ORGANISATIONAL IMPLEMENTATION OF STORAGE AREA NETWORKS AS A STRATEGIC KNOWLEDGE MANAGEMENT TOOL.

by

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CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that the thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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ABSTRACT

ORGANISATIONAL IMPLEMENTATION OF STORAGE AREA NETWORKS AS A STRATEGIC KNOWLEDGE MANAGEMENT TOOL

The growth of business data is proportional to growth in data storage systems. This growth in turn has driven management to examine more closely more effective ways of managing the functions of IT departments including the implementation of data storage systems. One such system is Storage Area Networks (SAN) which are complex and involve a vast array of different hardware, software, infrastructure setup and vendors.

Given that, business operations in the twenty-first century are fast moving from traditional methods to more sophisticated technology-based systems and tools. It is arguable that successful implementation of new technologies is also dependent on many factors such as the efficient management of resources including intellectual and tangible assets. However these resources can be utilised much more efficiently and effectively through the application of knowledge management tools such as SAN systems which are well positioned to capture, store, use and re-use organisational knowledge for the purpose of enhancing the competitive position of the company.

Some of the most important decisions facing organisations include: a) ongoing shortening of the development cycle of new products and services, b) effective and efficient communication with suppliers and experts from around the world, c) receiving and responding to customer feedback, and d) accessing research and development facilities around the world. However, in recent times, SAN systems as Knowledge Management tools have been rapidly emerging as critical tools for enhancing strategic advantage and for improving the organisation's standing.

The study provides knowledge on Critical (key) Success Factors or CSFs for companies which have already implemented or plan to implement SAN in their business operations. Furthermore, companies may benefit from the results by

utilising the assessment for planning and for strategic purposes. For example, as a result of better utilisation and better understanding of the implementation of SAN systems, cost savings and time savings may be achieved. In addition, simplifying business processes and improving quality and efficiency of organisational digital systems may lead to the additional benefits of improving the organisation's competitive advantage.

Two separate focus groups were convened to assist the researcher by providing input into the model, as well as questionnaires. Questionnaires were then mailed to a randomly selected list of companies that have implemented SAN.

The following statistical steps and procedures were used to analyse the collected data to develop the prediction model:

1) calculation of descriptive statistics;
2) examination of the non-response bias;
3) check of reliability and validity;
4) testing of the hypotheses; and
5) development of a prediction model.

As a result of the statistical analysis, seven CSFs for SAN system implementation success were identified. Some of the factors were identified to make significant contributions to the success of a SAN implementation as a strategic knowledge management tool in organisations.

Accordingly, this thesis provides both theoretical and practical new insights into the implementation of a SAN system and provides a framework for further development of the SAN and the IS research field.

It is also believed that the findings of this thesis may help extend the existing knowledge on SAN and implementation research.

The model used in this thesis is based on the industry conditions at the time and place when the research was conducted.

The results of this research should be interpreted with caution, as this research is the first of its kind and like any other research is subject to a number of limitations, some due to the lack of information in the area of research as well as the limitations on the survey data.

CHAPTER 1

INTRODUCTION

1.1 General

The explosive growth in business data comes both from the rapid adoption of computers in every facet of an organisation's operations and from the increased data generated from moving many of these operations online. The combined pressures of globalisation and growth in e-business have resulted in data storage and management becoming not only one of the most important functions of IT departments, but also one of the most important functions of the business as a whole. Most organisations capture significant amounts of data in highly structured databases, such as Enterprise Resource Planning (ERP) and Material Resource Planning (MRP) line-of-business systems (Jamoo 1999).

After the September 11, 2001 attack in the USA, organisations of all kinds were forced to re-evaluate how they need to store data. The attack has caused companies, realising the importance of storage, to place more emphasis on disaster recovery plans across all applications. Data is far more important and more vulnerable than it ever was in traditional business; therefore, it is time for companies to examine whether their existing storage architecture can perform those functions (Ashlee 2001).

There is no doubt data is exploding. Companies have viewed data as a strategic weapon so they cannot afford any downtime when data is unavailable. Companies are looking for storage backed up in multiple locations and greater redundancy of their network in case important parts of a network are disabled (Grice & Ames 2001).

According to the School of Information Management and Systems at the University of California, Berkeley, the total volume of information created worldwide is expected to double each year for the foreseeable future (Erlanger 2001). The same

study estimates that by 2001, a total of 12 exabytes of data worldwide would have been accumulated (an exabyte is about 1 quintillion bytes, or a billion gigabytes) but that it would take only 2.5 years to accumulate the next 12. It shows that data is accumulating at a dramatic rate so it is necessary to store data properly as it is so valuable.

The growth of information has become a strategic issue for all organisations across the globe. Storage is the hottest issue in our industry. To guarantee a successful position in the market today and maximise returns on investment, all businesses, whether small or large, need to ensure they have an effective storage infrastructure in place.

The term 'data-intensive' describes the fact that all electronic transactions can be stored for processing and subsequent analysis. Today we are faced with an explosion of data generated by e-business applications. This data must be stored and managed appropriately. There is also a requirement to distil information out of raw data using data-mining applications.

By definition, e-business must be open for global business across multiple time zones. Bank customers want access to their accounts on a 24x7 basis. Auction sites operate around the clock. Further, with global availability and intensive pressure on marketing-driven growth, transaction levels can spike erratically and inadequate storage management can drive major performance bottlenecks for web applications. Organisations require agile, scalable and affordable approaches that can support the often-unpredictable transaction volumes. Consumer-driven 24x7 availability requirements mean that it is no longer acceptable to take systems offline to execute important data management tasks. Further, even minor storage failures can be very costly to an organisation and harm consumer confidence. Forrester Research estimated that the largest 2,500 companies worldwide would spend US $19.3 million each on data storage by 2003, from the then-current $3.8 million level (Babcock 2000).

Storage industry dynamics are changing at an unprecedented pace. Annual IT spending in excess of $1 trillion (Moore 2001) signals that change is a core competency of the information age. We now see many concepts unfolding that were looked at quite differently by most of the industry less than two years ago.

The rising number of internet transactions and the corporate desire to capture data about online customers are driving increased spending on storage (Babcock 2000). And today, according to the experts, corporate information technology executives are more likely to spend their precious dollars on storage than on servers.

The internet caught most of the established business world by surprise and in a very short span of time transformed computing technology, thought and investment. It has transformed from a network of static pages in the mid-1990s (most often to complement corporate marketing efforts) to dramatically changing business practices. In short, it has significantly altered the corporate enterprise, bringing in several fundamental changes that include:

- adapting the enterprise to factors outside traditional business environments, factors that have high impact on operations;
- 24x7 availability of all applications; and
- making traditional capacity planning and management methodologies obsolete.

Furthermore, widespread application usage - ERP, data mining, email and internet applications - combined with price erosion of magnetic media is fostering a massive explosion in data. Volumes of data, critical to business continuity, are disseminated throughout the enterprise, adversely affecting performance and administration. In addition, technical managers are faced with increasing demands to ensure high availability and end user service levels.

According to Breeding (2001), *in an information environment, an organisation's success is tightly coupled to its ability to store and manage information.* Storage

systems provide a critical part of an organisation's network infrastructure. With the amount of data growing at an incredible rate, storage strategy must keep pace. The industry realizes that a new type of data network is needed to meet the needs for the new distributed environments. The outcome of this process is a set of standards defining Fibre Channel. Fibre Channel brings the best of both worlds together — the high speed and robustness of the storage channel with the flexibility and few distance limitations of a standard network (Werner et al. 2000).

To cope with today's business challenges, companies are rethinking how they design and manage their storage infrastructure. Customers' storage requirements are doubling every year, and storage has become the largest element of e-business success. Storage Area Networks (SANs) have emerged as the industry-standard solution. A SAN offers a new level of performance, storage management and flexibility not possible with previous generation technology. Trends such as globalisation, technology advancement, deregulation, emerging of new markets and industries, and economic restructuring have greatly increased the organisation's need to develop its unique strategy (AL Ghamdi 2005).

Currently storage networking may be the healthiest sector of IT. From a statistical standpoint, the Dell'Oro Group reports that sales of storage area networks (SANs) have risen by 10 percent or more for each of the last several years (Robb 2006). According to Mitchell (2006), the capacity of disk storage shipped in 2005 grew to 653PB (petabytes), which was a year-over-year increase of 54.6 percent.

The SAN is the latest breakthrough in knowledge management tools. SAN is emerging as the most promising way Unix and NT computing and storage resources are deployed throughout a business. Using high-speed storage networking technology such as Fibre Channel, a SAN allows servers, storage and tape devices to be interconnected in a synergistic way that was not previously possible. By interconnecting these with a SAN (Wright 1999), they can be consolidated, leading to improved data accessibility, more efficient data management, higher levels of service and lower costs of ownership.

In March 2006, the *Credit Union Journal* reported that with more than two terabytes of available storage space, 70 servers and 10,000 check images every day, SANs have become an attractive storage device for the mountains of data that are spilling from new high-byte technologies at University of Wisconsin CU (Jepson 2006).

An MIT Media Lab venture researching how babies develop the ability to talk began in March 2006. The project started using 14 microphones and 11 cameras mounted on ceilings throughout the house to record the everyday life of a baby boy. The required storage area is expected to be 1.4PB, or 1,400TB, of data compiled over the span of the three-year project (Mearian 2006). "This is a great marriage between industry and the academic world," said Frank Moss, director of the MIT Media Lab at a press conference (Mearian 2006). It is believed that 350GB of video will be processed during every 12-hour analytical run. The project has been amassing several terabytes of audio and video data per week of early-childhood learning and socialisation data to model human language acquisition, Roy said. "If you take all parallel tracks of data over three years, you'll have 400,000 hours of video and audio data," he said (Mearian 2006).

1.2 Research Problem

Organisations are quickly recognising the value of their intangible assets such as data/information and knowledge. It is clear that the deployment of SAN technology is a very important phenomenon for organisations that are relying on technology to accommodate the constant demand for storage capacity.

It is not clear what factors contribute to the success or otherwise of the implementation of a SAN. Organisations need to identify all these factors and in particular pay attention to those that are more practical than others.

Since no published research has identified the success factors for SAN and given the significance of SAN for organisations in a digital age, the research proposed is:

1. to find the factors that contribute to the success or otherwise of SAN in organisations;

2. to identify which of these factors are critical and which are not;

3. to develop a prediction model to guide managers and their organisations on the factors that are likely to impact on the success or otherwise of SAN before they embark on SAN implementation in their organisation.

Questions about what are the important success factors for the implementations of SAN, how important management support is in implementing SAN, and how implementation's effectiveness or the organisation's technical competency affects the success rate when implementing SAN are still unanswered. *This suggests that the understanding of SAN implementation is limited and research is needed.*

A major problem with today's SAN implementation is that little is known about factors that contribute to its success mainly because of its newness and a lack of theory and a universal business model.

Clearly, removing unwanted data/information and knowledge provides financial incentives as freeing storage spaces can save costs. On the other hand, the cost of not having data/information and knowledge when needed can be prohibitive. These cost functions are usually dependent on many variables such as the frequency of using the data/information and knowledge, the importance of data/information and knowledge to the decision maker and the availability of storage. Naturally a balance between these costs needs to be established in order to optimise the use of SAN and improve its performance. However, from a resource utilisation viewpoint, a model should be developed for the purpose of overcoming the business problems associated with the development, implementation and use of SAN and associated systems.

This study will identify critical success factors (CSFs) for successful implementation of SAN. A model will then be constructed based on the CSFs that are identified. The

model can help organisations to reduce their risks of failure associated with implementation of SAN.

Finding the critical success factors (CSFs) for SAN implementation can improve the success of SAN implementation as well as minimise the risks associated with the failure. Therefore, the main purpose of this study is to identify and analyse the most critical success factors in order to be able to develop and construct a reliable model for successful implementation of SAN in e-business organisations.

1.3 Research Objectives

The main objective of this Ph.D. research is to develop a model to identify the strategic CSFs for successful implementation of SAN in organisations. However, the model developed will be tested in real-life situations in organisations that have already implemented SAN. A differentiation between the use of SAN for information management and for knowledge management programs will be made. This differentiation will lead to further analysis and will necessitate the development of models for assessing the degree of usefulness or otherwise of SAN implementation and the extent of its impact on management of the organisation.

Accordingly, the aims of this research are as follows:

1. to develop and test a model for implementation and management of SAN in organisations;

2. to develop and test a model for assessing the success or otherwise of SAN implementation in organisations;

3. to provide a comprehensive analysis for the factors that could influence the success or otherwise of SAN implementation in organisations;

4. to develop and test an organisation's readiness model for SAN implementation and management in organisations; and

5. to provide a comprehensive analysis of the impact of the SAN implementation on the management of the organisation.

Strategic values will be examined with the aim of finding a set of CSFs that will increase the chance of success of SAN implementation in e-business environments. It is envisaged that this will lead to understanding the rules and/or conditions for maximising the benefits from employing SAN in e-business environments. The recommended key success factors for SAN would enable executives/ managers/technical managers and practitioners to effectively and efficiently use these strategies when developing and planning for SAN in their e-business environments.

The objectives of this study are as follows:

1. *to identify possible factors that contribute to the critical success or otherwise of SAN in organisations*. This was achieved by a very comprehensive review of the literature, case studies, digital papers, research studies and journals.

Rockart (1979) defined CSFs as "for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation". They are the few key areas where "things must go right for the business to flourish". According to Rockart (1979), "Critical success factors are the factors that constitute the critical or fundamental components of the system". They are the key areas where *things must go right*; in other words, if these components fail, the system fails.

The idea of identifying CSFs as a basis for determining the information needs of managers was proposed by Daniel (1961) but popularised by Rockart (1979). The idea is very simple: in any organisation certain factors will be critical to the success of that organisation, in the sense that if objectives associated with the factors are not

achieved, the organisation will fail - perhaps catastrophically so. Rockart (1979), by referring to Daniel (1961), gave the following as an example of the CSFs: "new product development, good distribution, and effective advertising for the food processing industry - factors that remain relevant today for many firms" (Bergeron & Begin 1989; Boynton & Zmud 1984; Goldsmith 1991; Leidecker & Bruno 1984; Pollalis & Frieze 1993).

2. *to apply a strategic approach to identify CSFs.* At the time of this study no empirical studies on SAN implementation success were found. Previous empirical literature has discussed measures for information systems (IS) implementation success but not SAN implementation success. Since SAN is a type of IS, some examples of IS implementation success measures are quite relevant for the model foundation. Some examples of the IS implementation success measures are: user information satisfaction (Ives et al. 1983), system utilisation, decision effectiveness, organisational performance (Ives et al. 1980) and CSFs for information needs (Rockart 1979). Therefore, this study applies a strategic approach to identify critical factors for successful implementation of SAN in organisations.

3. *to identify which of these factors may be critical and which are not.* Two focus groups were formed from academia, technical managers and management staff who have been involved in SAN implementation. The focus groups' aims were to review the research model and assist the researcher to review all the success factors and identify which ones are critical and which are not. In order to make a preliminary validation of the instrument, a pilot (pre-)test and discussion of the proposed research instrument were also undertaken with the second focus group.

Focus groups are seen as a means of gathering views, opinions and beliefs on a particular subject from a number of participants in a single session, for the purpose of eliciting the views and opinions of the group members through social

interaction where the feelings of participants are stimulated through the dynamic processes occurring within the group (Carney 2001).

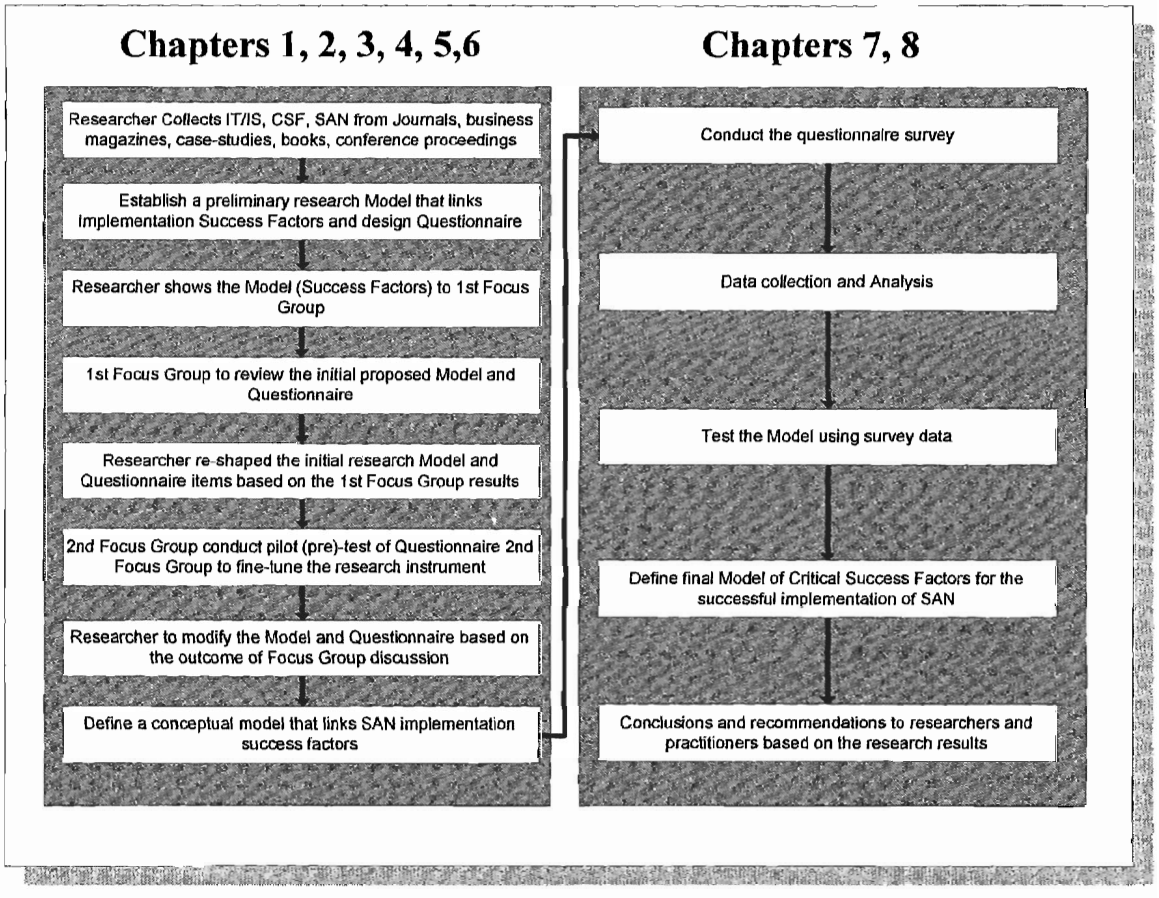
4. *finally, to develop a model that might predict SAN implementation success by using CSFs.* Rockart (1979) was the first researcher to apply the CSF approach in the field of IS. His aim was to provide chief information officers with the necessary information about the CSFs of their organisations from a business manager's perspective to help them develop IS solutions to meet their organisation's most critical needs. Based on the work by Gide (1999), Brancheau et al. (1996), Miles et al. (1995), Grover et al. (1995), DeLone & McLean (1992), Montazemi (1988), Magal et al. (1988), Yaverbaum (1988), Miller & Doyle (1987), Lyytinen (1987), Ives & Olson (1984), Ferguson & Dickinson (1982) and Martin (1982b), it appears that the CSF approach could help SAN managers to achieve more accurate implementation. The model will indicate to directors/managers the factors that are likely to impact on the success or otherwise of SAN before they embark on SAN implementation in their organisation.

