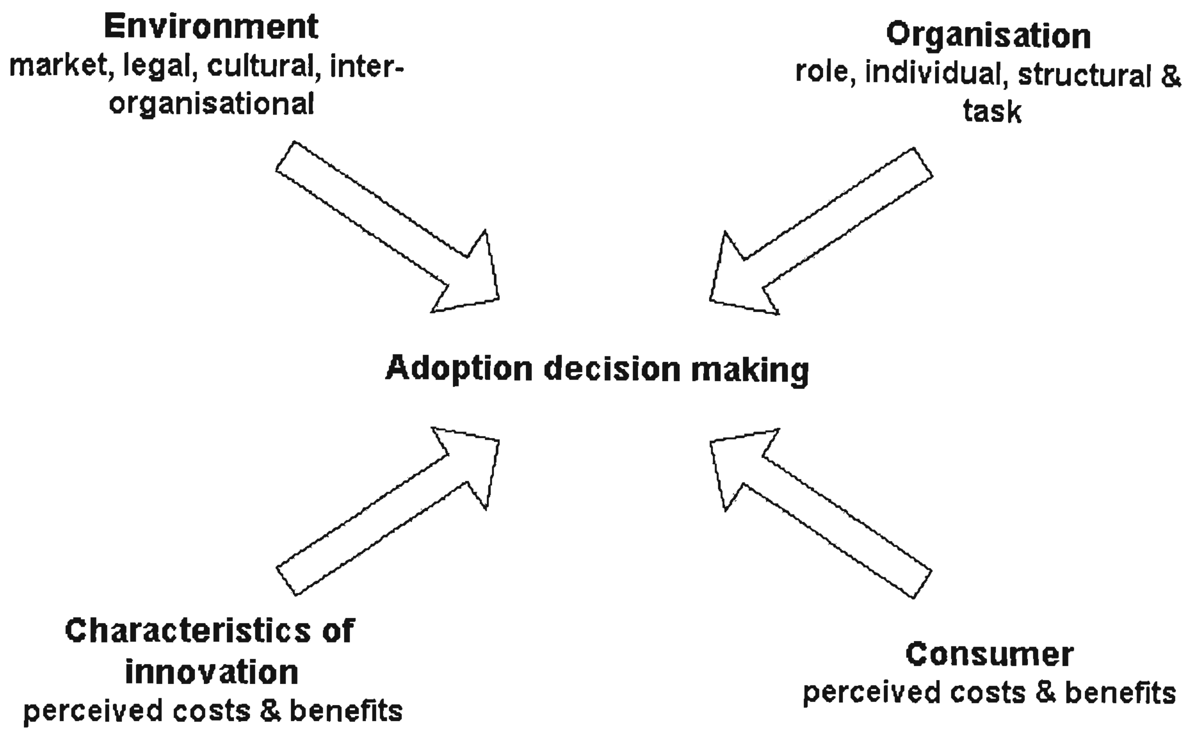

Figure 4.5 An integrative IS research framework.

Source: Elliot, S. 1998 p.179

This framework includes the consumer because 'the significance of consumers in adoption of smart-card payment systems is apparent from both empirical and theoretical perspectives: unless consumers use the systems to purchase goods and services the smart-card system must fail' (Elliot, S. 1998 p.178).