The following outlines the step-by-step process of the research study, illustrated in figure 1.1:

- identification of factors that contribute to the success or otherwise of SAN in organisations. This was achieved by a very comprehensive review of the literature, case studies, digital papers, research studies and journals;
- establishment of a preliminary tentative research model and survey questions that link implementation success;
- with the first focus group, a review of the proposed model and research questionnaires for SAN's implementation success factors;
- implementation of necessary changes to the initial research instruments and questionnaire items based on the outcome of first focus group results;
- a pilot pre-test with the second focus group participants and finetuning the research instrument;

- based on the outcome of focus group discussions, modification of the model and questionnaires;
- construction of the main survey;
- mail delivery of a random survey to companies that have implemented SAN;
- analysis of data and report on the results;
- analysis of the research findings, the contributions and limitations of the research; and
- conclusion of the thesis.

Figure 1.1: Step-by-Step Research Study



System implementation presents extraordinary challenges to information technology professionals and the organisations impacted by the implementations. A successful implementation can provide vast rewards in organisational strengths and efficiencies. A failure can drain an organisation of people, funds and vitality. Consequently, many

people have puzzled over the reasons for the successes and failures experienced with these implementations (Vaughan 2001).

There are numbers of published articles dealing with CSFs or SAN; none has combined the two. This study fills that void by combining both CSFs and SAN implementation theory and research.

Therefore it is envisaged that results from this research will indicate that perceived benefits as well as potential business opportunities for companies are likely to become key drivers for the use of knowledge management and/or knowledge-sharing programs.

Accordingly, this research will provide a comprehensive study of the implementation of SAN in organisations. Further, it will present a model for managing all the aspects of SAN implementation that are likely to influence technical, structural and cultural factors in organisations. It is hoped that the model will depict how companies can implement SAN as a knowledge management and/or knowledge-sharing tool to support their business operations.

1.4 Research Model

Since no published work on CSFs in SAN implementation has been found at the time of this study, the proposed research model uses some of the important, well-known and internationally recognised previous CSF studies in IS (Rockart 1982; Martin 1982b; Miller & Doyle 1987; McCredie & Updegrove 1999; Gide 1999; Kuang et al. 2001; Nelson & Somers 2001).

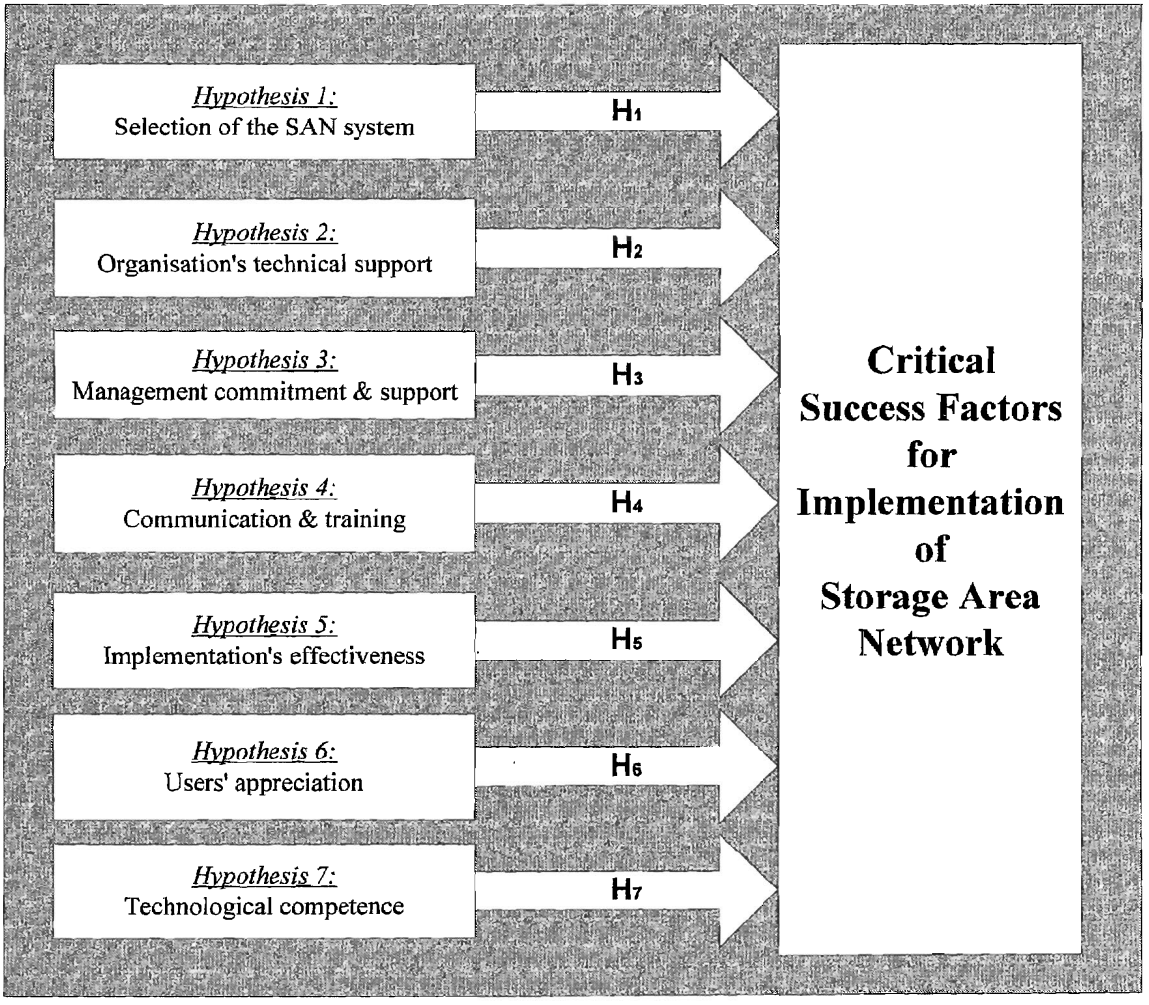
In this study, seven sets of hypotheses that are likely to impact on the success or otherwise of SAN implementation are identified. The independent variables were selected from various IT/IS-related studies.

The CSFs hypothesised are briefly as follows:

1. selection of the SAN system (hardware, software and network);
2. organisation's technical support;
3. management commitment and support;
4. communication and training;
5. implementation's effectiveness;
6. users' appreciation; and
7. technological competence.

The proposed conceptual research model is presented in figure 1.2.

Figure 1.2: The Proposed Conceptual Research Model and Hypotheses for Successful Implementation of SAN systems



1.5 Research Methodology

As there have not been any surveys published attempting to link the use of SAN-based systems with the performance of organisations, a new approach for establishing guidelines for constructing the research instrument needs to be identified.

The development of a theoretical framework is part of the research strategy that the researcher has adopted. The proposed framework has been formed by merging three theoretical perspectives: DeLone and McLean's model (1992) of IS Success, Eldon Y. Li's (1997) perception of the importance of IS success factors and Drury and Farhoomand's (1999) hierarchical structural model of IS success. Other papers consulted were Croteau et al.'s (2003) work on critical success factors of CRM technological initiatives, Soliman et al.'s (2001) work on critical success factors of the implementation of CAD/CAM in ERP environment, Nelson and Somers' (2001) study, one of the most extensive reviews of critical success factor in ERP implementations to date, and Gide's (1999) model for successful implementation of Internet e-commerce in business operations.

The theoretical framework was developed after an extensive literature review of existing quality frameworks and existing CSF models of IS implementations. The theoretical framework developed consists of seven factors.

The researcher of this study adopted a research approach using two-phased focus groups to guide the research data collection. The variables included in the model have been derived from previous CSFs studies (Rockart 1982; Martin 1982b; Magal et al. 1988; Bergeron et al. 1993; Cavaye 1995; Gide 1999) and focus groups.

Two separate focus groups were convened to assist the researcher by providing input into the model. The use of focus groups is appropriate when the concepts being investigated are relatively new (Sekaran 1992; Zikmund 1997 and Gide 1999). Questionnaires were also used.

The two focus groups were composed of a team of academia, experts and executive/managers/technical managers (mainly SAN-experienced). Gide (1999), Brittain (1992) and Clark (1992) used a similar approach for research. The use of a focus group in this situation is warranted for the following reasons.

1. There is no published research on this topic, and hence a focus group is likely to provide the guidance and in-depth analysis not found in the literature.
2. The use of a focus group ensures a non-biased formulation of the research instrument, limiting researcher bias.
3. Published results suggest that a focus group approach is an appropriate choice of research method for this type of problem (Brittain 1992; Sekaran 1992; Soar 1997; Zikmund 1997 and Gide 1999).
4. The results from this study are likely to be of interest to the organisations involved and hence a method to ensure the creditability of the outcome needs to be employed. The use of an independent non-biased focus group with industry experience as well as academia will enhance the creditability of the outcome.

Questionnaires were then mailed to a random selection of companies that have implemented SAN. There were no business indexes available for SAN-based user companies at the time of this research. As a result, companies were randomly selected from the SNIA (Storage Networking Industry Association) members list.

In order to achieve the objectives of this study, five statistical steps and procedures were used to analyse data:

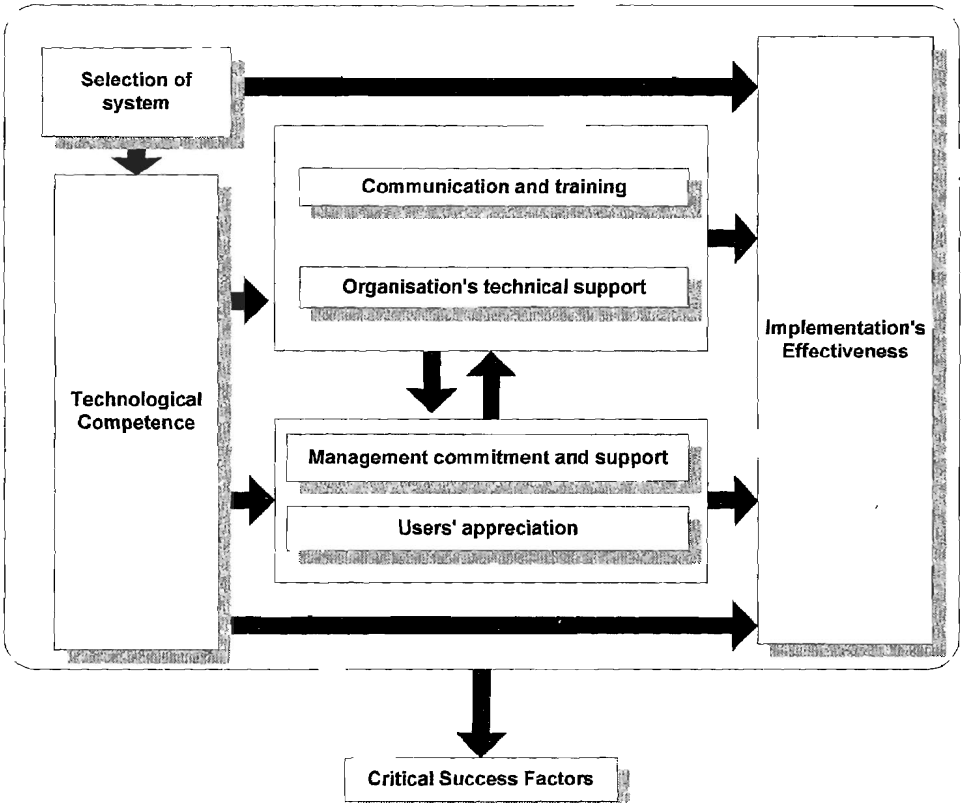
a) calculation of descriptive statistics;
b) examination of the non-response bias;
c) check of reliability and validity;
d) testing of the hypotheses; and
e) development of a prediction model.

This study used the SPSS (Statistical Package for the Social Science) for data analysis as follows:

- Demographics' chi-square analysis (to test non-response bias)
- Cronbach's alpha factor analysis (to test reliability and validity)
- factor analysis (to identify CSFs)
- canonical correlation Analysis (to determine relationships between CSFs and SAN implementation success)
- Multiple Regression Analysis (to develop a predictive model).

The figure below (figure 1.3) outlines the proposed theoretical framework developed for this research project.

Figure 1.3: Proposed Theoretical Framework

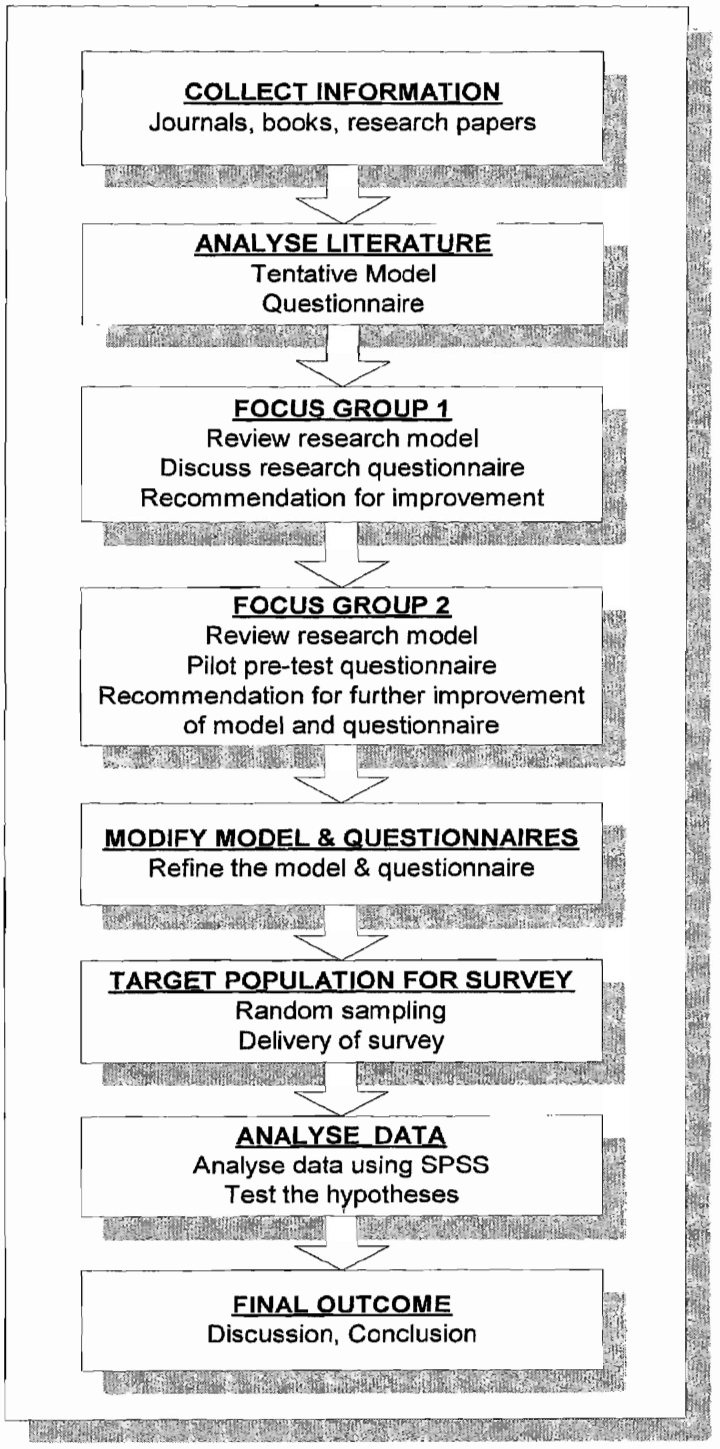


The theoretical framework was developed after an extensive review of the literature on existing quality frameworks and existing CSF models of IS implementations. The theoretical framework developed consists of seven factors.

The proposed theoretical framework will be used to address the existing gap in the literature. Therefore the proposed theoretical framework will be a basis model for future research in the SAN area. The proposed framework incorporates the ideal in-

built model of SAN implementation, which can also be a framework for further research and studies in this area. The figure below (figure 1.4) outlines the research flowchart.

Figure 1.4: Research Flowchart



1.6 Research Instrument

The questionnaire was designed in three parts:

1. The first part contained questions designed to identify SAN implementation trends and satisfaction.
2. The second part surveyed variables measuring the improvements in performance after SAN implementation based on managers' perceived evaluation. These items were based on, or obtained from, the recent literature.
3. The third part was designed to identify SAN implementation activities that influence implementation success.

According to Churchill (1979), for the research instrument to meet the requirements of accuracy and validity, several procedures must be adopted (Allen & Yen 1979; Emory & Cooper 1991).

- Reliability refers to the stability or the consistency of the measuring instrument. It reflects the accuracy of the measuring instrument.

- Validity refers to the extent to which the instrument evaluates what it is intended to measure. Two types of validity were tested in this study: content validity and construct validity.

Accordingly the following tests were conducted on the questionnaire:

1. non-response bias;
2. reliability;
3. content validity; and
4. construct validity.

Cronbach's coefficient alpha was used to check internal consistency and as an overall reliability measure. Both construct and content validity were measured to ensure that the questionnaires met the validity requirements. Canonical correlation analysis was used to test CSFs of SAN implementation.

1.7 Statement of Hypotheses

The conclusions and CSFs from this study derived from a two-phase research process.

a) Hypotheses formulation

The objective of this phase was to develop and refine a preliminary model (i.e., hypotheses) of what factors contribute to the success or otherwise of a SAN implementation, based on outcomes of focus group discussion.

b) Hypotheses testing

Since SAN had been in commercial markets for less than a decade at the time of this study, and in order to incorporate previous studies and some kind of justification of the model, IT/IS-related CSF studies have been used as a stepping-stone to build an initial tentative model (such as Rockart 1982, Martin 1982b, Miller & Doyle 1987). Literature reviews of existing measures of IS success have been conducted by Zmud (1979), Ives & Olson (1984), DeLone & McLean (1992), Cavaye & Cragg (1995) and more recently by Gide (1999).

Examining and explaining the importance of SANs and the resultant implementation impact on an organisation's performance are the main aims of the hypotheses. The power and influence of SAN also need to be established. However when this study began there were no comprehensive academic studies/surveys attempting to clarify the link between the CSFs and the implementation success of SANs.

The independent variables were selected from a variety of IT/IS-related literature as a result of very extensive research. The research has identified seven sets of hypotheses briefly as follows.

1. **Selection of the SAN system (hardware, software and network)**

   The first group of hypotheses is concerned with the selection of the SAN system for implementation. SAN systems are a combination of hardware, software and network components. The proposed SAN system should be selected to suit the proposed application. Systems that are out of fit with their intended use risk being either user-unfriendly or partially unusable.

   H_1: The selection of the SAN system for implementation is positively related to SAN success.

   H_{1a}: The appropriateness of the SAN system is positively related to SAN implementation success.

2. **Organisation's technical support**

   The second group of hypotheses deals with the technical support provided for the implementation of the SAN system. Appropriateness, adequacy and effectiveness of the technical support are related to the success of SAN implementation.

   H_2: An organisation's technical support for the implementation of the SAN system is positively related to SAN success.

3. **Management commitment and support**

   The CSF literature recognises top management support as one of the important factor for ensuring implementation success (Al-Mashari 2003; Nah et al. 2001; Smyth 2001; Esteves & Pastor 2000; Davenport 2000; Stewart 2000; Brown & Vessey 1999). IS implementation literature (Ginzberg 1981)

and general top management literature (Finkelstein & Hambrick 1996; Hambrick & Mason 1984) recognise its importance.

The key to successful implementation of SANs is top management's deep and lasting commitment and support. In an organisation, the support of management is usually necessary for any innovation (like SANs) to take place (Ruth & Schware 1996).

H_3: Commitment and support from top management are related to SAN implementation success.

4. Communication and training

Even with management commitment and technical feasibility, SANs implementation may not achieve the intended goals if people related to the SAN system are not ready for it. Because of its newness and complexity, the SANs represent a learning challenge that has to be met with a business education focus. By addressing management training needs early, management is able to better understand and absorb how to take advantage of the SANs effectively. The most informed managers take the best decisions.

The fourth hypothesis deals with the communication and training of technical staff and users.

H_4: Communication and training are positively related to SAN implementation success.

5. Implementation's effectiveness

Organisations need to be absolutely clear on their objectives for a SAN system implementation project. Therefore, any management task should be designed to achieve the organisation's objectives. So SAN implementation

should be designed to achieve an organisation's objectives. Bloch et al. (1996) indicated that building a system requires a strategy and vision of the goal to be achieved.

According to Mougayar (1997), by tackling individual elements without a comprehensive strategy, organisations may never realise its synergistic potential. A planned strategic approach is needed, including:

- a clear view on how an organisation will use the new technology
- an ability to transform internal and external business processes according to the requirements imposed by the new types of interactions
- an organisational framework led by a senior-level person whose role is to develop overall strategy, coach the senior executives to initiate calls for action and educate employees throughout the organisation.

Thus, this research examines the relationship between implementation's effectiveness and SAN implementation success. The fifth hypothesis deals with implementation's effectiveness.

H5: Implementation's effectiveness is positively related to SAN implementation success.

6. Users' appreciation

According to Ruth and Schware (1996), for many years it has been known that the successful introduction of any new idea, whether technology-related or not, requires a careful elaboration of the strategy by inducing the users to participate in the idea. Although the strategies vary according to the situation, a common requirement is aligning the user's behaviour patterns with the use of the intended new technology (like SANs). A determined, careful focus on

the end-user's behaviour is at the heart of a successful technology transfer application.

H6: Users' appreciation is positively related to SAN implementation success.

The research hypothesises a positive relationship between users' appreciation of SAN systems and SAN implementation success.

7. Technological competence

Technological readiness and access to technical competence are important for the successful implementation of a SAN system. Technological competence is related to the existence and use of the organisation's information technology infrastructure, in terms of hardware, software and human resources components, which support or enable implementation of a SAN system.

According to Nord and Tucker (1987), competence to introduce and manage an innovation (like SAN systems) has two components:

Firstly, a *technical side*, which has to do with the substance of the innovation. The organisation has to know what technology to use, how to use it, and how to judge its effectiveness in using it.

Secondly, a *social side*, which has to do with the ability of the organisation to activate and coordinate its resources. An organisation needs to be able to activate its employees in appropriate ways, to motivate performance and to integrate activities to achieve desired outcomes.

Social competence is derived from some combination of personal skills in working with others and structures that aid integration. The social or human component of technological competence, in terms of the level of information

technology knowledge, experience and expertise within the organisation, needs to be addressed when implementing change (Martinez 1995).

On the other hand, Grover et al. (1995) also suggested that taking good care of the required technology may be necessary along with other factors for successful implementation of an IT-related project. Many of the most serious problems occur when social competence is lacking and, as a result, a representative of the technical issues lacks appropriate resources and/or influence.

Therefore, a sustained SAN requires strong technological competencies and effectiveness, in order to optimise use of the resources devoted to it as success proves the validity of the business model. Thus, this study examines the relationship between organisation's technological competence and SAN implementation success.

H_7: The organisation's technological competence in implementing the SAN system is positively related to SAN implementation success.

1.8 Significance of the Research

The goal of this research is to identify CSFs in implementation of SANs in organisations and develop a prediction model, thereby providing a more effective SAN implementation for organisations that are planning to implement SAN.

The findings of this study may provide contributions to both academic research and management as well as to large corporations that have plans to implement SAN in the near future. The findings may also assist and help broaden the existing knowledge on SAN systems implementation as well as providing a basic knowledge for further research on SAN implementation.

Based on the findings of this study, management would be better prepared to implement SAN and to maximise the success of the implementation. The results of this study may also provide a valuable contribution to academic research, and the basis of a prediction model to be used for future research in the area of SAN implementation.

The expected main contributions of this research are as follows:

1. As far as the researcher is aware, this research is the first study of its kind in the area of SAN implementation. No published work was found in the field of SANs implementation as a strategic knowledge management tool in organisations at the time of this research.
2. The findings of this study will benefit management in better planning the implementation of SAN in their organisations.
3. The findings of this study may be helpful for further future research in the area of SANs and similar IT/IS systems.

1.9 Scope of the Thesis

The remaining contents of the chapters are given in the following order:

Chapter 2, SAN Systems as Knowledge Management Tools.
Chapter 3, Background information about SAN.
Chapter 4, Literature Survey.
Chapter 5, Research Methodology.
Chapter 6, Hypotheses.
Chapter 7, Data Analysis.
Chapter 8, Discussion and Conclusion.

CHAPTER 2

SAN SYSTEMS AS KNOWLEDGE MANAGEMENT TOOLS

2.1 Background

Continual technological advances in Information Technology such as the internet, Enterprise Resources Planning (ERP) systems and Knowledge Management (KM) systems make it essential that organisations should explore utilising these technologies to conduct their business or part of it. However it is arguable that the success of implementing these technologies is dependent on many factors including the efficient management of organisational resources.

According to Soliman et al. (1999a), knowledge and intellectual properties are a substantial part of organisational assets. These assets come in many forms and sizes. They could be stored in databases, printed on paper, integrated into enterprise policies or stored in an employee's memory. It is widely accepted that enterprises can benefit from understanding the nature and location of their knowledge resources while carefully dipping their toes into the pool of innovative knowledge management technologies.

Although some analysts believe that information technology is a key driver for knowledge management, others disagree with this view and believe that knowledge management is about people not technology. For instance, a Victorian government report made the point that technology is the "pipeline and storage system for knowledge exchange" but of itself is not knowledge management (Victorian Law Reform Committee 1999, p. 47). In addition, Eginton (1998) and Sbarcea (1998) reported that some firms have invested heavily in technology to underpin their knowledge management strategy, but have still planned the technology infrastructure to support and deliver the required knowledge capability, rather than being driven by the imperatives of information technology.

Quinn (1992) believes that the economic and producing power of a modern corporation lies in its intellectual and service capabilities rather than its hard assets. Quinn also points out that the value of most products and services now depends on "knowledge-based intangibles" such as technical know-how, product design, marketing presentation, understanding customers, personal creativity and innovation.

This view is an extension to that of Toffler (1990) who considers knowledge to be:

a) the source of power; and
b) no longer just an adjunct of money and muscle but instead the key element of power.

Vincenti (1990), Faulkner (1994) and more recently Coombs and Hull (1998) classified knowledge management activities and associated practices under the three headings:

a) knowledge processing;
b) knowledge domains; and
c) knowledge formality.

Furthermore, Soliman (1999) described the processes of managing knowledge in organisations as "the means by which value is added to *raw-knowledge* (inputs) in order to create *processed-knowledge* (outputs) i.e. adding value for their clients". The specific details of this will of course vary substantially across industries; however, in general, most organisations would utilise five processes for knowledge management in order to *create*, *capture*, *organise*, *access* and *use* knowledge (Soliman 1999). These five processes cover almost the entire scope of organisational functions and they are usually used to obtain the details of knowledge that would be stored in SAN systems.

The definition of knowledge management holds that knowledge management harvests and shares intellectual assets for breakthrough results in human productivity

and innovation. According to Sanchez et al. (1996) knowledge is the ability to sustain the co-ordinated deployment of assets and capabilities in a way that promises to help the firm to achieve its goals.

It is important to note that Yamanouchi (1995) has classified knowledge as either formal or non-formal. This definition is an expansion of the work by Nonaka (1990). Nonaka has identified two types of knowledge: "*explicit*" and "*tacit*".

Explicit knowledge is captured in databases, customer files, software, manuals and so on, and can be referred to as "structural" capital.

Tacit knowledge, on the other hand, may reside in the minds of the company's employees, suppliers and customers, and is also known as human capital. Human and structural capital make up the intellectual capital of the organisation. This intellectual capital should be fostered and further developed in learning organisations, defined as "organisations that promote collective learning so as to enable the continuous capacity to adopt innovations and thereby change" (Mohanti & Deshmukh 1999).

The task of joining the tacit knowledge with the explicit knowledge in any organisation is very complex. In spite of major advances in Knowledge-Based Technologies this process is still in its infancy. In other words, reconciling what employees store in their minds with what they store in databases or on paper requires extensive research.

It is interesting to note that the concept of using feedback mechanisms is not new. For example, Argyris (1976) advocated the use of a model which corrects errors in ways that involve the modification of the organisation's objectives, policies and standard routines. In other words, Argyris's model tries to activate participants to learn *know-why*, *know-what* and *know-how*, all simultaneously. This in turn calls for an integrated model encompassing learning processes, change management instruments and strategic initiatives. According to Soliman et al. (1999b), this can not

be attained without adequately managing the knowledge of the enterprise using appropriate tools which may include sophisticated SAN systems.

Sanchez et al. (1996) defined knowledge as the ability to sustain the co-ordinated deployment of assets and capabilities in a way that promises to help the firm achieve its goals. These assets, or "Knowledge Treasures", need a knowledge map which describes how to find, what to find and where to find useful knowledge within the organisation. Stewart (1997) believes that knowledge, or "intellectual capital", is found in three forms, namely human capital, structural capital and customer capital. The treasure map needs to cover all three areas for both tacit and explicit knowledge.

Joining tacit with explicit knowledge could be a very complex task and in some circumstances may not be possible. In other words, at present reconciling what is in employees' minds with what is stored in databases requires sophisticated SAN systems and, in spite of major advances in knowledge-based technologies, this task is still in its infancy.

However, since knowledge management is most useful as an integrated system which brings together several disciplines and shows their connections, this thesis looks at knowledge management from two perspectives:

a) the role of SAN as a knowledge management tool in an organisation; and
b) the goals of organisations.

By focusing on the place of knowledge management in these two issues, it is hoped to provide new insights.

2.2 Organisational Knowledge as Competitive Advantage

An increasing number of enterprises are now viewing the knowledge as a key competitive tool from which innovation can emerge, and are encouraging, supporting and rewarding collaboration between people. Moreover, while decentralised

enterprises may know where the bulk of their information resides, the problem becomes the dissemination of that knowledge to the people who need it. Using SAN systems as knowledge management tools can confer competitive advantage which may result in higher revenue and increased market share, especially in markets where time to market and high quality make a difference.

Implementing knowledge management programs within an organisation can be very costly, especially during the start-up phase. Therefore, looking at the business case for knowledge management is essential to ensure that the organisation has in place a set of strategies suitable for the implementation of knowledge management including implementation of SAN systems. The set of seven guidelines for such a strategy set may include functions such as:

2.3 Alignment of Knowledge Management with Business Directions

A key element in the business case is deciding how to apportion efforts aimed at harnessing tacit knowledge versus explicit knowledge. Hansen et al. (1999) argue that attempts to focus equally on managing both tacit and explicit knowledge may quickly undermine the business. They point to the models adopted in major consulting firms (considered to be benchmarks in managing their knowledge) that are primarily focused either on explicit knowledge or on tacit knowledge. They recommend using the 80:20 rule, i.e. spending 80 percent of resources on one approach and 20 percent on the other.

The way to decide on the best approach for each organisation is to know:

a) the market;
b) the profitable areas; and
c) whether the organisation provides one-off solutions or the same solution repeatedly.

If the enterprise primarily provides clients with a repeat of earlier solutions, then it should emphasise the capture and automation of explicit knowledge. This means investing heavily in IT and less heavily in the "best" experts. On the other hand, if the enterprise specialises in finding solutions for one-off projects, then knowledge management strategy should focus on tacit knowledge, i.e. hiring the best minds available.

Clearly strategies for implementing knowledge management efforts must be carefully developed and discussed before a significant investment is made. It is essential to be clear about what the benefits would be for the organisation and what impact is expected from its strategies. The role of SAN systems in identifying where the knowledge resides and how best it may be utilised and stored is important for the success of this strategy.

2.4 Identification of Knowledge Management Benefits

According to Clark and Soliman (1999), many of the benefits of knowledge management are intangible and difficult to quantify. Eginton (1998), Rees et al. (1999) and Sbarcea (1998) concluded that the benefits from knowledge management programs are clearly compelling and that it is important to a conduct full-scale business analysis before choosing a knowledge management program to suit organisation. In this regard SAN systems may play a key role in assessing employees' knowledge and in determining if major benefits to the organisation are obtainable from conducting the analysis presented in this thesis.

2. 5 Identifying Appropriate Knowledge Management Technologies

According to Hansen et al. (1999), when an enterprise considers developing a knowledge management strategy it must know its market and must also find an answer to three important questions:

a) what does the market want?
b) what are the driving forces? and
c) how may the enterprise can best provide answers?

The enterprise must also determine how the SAN systems could convert the knowledge and make it available. Nonaka and Takeuchi (1995) argue that there are four modes of knowledge conversion.

These conversions may be labelled:

a) externalisation;
b) internalisation;
c) socialisation; and
d) combination.

However when adopting a knowledge management program, the enterprise needs to plan for each of the four conversion modes taking into account the availability of sophisticated knowledge management tools such as SAN systems.

A good knowledge strategy needs to clearly delineate the resources to be dedicated to either tacit and/or explicit knowledge and should include strategies to improve knowledge sharing.