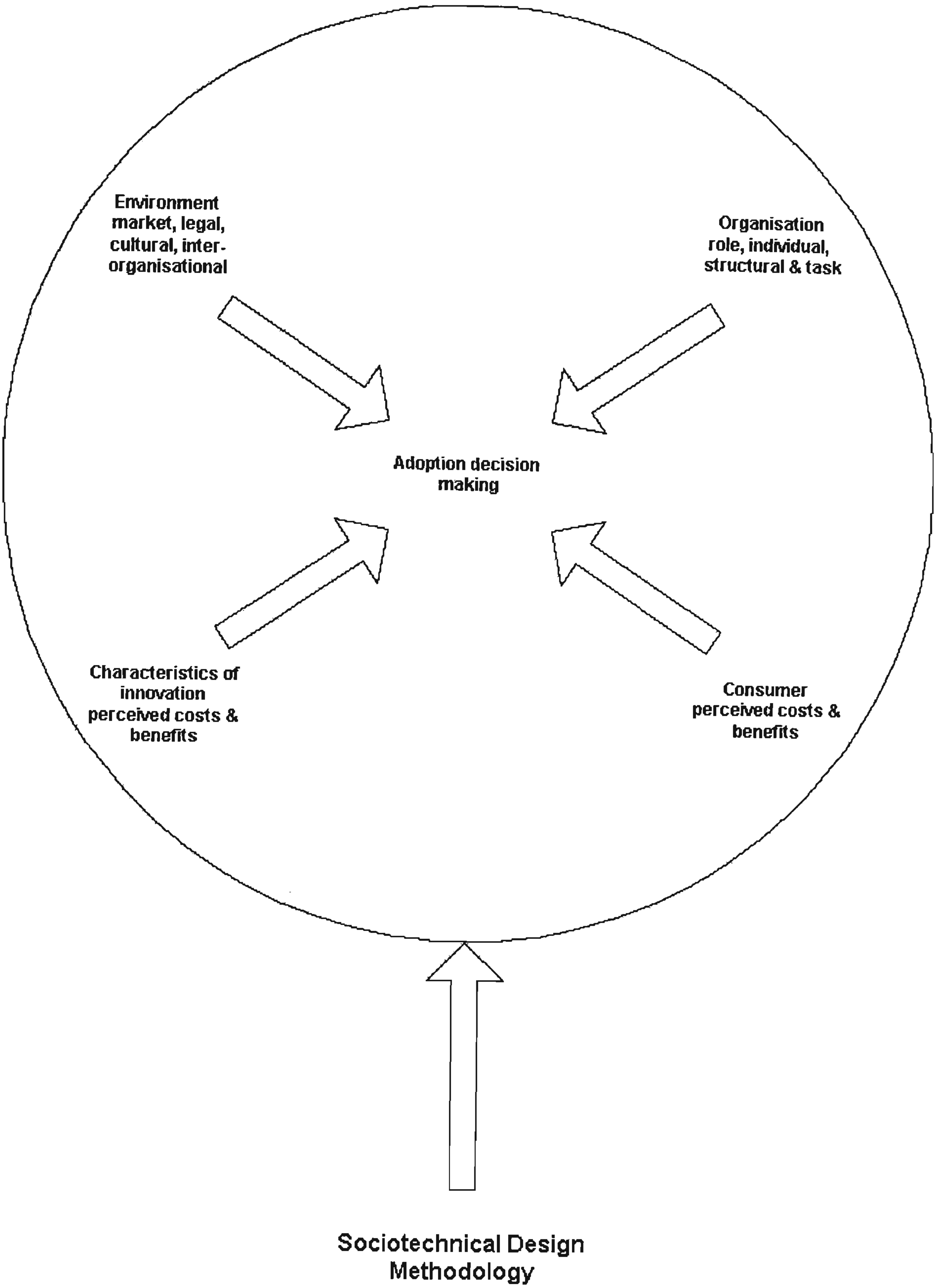

Figure 4.6 Research model integrating sociotechnical principles.

The framework proposed by Elliot was an extension to a model of innovation by Kwon and Zmud (1987). The Elliot framework is a model for adoption that incorporates innovation, organisational and inter-organisational, environmental and international, and consumer issues. These issues are sociotechnical issues. As previously discussed, sociotechnical theory describes the relationships between people, organisations and technology (Lindley, R. 1997 p.155).

The issue of environment in terms of cultural and international is one of the Elliot (1998 p.179) extensions. The assumption of a theory being equivalent in international markets is a possible reason for inclusion in any future research framework (Rosenzweig P.M., 1994).

The next step in extending the Elliot framework should be to incorporate a sociotechnical methodology. Thus an extension to the framework was proposed and is shown above in Figure 4.6.

The framework presented by Elliot is generic in nature. It does not specifically refer to smart cards or any other technology. For that reason the generic term 'Sociotechnical Design Methodology' is used in extended framework.