2.6 Developing and Implementation Knowledge Management Strategies

A recent study suggests that in order to harness and amplify the know-how, experience and expertise of employees, companies should implement a strategy which utilizes the deployment of sophisticated technologies such as SAN systems (Price Waterhouse Coopers 1999):

1. Focus only on what the business needs to know; i.e. become *knowledge-focused.*
2. Make important knowledge visible i.e. become *knowledge visible* (e.g. create or make explicit pathways to the experts and important wisdom within the company).
3. Pay attention to the vocabulary of knowledge; i.e. become *knowledge-defined* (e.g. customers' needs versus customers' feedback).
4. Go beyond the company to tap knowledge from customers, suppliers and competitors; i.e. become a *knowledge seeker.*
5. Make it clear to employees that knowledge sharing is a core value for the company; i.e. become a *knowledge culture.*
6. Measure the results of the implementation of the knowledge management program; i.e. become a *knowledge assessor.*
7. Top management should reward sharing expertise and intelligence; i.e. become *knowledge-exemplified.*

The above strategy could also assist as a checklist to ensure that the knowledge management program covers all key elements of the organisation. The role of SAN systems in harnessing organisational knowledge is therefore central to the success of this strategy.

2.7 Creating Supportive Environments for Knowledge Management Programs

Many firms have cultures that do not support knowledge management practices. For example, if employees are accountable for their time and the reward system and promotions are decided on the basis of value-added performance (i.e. performance in

adding value to products/services to the customer), it would be rare to find an employee who spends time on knowledge sharing projects if they are not recognised value-added activities. Similarly, if there were neither assessment nor credit given for knowledge management activities within the firm, knowledge management would always be at the bottom of in-trays, possibly never to be seen again.

There are at least two important roles for SAN systems in supporting knowledge management activities:

1. Timeliness: The timing of the knowledge management program is important for its success. The timing of facilitating support for knowledge management activities using SAN systems could assist the success of the program.
2. Learning and mistakes handling: If staffs are encouraged to discuss their mistakes openly, a culture of openness and seeking help could lead to the creation of a learning organisation. The use of SAN systems could assist in creating a learning environment far from fear of punishment and penalties. This could in turn facilitate the knowledge management activities.

Interaction between a knowledge management effort and the existing organisational culture will undoubtedly result in changes to that culture, which may indeed need to change for the program to succeed.

2.8 Using Appropriate Knowledge Management Tools

Many analysts believe that the emergence of technologies such as the internet, mobile telephones, the emergence of Knowledge-Based systems and utilisation of SAN systems facilitate the sharing of knowledge and could assist in the implementation of knowledge management programs. However, there is also a view that these technologies may actually be "anti" knowledge management. For example, without active oversight, technology may just add to the information glut in the organisation. Other technologies already employed by the enterprise could go at least part of the way towards employing the knowledge management approach. The sign of a real knowledge management system is a process and infrastructure aimed at

supporting the creation, capturing, storing, harvesting, assimilation and leverage of knowledge.

The commercial emergence of SAN systems represents a tremendous opportunity to enhance the practice of managing organisational knowledge. Unfortunately, much of the potential of knowledge-based systems to leverage expertise and promote organisational learning remains unrealised because of poor management of organisational resources and piecemeal adoption of the technology. With the impending shortage of skilled professionals in many economies, it is imperative to consider the technology of SAN systems so that the workforce can be effectively used.

Clark and Soliman (1997) have shown that managing the introduction of knowledge-based systems is a difficult task, which requires team effort and support throughout the enterprise. For instance, in the knowledge management chain a number of decisions need to be made. These decisions are required in each stage in the knowledge management chain, namely the creation, capture, storage, access to and use of knowledge (Soliman 1999). Each time a decision is made, input from various teams and groups across the enterprise would be required. In general, the complexity and nature of the input could warrant the use of knowledge-based systems and in turn SAN systems.

2.9 Creating the Knowledge Management Team

Until recently work was designed to avoid the sharing of knowledge and teamwork that are so critical in today's business.

Knowledge sharing may reflect employees' preference but also may not be a particularly accurate characterisation of relations between the individuals concerned. Indeed, by invoking the concept of knowledge sharing, a manager may be trying to bring about a unity of purpose that is currently lacking. It should be borne in mind that declaring people a *knowledge sharing team* does not automatically make them

one. However using a centralised SAN system might be the right step in the right direction.

2.10 Creating Knowledge Management Leadership

When planning implementation of a knowledge management program, the organisation needs to consider whether to create a leadership role to develop and drive the process, for instance a chief knowledge officer. Many firms have devolved responsibility on an existing or new position. Some firms used a cross-functional team to develop knowledge management, while in others the CEO has taken the leading role. According to Lloyd (1999), the characteristics and challenges of the chief knowledge officer/chief learning officer should include:

1. interpersonal/communication skills;
2. passionate visionary leadership;
3. business acumen;
4. strategic thinking skills;
5. championship of change and the ability to stand ambiguity and uncertainty; and
6. collaborative skills (this is a rare skill and is the ability to pull together people from different parts of the organisation to work as one team);
7. familiarity with emerging technologies such as SAN systems.

While it is useful to have a focal point (e.g. a knowledge manager or SAN system manager) to "lead the charge", it is not essential, and the need for this position may be transitory once the knowledge management discipline is embedded in the firm's culture and processes. Regardless of how the responsibility for knowledge management is shared, the SAN system is considered a critical tool for selecting and implementing the knowledge management program.

2.11 Drivers of Knowledge Management Efforts

It is clear from the above that SAN systems play a significant role in driving knowledge management solutions. However, organisations face the difficult task of ensuring that knowledge is not misdirected. For example it has been shown that many problems could be avoided through appropriate storage of data which in turn is dependent on the efficiency and effectiveness of the SAN system used.

SAN systems may be regarded as tools for driving the knowledge management interventions by assisting staff who are consistently experiencing difficulties such as:

a) lack of progress towards goals;
b) inappropriate leadership;
c) failure to make sound decisions;
d) interpersonal hostility;
e) role confusion or alienation; and
f) high turnover, absenteeism.

In addition categorising and organising knowledge could be a core competence for future organisations (Davenport 1999). Therefore SAN systems could contribute to:

a) deciding what knowledge is important;
b) developing a knowledge vocabulary, including a thesaurus;
c) prolifically creating indices and search tools; and
d) constantly refining knowledge categories.

2.12 Role of SAN Systems for Knowledge Mapping

Clarke and Staunton (1989) provided a model of the knowledge management process that could be useful for mapping human resources knowledge. Their model provides a guide to four key concepts that could be mapped with the use of SAN systems:

a) construction;
b) embodiment;
c) dissemination; and
d) use of knowledge.

According to Soliman (1998), the main activities of the mapping process are two fold:

1) deciding on *what is to be mapped?* and
2) deciding on *what level of knowledge mapping?*

The modified Clarke and Staunton model could provide an answer to the first question. However, the answer to the second question (how much knowledge mapping is required?) is guided by the *economics for the intended purpose* of knowledge mapping. Soliman (1998) provided a *micro-mapping* approach, which could be extended to cover the mapping of the four knowledge concepts mentioned above. To answer this particular question adequately, more research is needed, which is beyond the scope and the aims of this thesis.

According to Demarest (1997), to successfully manage knowledge, one needs to understand the three relevant infrastructures within which the knowledge process takes place:

a) cultural infrastructure;
b) organisational infrastructure; and
c) technical infrastructure.

The knowledge management process happens in the context of the cultural, organisational and technical infrastructure of an organisation. The technical infrastructure includes SAN systems as well as other tools that may be required for focusing on fundamental business issues of an organisation (Soliman 1998). Furthermore, because an organisation's reality is dynamic, not static, the knowledge

mapping process needs to be ongoing for the results to have reasonable currency. This in turn requires a SAN system that fits squarely within the organisation's objectives and strategies (Soliman 1998).

2.13 Role of SAN Systems in Managing Enterprise Knowledge

According to Leonard-Barton (1995), there are three key interconnected topics: innovation, knowledge and knowledge management activities (KMA). There is a voluminous literature on innovation which is now recognised to be closely connected to various key activities within the firm. These may include business processes, but are frequently less formal constructions often associated with company culture. These key activities tend to predispose the company to behave in a certain way, and it is widely accepted that companies have an "innovation trajectory". Many authors concerned primarily with innovation have suggested classifications of knowledge. The role of SAN systems is to facilitate this classification of knowledge.

Vincenti (1990) identified a number of categories, and Faulkner (1994) developed a composite typology of a broad range of knowledge. However, these categorisations are of limited use in developing and improving knowledge management activities. Further, Coombs and Hull (1998) discussed the effects of knowledge management on innovation. In discussing the potential for variety generation of firms in terms of evolutionary economics, they considered innovation through technology/hardware, knowledge bases and the business processes. They presented a framework for understanding knowledge management practices, which could assist in identification and evaluation of SAN implementation strategies.

Furthermore, Nonaka (1991, 1994, 1995) studied new product development in Japanese firms and went on to explore appropriate organisational structures for managing the knowledge creation process. He developed constructs which enable the role of both tacit and explicit knowledge in organisational knowledge to be defined more clearly. It should be mentioned that the concept of mixing the two types of knowledge is not new; however, the recognition and appreciation that SAN systems

are strategic knowledge management tool is new. For example, Polyani (1958, 1966) considered and proposed four patterns of interaction involving both forms. More recently, Nonaka (1988), as part of a search to improve organisational structures, argued that whilst new knowledge is developed by individuals, organisations play a critical role in articulating and amplifying that knowledge, and proposed new management models for information creation. That is why the role of SAN systems as a strategic knowledge management tool need be thoroughly researched as shown in this thesis.

It should be remembered that many companies produce products and services which are highly customised to meet individual customer requirements. Their major business activities would include tendering, design, manufacture, assembly, construction and plant commissioning. Whilst the products are primarily sold on performance, other factors such as cost of ownership and the ability to customise the product will also be highly significant. Furthermore, most of the business processes such as design and manufacturing systems are complex and dynamic. That is why knowledge bases and knowledge management activities (including tools such as SAN systems) are becoming increasingly recognised as major factors influencing the success or otherwise of developing new products or services. Furthermore, these developments, which require efficiency improvements, would rely very heavily on their fundamental *knowledge management tools* to capture, use and reuse and describe the continuing process of *know-why*, *know-what* and *know-how* to develop, identify and improve their products and/or services. Soliman et al. (1999b) have shown that one essential component of this *set of knowledge management tools* is the existence of tools such as SAN systems which must be managed effectively and efficiently in order for the organisation to attain a competitive advantage.

In other words, the management of SAN systems should lead to improvement in creating, harvesting, assimilating and leveraging knowledge to produce a smarter and more competitive workforce for the organisation.

2.14 Process of Managing Organisational Knowledge

Knowledge management is grounded in the belief that in order to generate a sustained competitive advantage it is necessary for the enterprise to manage its intellectual assets as well as its tangible assets.

During the past few years, researchers have attempted to describe the field of knowledge management and the practice of knowledge within organisations. For instance, Vincenti (1990), Faulkner (1994) and more recently Coombs and Hull (1998) classified knowledge management activities and the associated knowledge practices under the following three headings:

1. *Knowledge processing*: This group of knowledge management activities is concerned with the generation, transfer, utilisation, identification, capture/retrieval/storing, format and codification of knowledge.
2. *Knowledge domains*: This group is concerned with the classification of knowledge. For example, factors affecting knowledge acquisition in the following area differ considerably: internal and external knowledge, technical knowledge, product knowledge, process knowledge and project knowledge
3. *Knowledge formality*: This group is concerned with the format of knowledge. For example, the format of formal knowledge differs quite substantially from the format of informal knowledge. Similarly, time, location, dependency and technology used all have different formats for creating, capturing, storing, organising, accessing and sharing knowledge.

The processes of managing the organisational knowledge are the means by which value is added to *raw-knowledge* (inputs) in order to create *processed-knowledge* (outputs), i.e. adding value for their clients. The specifics of this will of course vary substantially across industries; however in general, there are four primary processes for handling organisational knowledge, which are common across most organisations (Soliman et al. 1999b):

1. **Adding value to organisational information:** This is the central function of many organisations today, resulting in: a) information products, which create value for clients; and b) internal information, which enables the company to make better decisions. This process is in fact a composite of many processes with one common aim, which is *to create a high level of value the process must be directed to a specific audience.* At the input stage, SAN systems filter the information overload, and to do this they must make sense of information (Weick 1995). Filtering is the first key process of adding value to information; the other key processes are validation, analysis, synthesis, presentation, ease of access, and customisation (Dawson 1999).

2. **Capturing and sharing of organisational knowledge.** Capturing and sharing organisational knowledge is increasingly becoming necessary for many organisations in order to develop their capabilities and maintain or enhance their competitiveness. To a large degree this involves the interplay between human capital and structural capital. For instance, if knowledge is effectively captured this means that human capital is converted to structural capital, while for people to be most effective at their functions they need to share knowledge which has been captured as information. Knowledge captured as structural capital could be made available for sharing through both databases, knowledge bases, SAN systems and processes, which enable people to perform tasks more effectively (Dawson 1999). Capturing knowledge involves codifying the experiences and best practices of the employees of the company. This can be a difficult task because a significant proportion of knowledge is tacit and defies documentation. In these cases, people can share knowledge through apprenticeships and other one-to-one practices. In many cases, just documenting what people know (areas of specialisation, key projects undertaken, membership of special interest groups) in a 'yellow pages' approach is an effective knowledge management tactic. Sharing knowledge requires trust between the company's employees as well creating a common tool such as SAN system. Consequently, knowledge management programs must also address the cultural aspects of the enterprise to ensure an optimal environment for frequent and effective knowledge sharing.

Providing opportunities for conversations (for example, special interest groups) or developing incentives for people to contribute to a knowledge repository are effective techniques. Technology including SAN systems can play an important role in information sharing.

3. **Creating or generating organisational knowledge:** Generating organisational knowledge is linked to innovation and consequently is essential to many organisations. This is because of the dynamic nature of knowledge value adding. It should be clear that this process could lead to the continual creation of new organisational knowledge in order to develop and maintain organisation competitiveness. There are a number of ways organisations can create knowledge. Knowledge can be obtained from external sources (consultants, stakeholders and academics); it can also be developed as a specialised function within the company such as the research and development function. Knowledge can also be fostered throughout the organisation through the use of SAN systems.

4. **Utilising organisational knowledge**. Once organisational knowledge has been generated or captured, then of course it must be stored before is used and applied within a specific business context to create or add value to the organisation product or services. This must not be confused with the process of adding value to organisational knowledge. Adding value to organisational knowledge is quite different from using organisational knowledge to add value to the product or services provided by the organisation. Naturally, this process is dependent on many factors such as the industry, the organisation and geographical factors as well technological factors such the existence of SAN systems. However the underlying processes for drawing on people with diverse expertise, training, skills and knowledge to enhance existing value chains, and to create new ones are often very similar. Utilising (using) knowledge also requires integrating it into the company's products and services. This can be facilitated by a combination of technologies such as SAN system that fits squarely within the organisational culture that values knowledge, and allows access to the appropriate knowledge content to provide the greatest possible benefit. It is essential that enterprise

leaders are able to convey what is important to the organisation to help guard against knowledge-workers falling into the trap of pursuing knowledge for knowledge's sake.

In addition to the above four primary organisational knowledge management processes, organisations must also have in place additional processes for organising and accessing organisational knowledge. For instance when organisational knowledge can be codified it must be organised in a way for others to find and recognise its relevance. It is only when the information is understandable, relevant and useable that it can be converted to knowledge and acted upon.

2.15 Organisational Critical Knowledge

The organisation that could keep critical knowledge in the hands of front-line workers (using SAN systems) has a competitive advantage because their core operations would be more efficient (Beckett and Soliman 1999). Furthermore, Mitskavich (1996) reported that "Immediate availability of critical information has made nearly every department more efficient, a big factor contributing to a 20% increase in sales and a 30% decrease in inventory. The company has also improved customer service, shortened production lead times and lowered labour costs." Chaleff (1995) added, "At the individual level, knowledge workers need to be trained to sort and process large volumes of information and work. At the group level, companies must establish a process to find the balance points in information systems between distributing critical information and performing productive work all systems move toward growing disorder and on the way there, they get more and more complex."

Clearly, in order to manage, managers need critical information and critical knowledge that facilitate their decision making and assist them to:

i) evaluate their employee's performance, budget reports, staff turnover etc.;
ii) determine short- and long-range plans for their departments; and

iii) co-ordinate and control their department's activities.

Soliman (1999) noted that when enterprises attempt to define their existing knowledge management activities, they are in a position of identifying areas for potential for improvement, which would yield advantages. The process of identification of knowledge management activities may involve the use of technology in the form of systems and knowledge bases. However, the "soft" interpersonal transactions associated with the knowledge management activities of knowledge workers must not be overlooked. Skelin (1999) suggested that these "soft" interpersonal transactions are factors which are critical to the successful implementation of knowledge-based systems. More CSFs can be obtained from the drivers for employing the knowledge management and/or knowledge sharing programs in human resources management.

Obviously, knowledge management and/or knowledge sharing programs could lead to higher productivity, produce higher quality and improve job satisfaction, motivation and increase employees' morale. Companies that are willing to rethink old ways and use knowledge management and/or knowledge sharing programs could profit from the change. Clarke and Clegg (1999) named this change a "new paradigm in management". According to Soliman et al. (1999a), additional drivers of the use of knowledge management interventions can be due to staff consistently experiencing difficulties such as:

a) lack of progress towards goals;
b) inappropriate leadership;
c) failure to make sound decisions;
d) interpersonal hostility;
e) role confusion or alienation; and
f) high turnover, absenteeism.

2.16 SAN as Facilitating Technologies for Knowledge Management

It is believed that the internet, intranet and extranet can facilitate the sharing of knowledge. However there is also a view that the internet, intranet and extranet may actually be "anti" human resources knowledge management. Without active oversight, the internet, intranet and extranet may just add to the information glut described earlier. Other technologies that enterprises already employ for other functions go at least part of the way toward employing the human resources knowledge management approach. These technologies include office information systems, collaboration tools, retrieval and navigation tools, and knowledge-based systems. However, despite a product's applicability to the problem, enterprises are warned that technologies possess limitations that will result in many interim versions before a solution is achieved. The sign of a real knowledge management system is a process and infrastructure aimed at supporting the creation, harvest, assimilation and leverage of knowledge. This infrastructure necessarily is people-intensive.

Increasingly, human resources knowledge management technologies are justified in terms of alignment with strategy, competitive advantage, and revenue enhancement or market share enhancement. Enterprises that have successful approaches to knowledge management did so by trying to manage knowledge of human resources in the organisation rather than identifying high-payback processes for which better knowledge management can yield significant business value.

Introduction of IT has radically transformed the world of industry and commerce, and significantly affected almost every factory and office worker. The need for a rapid and multi-directional flow of information in a complex, hectic and often turbulent environment has made it critical to manage effectively the associated technology (Martinsons 1993). IS have evolved from an administrative to a strategic orientation. KBS are now commonly used not only to enhance productivity, but also to improve effectiveness and create a competitive edge. Some financial services, health care and transportation firms have even secured enormous strategic

advantages by using information technology to transform radically the very nature of their industries (Clemons 1986; Porter & Millar 1985; Venkatraman 1994).

More generally, increasing numbers of computer-based IS are being applied to cross-functional and even inter-organisational activities, especially as core business processes are fundamentally redesigned (Hammer 1990). Nevertheless, there is still a clearly recognised need to develop specialised IT applications within a functional business area. This may be defined as localised exploitation (Venkatraman 1994).

It is clear from the above discussion that teams are required not only to improve performance and standing of the enterprise but also to ensure the effectiveness of knowledge-sharing programs. The more structured the implementation of the knowledge-sharing program, the more likely the success of the program. This of course means strategies for implementation of knowledge sharing must receive appropriate attention.

Knowledge management teams are required not only to improve the performance and standing of the enterprise but also to ensure the effectiveness of the knowledge management program. The more structured the implementation of the program, the more likely it is to succeed. This of course means that strategies for the implementation of knowledge management programs must receive appropriate attention especially from the human resources department.

Soliman (1999) identified the above five strategies for knowledge sharing as follows:

1. *Forming the knowledge-sharing teams.* Formation of teams around decision making means selection of knowledge-sharing tools such as use of SAN systems which play a significant part in the formation of the knowledge-sharing teams.
2. *Storming the knowledge-sharing program:* Storming the knowledge-sharing programs signifies the importance of the tools such SAN systems which may be used to react to the nature of the tasks and to the demands placed on them.

3. *Forming the knowledge-sharing rules*: Forming the knowledge-sharing rules is partially dependent on the tools such SAN systems which may assist members of the teams to agree on what has to be done, how it is be done and what roles the different members will take.
4. *Performing the knowledge-sharing activities:* Performing the knowledge-sharing activities requires appropriate tools such SAN systems that enable the goals of the knowledge-sharing programs to be met.
5. *Reforming the knowledge-sharing program:* Reforming the knowledge-sharing program requires sophisticated tools such as SAN systems. These tools facilitate the knowledge manager/worker to complete their tasks efficiently.

In addition, Soliman (1999) argued that knowledge-sharing program building is an investment in the *"people"* resource of an organisation. An assessment of how effective are the outcomes in relation to the money and time spent is important to investment decisions. Accordingly, it is vital to measure effectiveness, and this can be done through the use of appropriate knowledge management tools.

2.17 Conclusions

The mere use of information technology to automate IT/IS tasks is no longer sufficient in an increasingly knowledge-intensive environment. SAN systems can be utilised much more efficiently and effectively if organisations apply Knowledge-Management techniques for leveraging their knowledge and enhancing personnel management.

Although IT/IS implementation management has played an increasingly important role in the structure of organisations in recent years, there are still areas such as implementation of SAN systems where it can progress even further to improve the competitive position of organisations.

It is envisaged that the application of knowledge management and/or knowledge sharing programs would result in improving productivity, enhancing the business environment, and increasing levels of innovation due to sharing and utilising knowledge. Knowledge management tools such as SAN systems could be used to address problems on a local and global organisational level.

If knowledge management including tools such as SAN systems are implemented and used to reflect the characteristics of the organisation, then this would help to strengthen the trust, mutual respect, dedication and cohesiveness of the workforce involved. The variety of knowledge and information available to organisations through implementation of SAN systems could bring about a greater number of possible approaches to solve problems. This could lead to better management and higher outcomes. Knowledge management including tools such as SAN systems could assist in finding problem solutions and contributing to a greater understanding and acceptance of decisions made.

While effective knowledge management can be expensive, ineffective knowledge management or lack of successful implantation of SAN system is inevitably far more expensive.

CHAPTER 3

BACKGROUND ON STORAGE AREA NETWORKS

3.1 Background

As content becomes more sophisticated, storage consolidation will become an increasingly important part of a company's data management strategy. According to the International Data Corporation (IDC), the Redundant Array of Independent Disks (RAID) shipped in a recent one-year period reached 250PB (one petabyte is 1,000 terabytes) (Inrange 2002). Consequently, in data-rich businesses projections show that data continues to grow at a phenomenal pace, driving this issue to the forefront of discussion, along with the need to find effective data storage and management solutions to support this growth. One such solution that would meet this need is the Storage Area Networks (SANs).

As companies rely increasingly on internet, e-commerce, e-business, online transaction processing, databases and Enterprise Resource Planning (ERP), the amount of information that needs to be managed and stored can intimidate even the most experienced network manager.

The development of e-commerce applications makes the rapid delivery of data through networked storage set-ups more important than ever. If you don't have the right information to the right person on time, it's like not having it at all.

3.2 Exploding Volume of Data

The demand for graphic-intensive applications, the popularity of viewing digitised images at online auction sites, the migration from hard copy to soft copy and the demand for internet-enabled distributed access to medical images and records on the web demonstrate the continuing need for more storage capacity. In order to conduct business in the second generation of e-business, there are several areas where companies need to focus in their electronic infrastructure planning/investment,

including multi-platform integration capability, bandwidth, scalability, convergence–voice and data storage mobility (Whittaker 2001).

There is no doubt data is exploding. Companies know data is a premium asset so they cannot afford any downtime when data is unavailable. Datamation's report (REF) estimates the financial impact of information unavailable in US dollars based on various industries. For example, information unavailable in airline reservations and in brokerage operations can cause an average hourly loss of around US $0.11 million to $7.8 million (Zampetakis 2001).

As companies rely increasingly on e-commerce, online transaction processing and databases, the amount of information that needs to be managed and stored is increasing exponentially. For example, in Hitachi's 2001 survey, Amazon.com added 42 terabytes of customer and product information every six months and Mail.com added 27 terabytes every 45 days, while in the financial sector, Citibank collected 75 terabytes of data in 10 years (Hitachi Data Systems 2001). For e-business organisations, capturing market share is indeed important. However, capturing strategic data about their customers is equally compelling. As Hu Yoshida, Vice-President and CTO of Hitachi Data Systems pointed out, "every e-click creates new data and CIOs need to build an infrastructure to meet the performance requirements of today's business marketplace" (Hitachi Data Systems 2001). Furthermore, the company that is able to analyse, understand and respond to that data will gain a competitive advantage.

The explosive growth in business data comes both from the rapid adoption of computers in every facet of an organisation's operations and from the increased data generated from moving many of these operations online. The combined pressures of globalisation and growth in e-business have resulted in data storage and management becoming not only one of the most important functions of IT departments but also one of the most important functions of the business as a whole. Typifying this rapid increase is Northern Trust Corp. in Chicago whose data storage requirements "have exploded from 1TB of capacity in 1999 to more than 40TB". Vice-President, Karl

Huff estimated that this figure was expected to grow to 100TB by early 2001 (Mearian 2001).

According to Schmidt (2001), 10% of US enterprises (16% of large enterprises) had implemented SAN and 24% were evaluating it.

3.3 E-Business Phase

E-Business is the conduct of business on the internet, not only buying and selling but also servicing customers and collaborating with business partners. An e-commerce approach may be sufficient to allow an organisation to remain competitive in the short-term; however, sustainable long-term growth requires innovation. Strategic knowledge sharing, particularly external sharing, affects every aspect of the organisation's activities and is a necessity.

Thus e-business and knowledge management are interdependent: for a successful knowledge management program, e-business technologies are required, and for successful e-business strategy, knowledge management is essential.

E-business is becoming a strategic imperative for many companies worldwide. The driving force behind this is the need to cut costs, thereby improving profits. A second but equally important reason is the need and desire to expand a company's reach.

E-business allows businesses to communicate easily and cheaply with customers anytime, anywhere. E-business is changing traditional business models because it is network-centric, global and data-intensive. The foundation of e-business is the network itself, and the most widely used network today is the internet.

The internet is global in reach as it can be accessed from anywhere around the globe. The term "data-intensive" describes the fact that all electronic transactions can be stored for processing and subsequent analysis. As previously stated, e-business

applications are generating data at a rapidly increasing rate. This data must be stored and managed efficiently and be amenable to data mining applications.

The web economy is driving fundamental change across the entire business landscape. Organisations are increasingly leveraging internet service models to support internal and external customer requirements, and these customers are demanding instantaneous, accurate service. Any decision to compromise on speed or accuracy is a decision that will put a business out of business.

These industry trends are driving the requirement for more flexible and reliable access to data. The data resides on storage devices. This is driving the requirement for SANs. ERP, data mining and decision support applications are also driving the requirement for SANs because the data involved has to be accessed from or copied between heterogeneous environments.

Vision is not seeing things as they are, but rather seeing things as they will be. The banks had vision; they realised that if they could guarantee that people could more and retrieve their money more safely than they could at home and that it would always be available, they would create a financial storage utility that people everywhere could access. To further encourage new business and growth, the banks decided to add value to the money deposited and increase its value by offering interest and dividends. It wasn't too long before the banks became a financial utility for virtually everyone.

The banking model also serves as an example for the exploding data storage industry. As money was the most valuable asset for the individual a half century ago, the next century promises that data will be the most valuable asset of the information-based society. The IT industry has undergone an evolution in data storage since its beginning.

Throughout the 1970s and 1980s, storage deployment could be described as a "Many to One" with all storage devices connected to a server, typically a mainframe. During

the late 1980s and 1990s, a One to One relationship developed between the server and storage devices. Devices were dedicated to a particular server, as departmental and distributed servers became widespread. Servers and storage were co-located. This decentralised approach created islands of computing and storage that were costly to manage and replicated hardware, software and personnel across these isolated nodes of computing and data. Most often in this computing model, data was not accessible to another server in the LAN in case of failure, and applications that were not in a clustered or an SMP (Symmetrical Multi-Processor)-designed system were unavailable until they could be restarted. The most critical and valuable element of the enterprise, the data, was too often unavailable and the costs for an unscheduled outage remained severe for most every business. Like the bank, the evolving storage industry also has a vision and it has arrived in the form of the SAN.

3.4 Inadequacies of Traditional Storage Networks

Some inadequacies of traditional storage networks exist. As a result, organisations have increased costs in maintaining ineffective and inefficient storage systems. According to McKeefry (2000), some of the problems that arise when using traditional methods of information storage include:

- lack of data availability and lack of data centralisation;
- the problem of data not organised into useful information with "inefficient storage management on the part of the administrator";
- inefficient storage capacity utilisation;
- difficulty in data sharing, especially over geographic and time boundaries;
- possible long delays in down-time of servers, and high costs resulting from this;
- backup problems, with slow recovery speeds;
- inefficient clustering techniques, where the scenario exists that if servers fail, the partner server assumes the workload until it reaches capacity;

- low levels of data security; and
- high levels of data traffic and low levels of system performance.

These problems gave rise to the need to develop new storage methods. The inadequacies are seen by organisations as efficiency problems, and are factors that encourage the employment of SANs.

3.5 Background Leading to Development of SANs

The most basic way of getting storage devices on the network is to hang disk arrays or other storage devices off of servers, using an interface such as the Small Computer Systems Interface (SCSI) to make the connection. SCSI is a relatively high-speed interface that was developed more than 15 years ago.

This popular I/O interface connects not just storage-related devices such as tape and optical drives but also printers, scanners and external drives. SCSI has gone through a number of changes over the years, especially in the speed the interface supports. Initially designed to handle speeds of 5Mbytes/sec, it supports a throughput rate of 160Mbytes/sec in its current iteration, Ultra3 SCSI. Within the Ultra3 specification is a subset implementation, Ultra160 SCSI, that is gaining popularity among SCSI vendors as well as server and workstation manufacturers.

While SCSI has been a workhorse over the years for connecting peripherals at a relatively fast speed, distance limitations have kept this particular interface from evolving very rapidly. The SCSI standards put a bus length limit of about 6 metres on devices. While this distance limitation does not really affect connecting storage devices directly to a server, it does severely restrict placing RAID and tape libraries at other points on the network. This is where the concept of Network Attached Storage (NAS) comes in. NAS is straightforward in that disk arrays and other storage devices connect to the network through a traditional LAN interface such as Ethernet (or whatever the topology of choice might be). Storage devices would attach to network hubs much the same as servers and other network devices.

NAS makes storage resources more readily available and helps alleviate the bottlenecks commonly associated with access to storage devices. However, NAS does have a few drawbacks. First, network bandwidth places throughput limitations on the storage devices. Most NAS servers are placed on 10Mbit/sec or 100Mbit/sec Ethernet LANs, but even if a network is running at gigabit speeds, most NAS vendors today only offer interfaces up to Fast Ethernet. Another downside to NAS is the lack of cohesion among storage devices. While disk arrays and tape drives are on the LAN, managing the devices can prove challenging since they are separate entities and are not logically tied together. NAS has its place as a viable storage architecture, but larger enterprises need something a few steps beyond.

3.6 Network Storage

Storage systems have evolved over the years from data being stored physically separate from the actual processing unit to "network storage". Network storage is a generic term used to describe network-based data storage which is merely storing data using a method by which it can be made available to clients on the network.

There are three main types of network storage:

- Direct Attached Storage (DAS);
- Network Attached Storage (NAS); and
- Storage Area Network (SAN).

3.6.1 Direct Attached Storage (DAS)

DAS is the term used to describe a storage device that is directly attached to the host system. Examples of this include the internal hard drive of a server computer and storage devices that are housed in an external box. DAS is the most common method of storing data for computer systems. However emerging technologies have led to the development of new storage methods.

3.6.2 Network Attached Storage (NAS)

NAS is a data storage mechanism that uses special devices connected directly to the network media. These devices are assigned an Internet Protocol (IP) address and can then be accessed by clients via a server that acts as a gateway to the data, or in some cases allows for direct access. Use of NAS technology means that storage can be easily expanded and centralised as can the security, management and backup of the data.

3.6.3 Storage Area Network (SAN)

According to Zeisler (2001) "SAN is a dedicated, centrally managed, secure information infrastructure, which enables any-to-any interconnection of servers and storage systems". SAN allow businesses to move, store and access as well as manage information from one or more data centres.

SAN is basically an infrastructure that allows for storage and management of storage for an organisation. It connects one or more subsystems to storage devices allowing for a faster and more efficient data storage solution (Compaq 2001).

SANs are high-speed storage networks that rely on hubs, switches and gateways rather than traditional storage methods that use the legacy SCSI architecture, such as online disk and tape library systems (Weils 1999).

According to Toigon (2001), SANs would help to make business processes more efficient by enabling greater access to data for decision makers.

It must first be established that not all businesses have a real need for a SAN. Its primary utility is to deal efficiently with the massive amount of data which is implied within the operations of many e-businesses (Biggs 2000). However for an e-business with a relatively simple business model, limited data transfer and storage requirements, SAN could perhaps represent an unnecessary expense.

According to IBM (2001), SAN:

- facilitates universal access and sharing of resources;
- supports unpredictable, explosive information technology (IT) growth;
- provides affordable 24 x 365 availability;
- simplifies and centralises resource management;
- improves information protection and disaster tolerance; and
- enhances security and data integrity of new computing architectures.

To a growing number of companies, SAN technology promises to provide the accessibility, availability and recoverability needed for high-volume data storage.
In theory, a SAN is a secondary network that allows servers running completely different operating systems direct access to a common storage pool that contains a group of heterogeneous storage devices, which include disk arrays, NAS, RAID devices and automated tape libraries.

The easiest way to think of a SAN is as a separate local area network (LAN) dedicated to storage. Client machines are attached to the main LAN, while storage devices are attached to the secondary SAN. All servers would be attached to both the LAN and the SAN networks to make storage accessible.

3.7 Storage Area Network or Network Attached Storage

Often there is confusion regarding the terms SANs and NAS, which are sometimes positioned as rival technologies, with one seen as outselling or overcoming the other. The truth is that the two are a lot more alike than they are dissimilar, and are useful under different circumstances (Betts 2001).

In particular, both aim to do the same thing, to split data storage from the servers and move it out onto a network. The difference is in how they achieve this and in the complexity of the resulting set-up. Like other file servers, NAS appliances are file-

based, which makes them particularly suitable for tasks that are heavily file-oriented such as web caching and multimedia content distribution.

Many storage experts feel that the need for a second network means SANs are suited only to centralised applications, whereas NAS would probably be better for a distributed business with a number of branch offices, especially as the branches are unlikely to have the IT staff needed to support the more complex SAN option. Even with a single site, size is also an issue, with a rule of thumb suggesting that only once an organisation needs to store 500GB of data or more will a SAN become cost-effective (Orubeondo & Apicella 2001).