If applied directly to smart card technology the Cooper et al. (1996) identified key sociotechnical objectives (Table 2.1) should be incorporated. Thus the design processes integrated into the concept and specification stages of the waterfall model (Figures 4.1, 4.2 and 4.3) presented in this research could be used to incorporate sociotechnical objectives into the adoption decision processes.

The question of how would the smart card design processes scale to an international market is a complex one. There are both technical and social issues to consider. For instance, most countries have their own standards organisations. This results in the situation that not all standards are accepted internationally. An example would be wireless communications and GSM as a particular example. The European Telecommunications Standards Institute defines GSM.

The social issues are complex as observed in a study by Fowler and Swatman (2000 p.15) where cultural taboos and religious obligations were identified as possible failure factors for a university smart card system. Fowler and Swatman also mention a 'prophesy regarding a cashless society signalling an evil' in their survey results.

Rogers (1995 p.411) discusses cultural relativism and how 'each culture should be judged in light of its own specific circumstances and needs.' Thus it is difficult to judge how an innovation or theory will be accepted without knowing unambiguous cultural details. This could be the subject of future research into smart card adoption theory.

The aim of the case study was to refine a smart card design methodology and to determine the sociotechnical concerns and to observe relevant factors which account for the slow proliferation of such systems. An extension to an existing research framework has been proposed which could provide grounds for further research into smart card design and adoption theory.

Through the research case study it was observed that the designers and managers did affect the adoption of the innovation through their decisions and actions which manifested themselves in the perceived attributes of the designs and thus influencing the adoption.

CHAPTER 5 CONCLUSIONS

The research presented illustrates a snapshot of the smart card industry in Australia. It shows the sociotechnical and some of the proprietary issues and highlights some of the relevant factors which account for the slow proliferation of such systems.

The research analyses the sociotechnical principles from the Cooper study and proposes a set of procedures (a model) for the design of smart card applications. These procedures are based on the integration of a sociotechnical design model with the various design phases of a smart card application.

Cooper et al. concluded on the basis of their case studies that '... there is a high level of use of sociotechnical principles across the various projects and that this high level is maintained at an operational level through all stages of design from planning through to implementation' (1996, p.9).

In the research undertaken, there was little if any collaborator initiated use of sociotechnical principles observed. A possible reason for this could have been the size of the businesses involved in either study and the formal business practises and methodologies. The organisations participating in the case study presented were all SMEs. Cooper et al. do not define the size of the participating organisations.

The design and specification process models presented in this research are scalable due to smart cards use of standards. Smart card standards are constantly evolving. With a business world that is eager to implement such technologies and to remain competitive requires some guidance and procedures as to how to deal with this innovation.

The smart card projects involved in this research demonstrated that there is an effect on the adoption of the innovation by the design and specification processes. The outcome of these processes determines what the chances of innovation acceptance are. Several perceived attributes of an innovation were examined. These included relative advantage, compatibility, complexity, trialability and observability.

Relative advantage is the extent to which an innovation is perceived as being better that the one that it replaces (Rogers, E.M. 1995 p.212). The car park loyalty system had no relative advantage because it was not replacing a previous system. Due to the managerial decisions regarding user rewards and the proprietary nature of the system, it had no relative advantage to anyone other than the seller.

The proposed entertainment loyalty system was to provide a relative advantage over a previous magnetic stripe based scheme. The relative advantage most to the end user was to have been that the scheme's loyalty based rewards increased.

Compatibility can be technical and social. The car park loyalty system was technically incompatible with any other card based system – proprietary. Socially, the more familiar a system or product is, the more compatible it potentially is with the users requirements. Socially it was unfamiliar because it was the first such scheme in Australia.

Compatibility for the entertainment loyalty system was a design issue that remained unresolved. Compatibility with the previous system was unresolved due mainly to cost : benefit analysis of adding to an old system or creating a new system. The social compatibility aspect depended on the technical compatibility due to a previous system being used.

Complexity is the extent to which the innovation is perceived as hard to comprehend and use (Rogers, E.M. 1995 p.242). The car park loyalty scheme was difficult to understand for even the designers. The users often found it difficult to understand how the rewards scheme functioned. Thus the complexity has attributed to be high.

While the complexity of the entertainment loyalty system could not be determined due to a lack of a complete design.