The difference between the two technologies can also be seen as a tactical and strategic answer to the same question. NAS fixes the problems of storage being in short supply, for instance, and also consolidates it in one place where it can be protected properly. With the increasing speed of LANs, NAS can even provide networked storage that is faster than locally attached storage, according to Network Appliance's northern European marketing manager, Chris Gale. What NAS does not do is relieve the LAN of that extra traffic, nor does it address the storage pooling issue, and because it works at file level, its performance may not match that of a block-based alternative (Orubeondo & Apicella 2001).

3.8 Goals of SANs Implementation

The three equally important goals of SANs are a) to provide the network itself, b) to manage the central storage system, and c) to facilitate disaster recovery. A well-designed SAN builds upon an enterprise's existing storage devices to produce significant Return On Investment (ROI) (Zasman 2002).

One of the most powerful driving forces for the business organisation implementation of SANs is the ability to simplify and speed up backup operations by using the greater bandwidth available over Fibre Channel. With the current growth rate of data storage putting pressure on IT managers to find a large enough "window"

within which to accomplish a backup, many storage installations are now at a point where backup needs to be a virtually continuous process carried out in real time while the data continues to be actively used.

Only a properly designed SAN infrastructure can provide the distributed backup bandwidth and flexible access to data and backup media necessary for real-time backup and retrieval. Use of a SAN is imperative if valid snapshots of the data are to be gathered without affecting the users on a LAN/WAN network. SANs provide a 24-hour, real-time backup and recovery on actively changing file systems using standard backup software utilities.

E-business organisations implement SANs for numerous reasons. The transfer to storage area networks has been motivated by the requirement to manage the dramatically rising volume of business data, information and knowledge to mitigate its effect on network performance. Following are the main factors outlined in relation to implementation of SAN in business organisations (Zasman 2002).

3.8.1 E-business

Some e-businesses organisations have already migrated to SANs to securely transform internal business processes and improve business relationships to accelerate the purchase and sale of goods, services and information via the internet.

With the e-commerce explosion, IT managers are working to maintain pace in managing the explosive growth of data (multiple terabytes per year). Companies are installing high-performance storage systems to meet the demands for smaller backup windows and greater application availability. However, these systems are complex and expensive to manage. Additionally, they are often single platform, restricting access to information across the network. IT managers are increasingly seeking innovative ways to simplify storage management. Many companies, particularly those which have an e-business aspect in their organisation, have realised that more disk space is necessary in order for administrators to control data effectively and

efficiently. SAN allows e-businesses to manage virtually all storage requirements proactively while creating the high availability needed by the server (Fetters 2002).

For e-commerce and companies with extensive ERP implementations, "servers have become the heartbeat of operations and missing a beat could have fatal consequences" (Fetters 2002).

By sharing storage pools in a SAN server, sharing data sets can fail. Although with new high-speed Fibre Channel infrastructure between storage pools, companies can reduce disaster recovery from several hours to less than a few minutes. Suncorp Metway, for example, has implemented SAN in order to decrease both backup time and disaster recovery time.

3.8.2 Globalisation

Globalisation of companies has caused organisations to expand, and thus the amount of information stored has grown as well. Organisations have extended their IT systems across international boundaries due to globalisation. In order to manage the data, businesses have been inspired to deploy a SAN solution.

3.8.3 Zero Latency

Farley (2001, p. 260) defines *latency* as the "amount of time required for a network entity to queue, transfer, and process transmitted data". Zero latency is when information is required to be exchanged immediately for competitive advantage. Web sites that sell products for consumers require transmitting information instantaneously in order to retain customer service. To illustrate this point, Showtime Networks Inc, a cable-TV company, in New York implements a Fibre Channel SAN in order to move video clips in and out of storage quickly (Garvey 2000).

In a zero-latency enterprise architecture, the order entry application instantly forwards the data to the data warehouse where it is processed right away and pushed

to all applications that need it. Inventory could be checked automatically, and shipping could be alerted to pull and package the order. If the items were not in stock, production systems could make adjustments immediately. Orders to supply chain partners could be sent via the extranet for immediate action. Customer relationship management software could pull the new data, and a courtesy call could be made to the customer when the order is on the truck (Gibbs 2000).

Zero latency lubricates a business allowing it to respond to new data on a real-time basis. Another example of how the installation of a SAN has helped reduce latency and increased the efficiency of the whole operation is that of Sony pictures DVD centre. Their existing storage network didn't allow the simple application of sharing data between workgroups, hence placing large constraints upon the number of projects each workgroup could handle at one time (SNIA, www.snia.org).

3.8.4 Transformation

Businesses need the ability to continually adapt, while immediately accessing and processing information to drive successful business decisions. Storage networking must be able to meet the need for speed in altering systems configurations and supporting websites, whereby constant design and content changes occur. Storage implementations that thwart fast change will be rejected in the internet data centre. High-level web host companies provide the servers, the connectivity and the support, and guarantee the reliability of the site or computer network. Hosts in this field handle total business, usually for blue-chip clients or those specialist computing companies that can afford to pay for the best service (Barker 2002).

3.9 E-business and Storage Area Networks

Today, in a fast-changing business climate where it is often impossible to predict which data will become important to which applications, the design of storage network architectures is becoming as vital as the design of application architectures. SAN may be helpful for e-business organisations to solve the expanding data in the second generation of electronic business. However, it does not mean that every

company should implement a SAN. As companies examine the needs of their businesses to find out whether a SAN is the solution that would work best for the business, several criteria need to be considered as follows.

3.9.1 The Size of the E-Business Organisation

The successful management of data is very critical to any e-business organisation, so implementing a SAN may be the first choice to solve this problem. However, the size of the e-business organisation can affect their decision whether they should implement a SAN as their storage system. But for some e-business organisations that do not have huge customer bases and cannot afford the expensive storage infrastructure, SAN cannot be their first choice. The solution for small- to medium-sized e-businesses is a NAS system, which is a simple, reliable and cost-effective way to manage their data (Ortegon 2001).

SANs represent state-of-the-art-technology that targets organisations with large-scale and complex data storage requirements (Mearian 2001). SANs can be suitable for organisations that have large customer bases and huge data storage requirements. Such organisations need to implement a SAN to solve the data explosion problem. For example, the Depository Trust & Clearing Corp (DTCC), a New York-based firm that provides the primary infrastructure for the clearing and settlement of the majority of the equity, corporate debt and bond transactions in the US, implemented SAN in response to enormous growth in data related to increased trading. DTCC's customer base includes 11,000 companies worldwide in the financial services industry, including the National Association of Securities Dealers and the New York Stock Exchange. The advantage of the SAN is an increase in the data throughput related to backup speeds and consolidating 350 to 400 servers throughout the company into two data centres for ease of control (Mearian 2001).

Before implementing a SAN, it is necessary to consider the size of the organisation's data storage requirement. No matter which storage infrastructure organisations select, SAN or NAS, they can find out the best choice to fit their requirements.

3.9.2 The Organisation's Expertise in SAN

SAN is a new storage technology, so there are few people who know what the SAN is all about and how it works for e-business organisations. When an organisation lacks skilled people to handle this entire new technology, it will run risks in implementing it. Therefore, e-business organisations need to consider this factor before implementing a SAN. However, outsourcing may be an option for the e-business organisations that do not have expertise in-house. Organisations can find that outsourcing provides instant expertise in building, integrating and running a network. As a result, e-business organisations do not need to worry that they do not have skilled persons to handle all of problems. On the other hand, e-business organisations also need to provide training programs for their employees so that they will understand how the organisation will change its processes after implementing a SAN.

3.9.3 The Financial Resource Availability to Implement SAN

E-business organisations may appreciate the tremendous advantages that SANs offer. However, there still questions for any e-business organisation, whether the cost of implementing a new architecture is worthwhile and what the real value of the benefits might be. SANs are very expensive and very complex, and require a big company like EMC or IBM to install, manage and service them (Nash 1999). Nevertheless, it does not mean that small companies cannot implement SANs. Following is one example to show a small company can still implement a SAN.

Integrated Archive Systems (IAS) implemented a SAN to help their customers manage their storage. This move has propelled IAS from a one-office, one-employee company to a $32 million company. The emergence of SAN technology could generate new streams of revenue that may push IAS over the $100 million mark Therefore, IAS believed that SAN technology was a win-win situation for them and their customers (Hess 1999).

IAS is a fortunate company because they can afford to implement a SAN and then generate income from the technology. However, this may not apply to every company's situation. Therefore before implementing a SAN, every company should ask itself whether they could generate sufficient return from this large investment. If the answer is positive, they can consider implementing a SAN but they should not implement a SAN if they do not have financial ability to do so.

E-business organisations may decide whether they should implement a SAN by themselves or outsource. Organisations that lack expertise in-house and do not have enough knowledge about SANs may consider it worthwhile to outsource storage solutions from other vendors. Outsourcing costs may be less than implementation costs by e-business organisations.

3.9.4 The Evolution of E-Process

When a company needs improvement in its global competitive position, important investments tend to be made in distributed information systems, such as centralised network management – SAN. To implement a SAN does not mean that e-business organisations have competitive advantage. Organisations need to know how to use advanced networking storage infrastructure wisely to achieve major business changes. SANs offer the means to increase data sharing, reliability and scalability, and lower costs. However, the challenge for organisations is to understand how to change the organisation and its processes to take full advantage of the benefits offered by SANs.

Once the storage system has been changed, it will affect other areas. In order to maximise the advantages of SANs, it is necessary to examine the e-process within the entire value chain so that it can create value for the organisation and its customers. Some organisations only implement a SAN, but do not how to evolve the e-process. In this situation, it is a waste of time and money to implement a SAN without gaining any benefits out it. Therefore, the successful e-organisations do not only implement a SAN but also know how to use it to improve their original e-process to create new value for themselves.

3.10 The Promise of SANs

The Promise of SANs is one of a series of research studies commissioned by IBM to study the ways companies prepare strategies to handle the impact of e-business (Werner et al. 1999). Its findings showed that:

- 89% of respondents believed that SANs offer improved manageability of data growth, as well as an easier way to expand storage capacity;
- 87% believed that SANs are credible solutions to improving data sharing and data access
- 84% said SANs are credible in improving performance;
- 82% believed that SANs can aid in disaster recovery;
- 45% were already considering using SANs, compared to 32% polled 3 months prior to the survey.

The businesses in the poll also believed that SANs would be able to:

- centralise control of data (89%);
- improve administration (82%);
- lower costs (77%); and
- enable companies to better leverage existing server and storage investments (76%).

Storage management is an extremely pertinent issue for many e-business organisations, due to their vast storage requirements. "In the past five years, storage growth has quadrupled. In the next three, storage shipment will increase to more than 1,700 terabytes" (Inrange 2001). A Gartner report predicted that external storage would have grown to over 3.8 million terabytes by 2005. It was also estimated that 72 percent of that storage would be SAN-attached (Brocade 2001).

The research conducted by Gartner Group determined that in 2000 corporations spent 25 percent of their computer infrastructure budgets on storage and 75 percent on hardware (Isakovich 2001).

Worldwide revenue for external disk storage systems rose to $4.3 billion in the third quarter of 2006, a 9.9% increase compared with the same period lasting the previous year, according to research firm IDC (Mullins 2006). This is the 14th consecutive quarter of storage revenue growth, a trend IDC attributed to more companies buying storage because of the demand to save more data (Mullins 2006).

The depiction of data in an organisation as critical has led to the increasing importance of storage management in most organisations. This increase in critical data affects many industries, and most organisations are now aware that the true value of data lies in how it is used throughout the organisation. For example, customer data is critical not only to fulfilment, billing and accounts payable, but it is also of value to marketing, strategic planning and inventory management.

3.11 Key Drivers for SANs

The major driver for e-businesses to move towards SAN is that the current technology is not sufficient to support high-speed data transfer rates or efficient data consolidation. SANs are capable of high bandwidth, and flexible network topologies as well as connectivity over larger distance (Rapaport & Baltazaar 2001). These key benefits of SANs are extremely important for e-businesses which compete on speed and the ability to access data with minimal or no latency. There is also very little technology today that supports the following features that SANs can offer.

3.11.1 The Storage Explosion

In 2002, IDC estimated that the disk storage shipments would have doubled each year with revenue increasing from $16 billion from 1999 to more than $46 billion in 2003 (Inrange 2002). SANs are able to manage this ever-increasing storage growth, whilst increasing data availability and accessibility. Traditionally, creating a SAN was only made possible with the use of extremely expensive, proprietary hardware by a particular vendor. Today, organisations can select from a variety of hardware

without being constrained and locked in by a particular hardware vendor, allowing businesses to have the desired level of performance scalability without a practical limit (InfraStor 2001).

3.11.2 The Internet Economy

According to Inrange in 2002, more than 70 percent of organisational data was managed data that resides in a relational database management system (RDMS). E-commerce has high storage requirements due to: search engines, online-catalogues, business-to-business transactions, customer relationship management (CRM), sales automation and ERP tools (Inrange 2002). The global nature of e-businesses has resulted in the elimination of even scheduled downtime. This puts pressure on IT operations to protect data, add storage and do maintenance while systems continue to be accessible.

3.11.3 Increasing Information Technology Productivity

SANs provide organisations with a situation were the same number of IT staff can manage an increased data workload.

3.11.4 Storage Consolidation

SANs reduce the time it takes to "add storage, allocate volume, backup, archive, replicate or mirror data, recover data or files, manage storage and troubleshoot and repair problems" (Inrange 2002).

3.11.5 The Unacceptably High Cost of Downtime

The cost of downtime for an organisation is in the form of both direct and indirect costs. Loss of current revenue, future revenue, customer confidence and supplier confidence should also be considered (Inrange 2002). Scheduled maintenance and upgrades will no longer cause downtime to the network as a server can partition its extra space to serve another storage-starved server running on a completely different platform. As mentioned explosive growth in data, reduced downtime as a result of server upgrades is a very appealing option for many e-businesses.

3.11.6 Cross Platform Compatibility

SANs allow organisations to alleviate the problem of sharing data across incompatible operating systems. With SANs, a UNIX server can share information with a NT server and so forth, allowing greater flexibility and eliminating compatibility problems.

3.11.7 Serverless Backup

Network professionals are trying to find ways to reduce network traffic during backups. With the fast growth of data traffic, backups can create major administrative problems. SANs allow the organisation to perform backups outside the LAN (local area network). Data moves directly from the disk to the backup media (e.g. tape) through the SAN fabric without further involving the server or the LAN (Neema 1999). Serverless backups, more importantly, allow organisations to recover data at 10 times the speed of current methodologies while freeing up CPU resources (Connor 2000).

3.11.8 Remote Mirroring

Fibre Channel's (FC) basic range of 10 km was overcome by substituting WAN links using dedicated dark fibre, which could reach 100 km. With the use of Dense Wave

Division Multiplexing (DWDM), the range could reach 320 km (Robb 2006). Then along came multi-gigabit IP transport for both FC and internet SCSI (iSCSI), which can span a few thousand kilometres, depending on the bandwidth and application (Robb 2006). This allows businesses to establish remote sites for disaster recovery purposes or to conduct remote backups.

3.11.9 Real-Time Backup

This allows backups to be created periodically and automatically without affecting normal system processing operations.

3.11.10 True Data Sharing

SANs allow the sharing of data across multiple platforms without the need to duplicate any data. This is referred to as true data sharing (Neema 1999). Not only does it improve operational efficiency, but it also utilises available storage resources more efficiently.

3.11.11 Fast Data Retrieval (Zero Latency)

The fibre channel used in SANs provides true 100MB/Sec data transfer rates, compared to current SCSI technology of only 40MB/Sec or 80MB/Sec. Thus information can be made available on demand with no latency.

3.11.12 Unlimited Scalability

Compared to the impractical limitations of conventional networking architectures today, there is no effective limit on the maximum storage capacity an organisation can add to a SAN (infraStor 2001).

3.11.13 Intangible Benefits

The above benefits also result in intangible benefits that are difficult to quantify, such as improved customer satisfaction and reduced time to market.

3.11.14 Higher Application Availability

Storage is externalised, independent of the application and accessible through alternate data paths such as found in clustered systems.

- With certain SAN architectures, data is available (uptime) from 99.99% of the time to 99.999% of the time. This translates to downtime (planned or unplanned) from 53 minutes per year to 5 minutes per year.
- SAN provides overall reductions in planned and unplanned downtimes compared with the existing storage topology.
- SAN performs data replication to remote sites for faster recovery in the event of an unexpected disaster.

Several factors are driving the SAN market, the most obvious of these being the unprecedented growth in data that most organisations have to struggle with. According to Fetters (2002), in the year 2000 alone the total amount of shipped disk storage doubled from around 700,000 TB (terabytes) to more than 1.4 million TB.

Other factors driving SANs' popularity include both high availability and disaster recovery. SANs contain a central storage pool; hence there is no need to replicate data across servers. If one server crashes, a secondary server can be brought online seamlessly, with full access to the exact data store. Furthermore, additional storage pools can be brought online and datasets rebuilt without hindering server performance (Fetters 2002).

3.12 Strategic Values

Isolated, these two terms have their own dictionary inferences. Strategic is "of or relating to strategy". Values, on the other hand are defined as "worth in usefulness or importance to the possessor". It is essential to note that the idea of value is different for each individual; hence it may have different "importance to the possessor". Hence strategic values are "important or essential in relation to a plan of action" and have their own degree of "perceived usefulness and significance" (Houghton et al. 2000).

3.13 Strategic Values in E-Business

In the fast-paced environment of the internet, having a good strategy for an e-business is vital. This has also changed the way normal offline business is run, and these changes are caused by:

- the increase in customers, and suppliers doing business in a more automated way;
- the accessibility of information – it is now online and needs to be secure;
- high speed in processes, which can potentially be automated – making it faster, with more agility (Rayport & Jaworski 2001).

This section will discuss the strategic values that an e-business requires of the SAN – particularly those mentioned above. As an introduction, many companies have found that SAN technology is the most suitable solution. With SAN, many companies have the ability to stay connected with their suppliers, partners and customers, thus forcing all businesses to adapt to some form of e-business.

The use of the electronic format to store important data increases the need for security. The use of electronically stored data has grown in the workplace, so much that better storage capability is required to grow exponentially. This is what attracts

business to SAN technology, and even more so for online stores in which all their processes are electronic.

The key strategic values that technologies like SAN will need to meet in today's digital economy include:

- An improved e-business requirement: The internet has developed into a demanding arena that requires e-businesses to possess a secure, effective and valuable medium for all its associated parties (such as customers and suppliers). The key to improving an e-business is to securely transform internal processes to improve business relationships and at the same time expedite the buying and selling of goods, services and information via the internet (IBM 2001).

- Storage: A Strategic Tool. As mentioned before, increasing volumes of data have increased the need for storage so much that improvements for storage systems grow exponentially (IBM 2001). However, many organisations have not taken notice of this with their storage systems, and have not understood that storage is in fact a strategic tool. This is beginning to change, though, as companies realise that business data is to be treated in the same way as the business strategy of a company.

- Zero Latency: Business cycles have also evolved into a much shorter timescale. Businesses are now measured on how fast they can deliver a product, or how quickly they can meet the customers' needs in a specified time (IBM 2001). Information is also required to move at speeds identical to that. Both exchanging and accessing information immediately are now requirements for competitive advantage.

- Transformation: There is now a need for the ability to continually adapt, while immediately accessing and processing information to

drive successful business decisions. Not only should businesses be able to change, but also to do it without interruption: this is the real challenge.

- Technology Demands: The biggest mistake to make in an e-business is to have technological solutions that do not possess the right attributes (scalability, performance, robustness, speed etc.). The demands on e-business systems are totally unpredictable and so it is important for corporations to find quality systems that possess those characteristics (IBM 2001) as well as being able to adapt to changes related to technological demands.

- Globalisation: The opportunity to increase market share is now not only within the country, but across international boundaries. Technological solutions should be able to stretch a company to cover the world and meet global demands.

The need to manage data at unprecedented speeds is a major strategic value that technologies such as SAN need to have. This and those mentioned above are the requirements of a SAN to make it strategically rich in value.

The following are basic characteristics that storage systems must have to achieve these strategic values:

- **availability**: the ability to continually serve customers and internal personnel regardless of how many there are and how much data there is (i.e. the ability to overcome/avoid congestion);
- **scalability**: the ability to upgrade requirements without interrupting service operations;
- **security**: protection from all threats including, viruses, unauthorised access and the corruption of data;

- **manageability**: the ability to monitor all operations and applications that are used in the business cycle and to act in a way that is just as easy.

3.14 Strategic Values of SAN

As mentioned previously, SAN is a high-speed data communications platform, which interconnects servers and storage. By combining LAN networking models with the core-building servers of server performance and mass storage capacity, SAN eliminates the bandwidth bottlenecks and scalability limitations imposed by previous SCSI bus-based architectures (Ottem 2002).

In addition to the fundamental connectivity benefits of SAN, the new capabilities, facilitated by its networking approach, enhance its value as a long-term infrastructure. These capabilities, which include topological flexibility, fault tolerance, high availability and remote management, further elevate SAN's ability to address the growing challenges of data-intensive, mission-critical applications. From a client network perspective, the SAN environment complements the ongoing advancements in LAN and WAN technologies by extending the benefits of improved performance and capabilities all the way from the client and backbone through to servers and storage.

In a connected digital world, managing, accessing, copying, backing up, protecting, storing and moving information are more important than ever. Research firm International Data Corporation estimated that "storage demand for an average Fortune 1000 company will grow an astonishing 650%, from 40 terabytes to 300 terabytes, over the next five years" (Chadha 2001).

Hence it is highly beneficial for an organisation to adopt SAN in many aspects. By exploring these aspects, we will be able to see the type of advantages that SAN can bring to an organisation.

The core values of a SAN involve:

- efficient communication;
- centralised resource management;
- universal access and availability;
- security and data integrity;
- disaster tolerance;
- globalisation;
- cost reduction;
- high availability; and
- superior connectivity.

3.14.1 Efficient Communication

Companies are moving towards e-communications to reduce costs, increase efficiency and gain greater knowledge about their customers (MacSweeney 2001). SAN can provide core strategic value to companies that are increasingly using electronic forms of communications to interact with their customers.

Companies that performed a high volume of web transactions can use SAN to capture information and process information. For example, customers who use the internet to apply for a home loan will need to fill in quite a lot of information. Most banks will need to contact the customer to gather more information after the customer has applied online. With SAN, banks can store information and continuously update it. So when a customer contacts the bank, the bank can effectively communicate with customers because they have effectively captured information about them.

The above example is just one indication of how SAN can improve the communication process between a company and its customers.

3.14.2 Centralised Resource Management

In today's competitive environment, it has become crucial that information can be extracted effectively and efficiently. SAN can help companies centralise their data so that the extraction of important data is made as easy as possible.

The other key benefit of having a centralised resource management system is that it saves the organisation money and time. Data that is stored at various remote locations requires servers and technology platforms to manage the data, and by having a centralised system, the company would not need to manage multiple resources, thus saving the company money.

SAN implementation can actualise the following data storage management benefits:

- staffing requirements for storage management can be reduced significantly;
- administrators can support more storage in a SAN environment than in direct-attached environments;
- fewer tape libraries for backup are required;
- there is a reduction in application Central Process Unit (CPU) cycles with the process of off-host backups;
- server use in terms of server processing cycles is improved; and
- data storage costs can be allocated to departments based on need.

3.14.3 Universal Access and Availability

From time to time, many organisations around the world will need to access information in various locations. This could simply be an employee accessing information from home or an executive on a business trip. The need to access information anywhere and anytime is increasingly becoming an important part of the day-to-day functionality of many organisations.

SAN changes the way people access data by allowing 24 hours a day, 7 days a week availability anywhere in the world. It also allows for a host of critical applications and business processes that demand real-time access to data (Chadha 2001). For example, an employee is on a business trip in Hong Kong but his company's headquarters are in Sydney. However, by adopting a SAN system, this employee can log onto the network and view vital company information to which he or she is authorised, regardless of whether they are in Hong Kong or Sydney. This is a key value to companies who require universal access and as well as 24x7 availability of data.

3.14.4 Security and Data Integrity

Computer downtime can cause a company many problems such as losses in revenue, data error and general frustration for those who are waiting for the data to be processed. Companies that relied on disk storage are often more prone to downtime due to disk drive failures. SAN reduces the chances of downtime because it can incorporate fibre channel connectivity, which improves the performance and reliability of a data centre.

Since data is more reliable and less likely to encounter downtime with SAN systems, data is better protected and its integrity is enhanced.

3.14.5 Disaster Tolerance

In this day and age, no company can afford to lose or misplace valuable data that is crucial to the operations of a company. As companies start to realise the importance of valuable data, there has been an increase in data being backed up at various locations.

SAN can speed up disaster recovery processes because SAN uses fibre channels which process data at an incredibly fast rate, "backup and recovery processes become much more effective providing a real opportunity to reduce downtime, thereby lowering risk and reducing losses" (Zeisler 2001).

SAN can also help protect information because the infrastructure of SAN is more secure than other storage devices. With the adoption rate of SAN growing quickly, businesses face the fundamental challenge with the architecture and design of the SAN infrastructure. By proving a more secure system to protect information, companies will be able to securely managed data better, thus reducing the chances of data being lost as "backup and recovery are becoming mission-critical for ensuring e-commerce and enterprise continuity" (Chadha 2001).

Disaster tolerance is one of the more vital strategic advantages that SAN provides. A corporation without knowledge will not be able to function either efficiently or successfully.

3.14.6 Globalisation

The extension of IT systems across international borders allows for worldwide access, which provides value especially to corporations with branches globally. Global organisations are being inundated with huge amounts of unstructured content. Users cannot quickly locate the information they need to make effective decisions and as a result, companies lose millions of dollars annually due to duplicated work and missed opportunities. Through the use of SAN, companies are able to tap into their stored knowledge from anywhere in the world. This is especially significant to worldwide corporations. It also assists companies with networks and alliances to be able to have global access to the company's information.

3.14.7 Cost Reduction

It is more effective to deploy a geographically dispersed SAN as the costs for such fibre optic technology are dropping. In consolidating "multiple, disparate systems across a single platform" businesses are able to save circuit costs while being able to grow easily as the infrastructure is already in place. This will also enable them to more easily manage their entire networks (Zeisler 2001).

Strategic values involve being useful and significant: therefore cost reductions to a company is a strategic value which SAN provides.

3.14.8 High Availability

The SAN dramatically improves the availability of business processing. For example, any server can take over from a failed applications server - as they share access to the same storage and users. No longer are businesses constrained by bottlenecks in terms of how to access to data. It is now possible to reach corporate data through any application server because of improved clustering solutions. In addition, data can be automatically replicated to where it is needed in business terms. Technology now becoming available will enable such replication to occur at either the disk/volume level or at the database/file-system level. For highly critical applications, a change of data value can be updated on all replicas simultaneously - synchronous replication.

For most data, however, it is perfectly acceptable that replicas are a few seconds or minutes out of date to their master copy - asynchronous replication. A fundamental utility within SAN is a set of facilities to meet these needs. These replication facilities must be completely accurate and reliable, exhibit very high performance and thereby give the company confidence to remove all "private" copies that may exist to date. Hence the SAN model provides inherent availability of data, the use of automatic data redundancy, automatic backups and the maintenance of nearby recovery copies.

3.14.9 Superior Connectivity

In addition to superior flexibility in scaling server processing capacity and data storage capacity, the networking approach of SAN introduces aspects of interconnect scalability that have not been possible previously. Through the use of modular networking devices such as hubs, switches, bridges and routers, advanced SAN topologies can be created to scale over all bandwidths and enhance availability.

The physical distance capabilities of a storage network have been steadily advancing in recent years. Fibre Channel's basic range of 10 km was overcome by substituting WAN links using dedicated dark fibre, which could reach 100 km, or Dense Wave Division Multiplexing (DWDM), which could reach 320 km (Robb 2006). Then along came multi-gigabit IP transport for both FC and iSCSI, which can span a few thousand km, depending on the bandwidth and application (Robb 2006).

In a SAN environment, every server on the network can address all the storage on the network. In fact, any storage device, if it has enough intelligence, can talk to any other storage device on a network and it can even serve different types of platforms or operating systems. This capability enables the utilisation of existing storage resources that may be scattered throughout an enterprise building or campus, and encourages broader adoption of remote vaulting, mirroring and clustering solutions. This level of connectivity will enable sharing business-critical data between two different systems.

3.15 Role of Storage Area Networks

In SANs a subnetwork built on fibre-optic cable consolidates server-attached storage into a centralised high-speed ring. In NASs large volumes of storage are attached to a high-speed Gigabit Ethernet, wherever that storage occurs. The debate on the use of SANs vs NASs hinges on price and speeds of transmission. The rising number of internet transactions and the corporate desire to capture data about online customers are driving increased spending on storage (Babcock 2000).

Until now, open systems platforms have typically been dispersed throughout an enterprise as individual islands of operation incapable of sharing resources. As a result, valuable business data has not been accessible throughout the enterprise. With a Fibre Channel SAN, businesses can now interconnect these distributed islands of operation, combining them into larger and more efficient continents of operation with the resulting advantages of expanded data accessibility, economies of scale and true scalability for the internet economy. Expanded data accessibility can multiply

the value of data many times over by making it available wherever it is needed for enhanced decision support and, ultimately, competitive advantage (Wright 1999).

According to Wright (1999), SANs enable the vital new e-business and e-commerce applications that are so crucial to the ongoing success of today's prominent businesses. By leveraging the increased speed and connectivity offered by Fibre Channel over its SCSI predecessor, enterprise SANs deliver the computing infrastructure for the new millennium and the internet revolution. With an enterprise SAN, data can be consolidated and shared as needed within the company and with suppliers, partners and customers in the data value chain.

By definition, e-businesses must be open for global business across multiple time zones. Bank customers want access to their accounts on a 24x7 basis. Auction sites operate around the clock. Further, with global availability and intensive pressure on market-driven growth, transaction levels can spike capriciously and inadequate storage management can drive major performance bottlenecks for web applications. According to Mohebbi (2000), one successful advertising campaign or one hit Super Bowl commercial can jam website traffic off the gauge. In this environment, the days of monolithic storage solutions are numbered. Organisations require agile, scalable and affordable approaches that can support the often-unpredictable transaction volumes. Consumer-driven 24x7 availability requirements mean that it is no longer acceptable to take systems offline to execute important data management tasks. Further, even minor storage failures can be very costly to an organisation and harm consumer confidence.

In too many circumstances, the requirement for speed runs counter to the requirement for accuracy. While customers want immediate access to their bank records, a storage crash that drives failure to log even a single transaction translates into expensive customer service calls, erosion of the customer/revenue base and collateral damage to the brand. As the sheer volume of web and internet content increases exponentially, players in the internet economy are demanding that storage solutions track beyond linear advance. These new market realities leave internet,

Application Service Providers (ASPs) and traditional brick-and-mortar organisations scrambling for reliable and scalable storage solutions. Under the old world approach (Mohebbi 2000), this would have driven expensive growth in organisations' requirements for server storage to support additional applications, operating systems, databases and web storefronts.

In the context of e-commerce, we are witnessing a huge increase in interest in emerging SAN and NAS solution offerings. In fact, International Data Corporation projected that the NAS market would have hit $6.5 billion by 2003 (Mohebbi 2000). These numbers were eclipsed by analyst projections that pegged the worldwide demand for SAN solutions at more than $15 billion by 2002. The industry notes that as applications become larger and more demanding, NAS and SAN solutions will become increasingly mission-critical. In this environment, organisations are increasingly likely to bring hardware and software from vendors specialising in enterprise storage, interfacing traditional servers with midrange computers and even mainframe machines.

During the past ten years, a major shift has occurred away from the legacy mainframe host-centric storage model to the distributed storage that is currently in vogue in the client/server model. Storage, for the most part, remains connected to the processor it services via a dedicated channel such as a SCSI bus. However, the large number of servers creates a complex environment and is difficult to manage. The high-dedicated SCSI channels tend to be inflexible, especially in terms of distance between the storage and the processor. At the same time, in the client/server model, the servers are interconnected via network protocols such as TCP/IP, so that these servers can communicate with each other. These networks, LANs and WANS, tend to be slow but very flexible. Interconnectivity is easy, but large blocks of data traverse the network rather slowly and network disturbances are frequent (Werner et al. 2000).

Today many vendors are rushing to the market with new Fibre Channel products and putting them together into SANs. The promise to resolve many of the industry's

major issues (speed, connectivity, availability, reliability and manageability) is creating quite an energetic marketplace (Werner et al. 2000). Using a SAN can potentially offer the following benefits:

- improvements in application availability: storage that is independent of application and accessible through alternate data paths;
- higher application performance: delegating storage processing to a storage subsystem off-loading server;
- centralised and consolidated storage: simpler management, scalability, flexibility and availability;
- data transfer and vaulting to remote sites: enabling remote copy of data for disaster protection; and
- simplified centralised management: single image of storage media simplifies management.

The long journey for the new architecture called SAN is just beginning, but promises to transform islands of data to the level of a true utility--universally accessible, sharable and ubiquitous. According to Moore (2001), the SAN may be ahead of its time, but it isn't ahead of its vision. The longer view for SANs significantly challenges, and will eventually replace, the traditional practice of using a general-purpose server with a dedicated storage repository.

In contrast, the high-speed network fabric constructed from storage interfaces connects a pool of data storage devices to a group of servers, allowing storage devices and servers to be added and removed independently of each other. In the SAN, data is shared among connected servers, rather than connected to and owned by a server. These servers might be using the same or dissimilar operating systems. In the SAN model, an unscheduled outage on a server doesn't need to affect access to data. The result is much higher availability and easier, more centralised data management.

According to Moore (2001), "choices for storage architecture are yesterday's direct-attached model or the promise of tomorrow's high-availability, shared storage pool".

Fibre Channel is based on a network definition of five layers (Werner et al. 2000), where the lowest three physical-level layers define the pathway and the upper two layers enable the software protocol to move the actual data.

3.16 Drawbacks of Storage Area Networks

Even though SANs bring benefits to firms, some drawbacks do exist. These problems need to be reviewed when assessing SANs as the solution to an organisation's storage problems. As a result, further storage solutions need to be devised to remove current problems. Some of these drawbacks include the following:

- SAN can be seen as a risky, immature and expensive technology with interoperability problems (Ohlson & Lais 2000). Large outlays of money and time are needed to establish SANs, which can be a deterrent to employing such storage techniques. The time taken to introduce the system until deployment has been estimated between 6-9 months for an individual customer (Cook 2000).

- Vendors are providing SANs as pre-packaged solutions, which is likened to providing "SAN-in-a-box". There is an argument that SAN solutions need to have unique requirements to meet individual business needs and cover possible contingencies, as distinct from using a generic solution "from the box" (Cook 2000).

- Data transfers are slowed down when using SANs for small files. A need exists to use more than five servers to collectively access the disk storage for SANs to be of benefit (Mier & Percy 2001).

- While SAN storage capacity can be added as required, SAN does not place the storage sub-systems directly on the network. Instead they put an I/O network with switches in between the storage sub-systems and the server. This normally adds some degree of throughput delay in the form of network latency (Moore 2001).

- SAN solutions tend to be vendor-centric, which make it costly and difficult to implement total storage solutions provided by multiple vendors. High integration costs (including interoperability tests) and expensive training costs face organisations in this situation.