For the car park system, there was no way to try or test the scheme before the consumer committed to the system. Hence, it had no trialability.

As a contrast, the planned entertainment loyalty system provided a user with the ability to use a test card at a kiosk to observe a sample transaction and a reward. This characteristic effectively would have allowed the consumer to trial the innovation and reduce any perceived complexity and increase observability.

A major problem for the car park system was that being hardware based, everything happened in the software. There was no observable benefit at the car park for the user. There was no flashing light to catch the user's eye, and thus it suffered from an observability perception problem.

The relationship of these perceived attributes to the case study projects showed that the design and specification processes do determine, to an extent, how a smart card based system is adopted. The literature showed that there is no finite method to determine the extent of the adoption. It was found that an empirical analysis may be used to gauge the possible degree of adoption.

The perceived attributes are only an indication that should be used for prediction based on previous results. It is always difficult to predict how a social system will accept or reject a new technology. There are many factors and variables that are beyond the scope of several simple criteria; for example the economic climate, government policies and social issues.

Future research may consider further refinement of the proposed design and concept processes and their implementation through the other processes of the waterfall model. An extended research project may focus generally on the model, or on one specific process.

The research also explored the cost : benefit analysis performed by the collaborators in the case study. One project was abandoned due to cost issues, while the other continued regardless of the analysis outcomes. This provided a view to managerial influences into the concept and specification processes and highlighted a need for formal business processes and structure to prevent wrong decisions.

An integrative research model was proposed that incorporated formal links to sociotechnical design methodologies. This extension highlights what may be deemed as an obvious link to adoption issues such as perceptions and the consumer. The innovation is affected by the consumer. Thus the links between the sociotechnical issues which relate to the consumer and the innovation should be established in a research framework model for smart card based systems. The detailed expansion of that model would provide a possible starting point for future research.

Research into the interoperation of the relevant standards and specification would be an admirable and lengthy goal for some future research. The effect standards, specifications and emerging technologies have on the innovation adoption process is another possibility. From a business perspective, the business case to justify the cost of migrations to smart cards and the relationships to diffusion and adoption is another future research project.

Smart cards are an emerging technology tool that have the potential to blossom to change several industries, including the banking industry and amongst others the customer-business 'relationship and database marketing forever' (Cross, R. 1996 p.30). The relevant standards are also constantly changing too fast for business to follow.

The prediction of Allen, C. and Barr, W.J. (1997 p.vii) of 'two billion smart cards to be in circulation by the year 2000' should have signalled an awaking in the business community. Yet, the reality remains that 'few executives are equipped to make critical strategic business and investment decisions rapidly emerging smart card technology will demand.' (Allen, C. & Barr, W.J. 1997 p.vii) This can largely be attributed to the lack of defined models or procedures that a business can follow to take advantage of changing smart card technology.

Australia has the potential to be on the forefront of this technology in the region mainly because of the slow progress in the North American region. To fall behind at this critical stage is to let another major business opportunity pass.

This research helps to demystify the concept and specification processes involved in a smart card system. This was achieved through concert with industry collaborators of incipient customer loyalty smart card projects.

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GLOSSARY

Application. The application protocol between the card and the terminal and its related set of data.

Byte. Eight bits.

Chip Card. Any plastic card containing one or more integrated circuits; also known as a integrated circuit card (ICC).

Contact. A conducting element ensuring electrical continuity between integrated circuit(s) and external interfacing equipment.

Cryptographic Algorithm. An algorithm that transforms data in order to hide or reveal its content.

EEPROM. Electrically erasable, programmable ROM.

EFTPOS. Electronic Funds Transfer at the Point of Sale.

Embossing. Characters raised in relief from the surface of a card.

Integrated Circuit(s). Electronic component(s) designed to perform processing and/or memory functions.

Magnetic Stripe. The stripe containing magnetically encoded information.

Memory Card. A chip card without a microprocessor.

RAM. Random access memory.

ROM. Read-only memory.

Smart Card. Chip card whose integrated circuit contains a microprocessor for managing and access control to stored data.

Sociotechnical. A system design methodology that incorporates social considerations with technical issues.

LIST OF TABLES

LIST OF ILLUSTRATIONS