- Shortages of properly trained personnel make it a costly exercise to set up and maintain such new storage systems. This lack of human resources can be a deterrent to employing storage area networks.

3.17 Common SAN Implementation Mistakes

Most mistakes and overspending on storage can be avoided if storage managers first look within their own enterprise - at the data, the infrastructure, the people and processes and, most important, the business.

The following is an overview of the biggest, costliest storage mistakes that enterprises make and how managers can avoid them (Ohlson & Lais 2000):

- IT managers haven't clearly defined business requirements.
- They become bogged down in the technology.
- They don't know enough about their existing storage.
- IT managers don't consider the network.
- They don't know their data.
- They don't consider the entire data life cycle.
- They can't justify backup requirements.
- They don't know the limitations of storage software.
- They are unprepared to become integrators.
- They don't make shared storage a team effort.
- They don't pay enough attention to administration requirements.
- They don't know where they're trying to find their return on investment.

3.18 Limitations of SANs in E-business Organisation

According to Rapaport and Baltazaar, (2001), given the current state of the fibre channel market, the deployment of SANs is generally only recommended for large enterprise-class companies, though mid-size and smaller companies with proper support infrastructure can also derive benefits for various applications. Interoperability is still a problem facing early technology adopters and it will continue to be a problem as the standard continues to evolve to 2Gbps speeds and beyond.

The Gartner Group had thought that operating systems, software and applications would not have been ready to interoperate with SANs until late in the year 2003 (Biggs 2000). Whilst big companies can overcome these problems through extensive testing, building a SAN is well beyond the capabilities of most users.

For smaller companies, NAS is generally considered more appropriate. It can be installed within minutes into existing Ethernet networks and for a small business its performance isn't noticeably slower than SAN (Rapaport & Baltazaar 2001). NAS is much simpler to operate and manage and relatively inexpensive compared to SAN. However, NAS is far from a substitute for SAN; rather, it is a more appropriate and cost-effective solution for some businesses. This further emphasises that the impact of SAN on the success of an e-business firm is very reliant upon the business and its compatibility with the implementation of SAN.

IDC's research uncovered three primary areas of concern for SAN users. First was the multiple standards that currently exist, second the high cost of implementing SAN and the issue of justifying such costs, especially when the current system is still operating reliably, and finally the issue of linking application functionality to enterprise objectives.

Despite claims that SANs provide cost savings in administration, storage tasks such as management and backup are driving up the annual cost of storage administration to over five times the price of hardware (McData 2001).

SANs require the installation of a new storage infrastructure. This cost, combined with networking hardware costs including interconnecting devices and fibre channel cabling, must be accounted for in the overall cost of implementation (Brocade 2001).

Interoperability is a major concern within the industry: "there is no overreaching platform, no standard for storage management and that is causing a lot of headaches" (Isakovish 2001). Interoperability has come a long way since the early days of SANs, standards have emerged, and interoperability labs have been built and are being used by vendors as well as industry organisations such as the SNIA.

Despite a lot of talk in the industry regarding multi-vendor SANs as complex and expensive, Nortel provides a good example illustrating that it can work. Nortel built its SAN with components from Brocade, Sun Microsystems Inc, IBM and Hewlett-Packard Co (Hoard 2001).

Nortel derived numerous benefits from their SAN implementation, including a reduced backup time of 30 hours, a 30 percent decrease in network connection and a reduction of backup costs from $28 per gigabit or storage to $18 over a two-year period (Hoard 2001).

The major impediments to SAN implementations include *management, cross-product virtualisation, zoning and interoperability.* In addition to these factors, issues such as costs and knowledge base pose an extensive limitation to the widespread execution of a SAN.

Despite claims that SANs will reduce management costs by consolidating storage, the fact remains that SANs still need to be managed the "old decentralised way" (Isakovich 2001). In order to successfully operate a SAN, five management levels are recommended by Tivoli systems: application, data, resource, network and element management (Tivoli 2002).

SANs have yet to penetrate the mid-range of the market. This can be largely attributed to management issues that are yet to be resolved (Isakovich 2001). It should be noted that SANs alone don't solve management problems; additional software applications such as: failover software, volume management. SRM and backup management are also required.

Complexity can be regarded as a byproduct of many SAN implementations. New York Life, a mutual insurance company, provides a good example of a complex SAN environment. Although the move from NAS to SAN boosted their overall network performance, it also increased their IT complexity, a situation that they were hoping to resolve in the near future (Horwitt 2001). "While SANs made it possible to ensure better performance and fault tolerance for applications by distributing shared databases across multiple volumes, those capabilities also make it a lot more difficult to design applications" (Horwitt 2001).

There is a lot of talk in the industry in regard to the business continuance advantages provided by SANs. However there are two major factors hindering wider deployment of SAN implementations. "In order for the benefits of SAN infrastructures to truly penetrate the small departments segment of the market, they must become lower cost and easier to deploy and manage" (Berman 2002). It is for these reasons that management and pricing issues will need to be overcome before there is a more widespread usage of SANs.

Despite the benefits of implementing SAN in organisations, there are also disadvantages in having this system since it is a new paradigm in the storage area network industry.

Although there are many advantages to SAN, there are also some disadvantages as follows.

3.18.1 High Cost of Start-Up

Using a SAN means more expensive hardware and being confined to one or two vendors (Erlanger 2001).

Kranz (2001) stated, "Industry experts say a comprehensive SAN could cost hundreds of thousands of dollars, putting them beyond the reach of most small enterprises. Although a SAN could yield savings through the need for fewer IT professionals, the upfront cost intimidates most companies". Companies have to determine the payoff between reliable knowledge management and price. Fibre Channels, switches and other infrastructure to set up a SAN system are expensive, particularly for smaller organisations.

IDC, an international consultancy group specialising in IT services, stated that while the initial investment for a SAN can be exorbitant, total costs of ownership are approximately five times this amount, making it beyond the reach of small enterprises (Kranz 2001). Costs such as change management and retraining or hiring of new staff must also be factored into the cost equation. In choosing a SAN for a business, it is crucial to choose one which meets the capabilities and needs of the enterprise. Mismatching the SAN could cost the company millions and provide little benefit, thus making it cost ineffective.

For high availability in mission-critical data centres, it is more appropriate to go to an established vendor, which offers somewhat more mature architecture, sophisticated management and support capabilities and an established track record. However, companies with less critical needs could find SANS which cost substantially less. However the disadvantage is that the architecture may be quite basic and in order to achieve maximum utility it may be necessary to add components, thereby increasing the costs (Clark 2000).

Some companies may not even need a SAN system. A NAS or similar system may be more beneficial, depending on the type of business which the company operates within.

High implementation costs were a factor for several companies studied: Amro Information Technology Services, Showtime Networks Inc, Fidelity Investments Systems and Blue Cross Blue Shield. These companies did not highlight the costs as disadvantages to the implementation, as business planning factored these costs as a consideration from the outset (Garvey 2000). It is, however, important to look at the general costs as many e-businesses simply would not be able to consider SAN as an option because the costs associated go far beyond what they can afford.

The implementation of a SAN can run into millions of dollars and is therefore not practical for many small and medium-sized businesses, which may seek alternative methods such as renting space from a company that outsources storage to meet their storage needs. Cost is certainly a concern for responsible managers within large multinational corporations. However, it appears they are more concerned about scalability, reliability and customer service issues (Vecchio 2002). It may be more cost-effective for agencies to add storage rather than implement a SAN: a server with 36GB storage space can be purchased for under $2,500, assuming a 3-year life span. Using the estimation of $20 per GB per month, the same amount of storage would cost an agency $25,920 for 26 months (Vecchio 2002).

If high availability is a priority and there is a risk of one server being "down" and if access to that stored data is critical, an investment of between $5,000 and $7,500 in a server-class machine with ATAPI drives and standby server software may be more efficient (Doering 1999). In a survey conducted by RBC Capital Markets and the Computing Technology Industry Association, 62% of companies that had not implemented a SAN cited high cost as the reason why (Simpson 1999).

The expenses of SANs identified by Fidelity Investments Systems Inc are (Garvey 2000):

- fibre channel switches;
- fibre channel to SCSI routers/bridges;
- fibre channel host bus adapters;

- networked Storage Pool Solution;
- fibre channel cabling; and
- training in SANs and Networked Storage Pooling.

Expanding beyond large-scale sites is a significant limitation of SAN solutions. Small to medium-sized networks where budgets are a primary concern place a strong focus on ROI (return on investment) and may not be prepared to spend between $50,000 and $150,000 if an investment of from $15,000 to $20,000 will suffice (Doering 1999). The *proprietary phase* keeps costs at a higher level. However it is expected that this will change with time (Ottem 2002). Solid business case analysis is essential for SAN design and justification. Failure to do so may impact on both cost projections and ROI (Merrill 2001).

One drawback to SANs is "there is an incredible range in price", according to Jim Porter, President of Mountain View, Calif.-based Disk/Trend Inc (Walker 1999). A SAN with of a couple of servers could cost between $20,000 and $30,000. A high-end SAN could cost $4 million or $5 million depending upon the capacity and nature of the system, Porter says (Walker 1999).

3.18.2 Difficult to Deploy and Maintain

The implementation of a SAN is complex, and great care must be taken in its design and implementation.

3.18.3 Requires Additional Fibre Channel Network

Implementing a SAN means learning a new networking architecture called Fibre Channel and a considerable investment in Fibre Channel-specific hubs, storage devices and switches (Erlanger 2001).

Large organisations have been the early adopters of SANs. Geographic diversity and the need for heterogeneous connectivity are normal in these environments. Fibre Channel SANs are top-tier solutions for these campus or data centre deployments.

However, very few solutions are available for connectivity outside the campus or data centre. The solutions that do exist are expensive, software-based and relatively slow.

3.18.4 Lack of Qualified Staff and Other Necessary Resources

Although with storage moving off servers and onto a centralised, accessible storage device, managing storage can be quite a challenge. Mandelbaum (2001), Vice-President of Information Systems in the Internet and Lotus emerging technology environments, at Newark stated: "We are trying to consolidate our storage and manage it as a resource so we can control it, ... Storage utilization rates are not what they could be. We have a whole newly formed team that is focusing on storage management."

Organisations are being faced with issues of finding qualified staff to manage the new SAN technology. There is a lack of qualified staff available, as IBM's Underwood said: "...finding the qualified people to manage storage can be difficult" MacSweeney (2001).

A major component of this issue was the lack of trained management staff to assist once the solution is implemented. The management of SAN is a complex task. It can be difficult to implement within a company's existing information systems architecture and usually requires specialised staffing. In addition, without powerful software to manage the storage devices, systems management is complicated (Vecchio 2002). The expertise required to manage these software solutions is scarce and it may be necessary for e-businesses to train an in-house staff member for this task alone.

In a test of different SAN systems conducted by Internetweek.com, lack of management systems to support the implementation of SANs was noted in the majority of cases. Without this, a complete solution is elusive (Zeichick 2000).

There are three basic dimensions of systems management:

- notification of failure;
- prediction of failure; and
- correction of failure.

Additional management system tools available include notification by email or SNMP of a server's redundant links failure. The system must also identify where the problem lies and provide a comprehensive event log.

Notification of failures must display the operational status of a given component and clearly indicate if and when any unit failed. The corrective action is to replace the failed component as soon as possible.

Since a fire-fighting management style is especially costly in a SAN, it is better to adopt a more proactive management approach. In order to become proactive, it is necessary to gather performance information from several subsystems over time, thereby enabling prediction of system failure. Degrading subsystem performance can be a forewarning of a larger system failure. If a system failure can be predicted, system maintenance may be scheduled ahead of time, ensuring the desired degree of system uptime.

Both failure prediction and failure notification rely on system monitoring. A highly specialised, distributed and automated approach seems the most desirable. However certain management functions only become feasible if they exist close to the source of a given problem (Jensen 1999).

With an enterprise network, managing heterogeneous access across platforms that may or may not have the same file systems may pose difficulties. At the same time, an organisation may not have any choice but to deal with multi-vendor software. In the ideal IT environment, organisations use one common interface to take care of systems management across the SAN. As with any growing industry, common

standards become the key enabler for making a technology, such as fibre channel, work. There is a need for these to be universally accepted (Ferrarini 2002).

There is a direct relationship between cost, staffing issues and interoperability. Fear of SAN failure is made all the more vexing by staff inexperience with a new technology (Webster 2000). Showtime Networks Inc, discussed above in relation to software management, experienced this firsthand. They also found that employing support staff once the SAN was implemented was difficult because of the lack of expertise in this area. It is clear that this will change over time, as more professionals become trained in the management and implementation of storage solutions.

SAN will operate far more effectively and efficiently if a consultant specialising in that area of focus is employed. The problem here lies in finding such knowledgeable professionals (Schuchart 2002). Professionals with a working knowledge of SAN applications are thin on the ground and difficult to find.

Lack of trained staff is an industry-acknowledged problem and companies implementing SANs find this to be a disadvantage that needs to be addressed and considered in the overall benefits analysis of implementing a SAN. Companies have shown initiative in this area by training their own staff to be competent in SAN management (Garvey 2000). E-businesses implementing SANs need to be aware that it may be necessary for them to have an in-house manager of the system.

There are very few people who come already experienced in the wide range of skills ideal for SAN environments. As a result, it makes it difficult to train the people.

For decades, storage has been handled as just an add-on to IT strategy and as JBOD – the storage professionals' acronym for "just a bunch of disks." IT needs to raise the strategic discussion of storage in the same way and to the same degree that telecommunications did when they moved in the 1990s from cables and boxes to e-

business architecture and in the same way as when databases have moved from software to CRM (Keen 1991).

Storage vendors and buyers need to build an entirely new dialogue. In the JBOD world, vendors are box salespeople and IT organisations are box buyers. Both are in a commodity transaction, not partners in enterprise storage strategy. The JBOD suppliers come in with feature lists, prices and service promises. This is satisfactory with semi-commodities such as low-end servers, PCs and internet hosting. But it is inappropriate when the discussion is about the architecture for the firm's customer data resources or its e-business strategy and platform architecture - and recognising the importance of never putting either at risk.

For companies that hope to gain the advantages of SAN solutions, the next great challenge is communication, but not the communication between fabric switches and loop switches, storage systems and servers or storage management software and system management frameworks. The coming challenge has nothing to do with component, system or software interoperability. The next great challenge is the communication, or rather lack of communication, between data centre managers and business unit executives (MacArthur 2000).

IT professionals must have extensive knowledge to manage SANs properly as SANs encompass both storage and networking technologies. This combination of network and storage technology makes SANs more difficult to manage than traditional storage systems. Normally, network managers do not purchase SANs. System administrators buy SANs, and they usually know little about LANs (Connor 2001).

3.18.5 Immaturity of Technology/Early Adoption

Companies have been slow implementing SANs because of SANs' lack of industry standards. Storage firms are currently developing standards through the Storage Networking Industry Association. However, Didsbury thought in 2001 the adoption of acceptable standards may be some time away.

Despite recent improvements in SANs and imposition of some standards to govern the new technology, it is still recognised as being in the early stages of widespread dissemination. Furthermore one could suggest that technology currently being developed will eventually supersede SAN systems as it will not carry with it some of the limitations of SANs such as lack of standards and interoperability issues.

Many companies that have already implemented a SAN are finding that the technology falls short of what was promised. Many major SAN vendors make unrealistic claims about SANs which lead companies to believe that the technology is heterogeneous in all respects and will enable a much more efficient means of data management (Trotman 2000).

In order to get SAN technology into the mass market, analysts suggest that improvements in backup application space and other applications such as multiplatform centralised storage and performance enhancing clustering for Windows NT and other Intel corp. processor-based platforms must be developed in order to round out the SAN (Moore 2001).

Fibre channel and vendor interoperability issues and the lack of management utilities must be overcome before widespread application will occur, and while efforts are being made in an attempt to impose workable standards, vendors will not be imposing them until new developments in SAN technology are on the way. Furthermore it should be noted that companies considering SANS in this early period need to expect at least a year from investigation and roll-out to a time when they have implemented and tested a workable security system, fault tolerance and disaster recovery plans so that if the SAN is to fail in any respect, the company can continue with its operations until a suitable alternative is found or the SAN is modified to take care of any faults.

The bottom line is that current generation products act and look quite immature. They are not well managed or provide highly accessible storage infrastructure.

Therefore they are relatively cost-ineffective and need to be modified before they are implemented by the mass market.

Despite the economy of scale, costs and technical complexity have kept adoption rates of SANs low. It was estimated in 2002 that only 6 to 11% of Fortune 500 companies had installed SANs (Mearian 2001). In a few years, however, SANs could become a necessity for all organisations with growing data storage demands, especially given the projected growth of e-commerce. SAN has the ability to lower total costs of ownership and quicken return on investments. The Sept 11 attack on US has caused companies to place more emphasis on disaster recovery plans across all applications, realising the importance of storage.

With anything but a smooth entry into the market, SAN vendors floundered as they attempted to define their own Fibre Channel standards. The Fibre Channel Industry Association, the Storage Networking Industry Association and other organisations have pushed the technology and pooled resources to help develop a set of standards for management. However these groups have yet to develop standards to address the lack of interoperability between switched fabric implementations (Fetters 2002).

As the early days of IP networking have shown, collaboration among industry leaders is essential in bringing real customer solutions to the market and storage area networking is no different (Rassmussen 2001). Device management and compatibility in Fibre Channel arena are so fragile that only the latest hardware products have a reasonable chance of being managed directly by third-party software. Older equipment will probably never be manageable by this kind of software (Schuchart 2002).

Lack of industry standards is not an issue that is necessarily considered from the outset when deciding how or if to implement a SAN, but is more likely to be highlighted by staff dealing directly with SAN management when the resultant interoperability issues arise (Garvey 2000).

3.18.6 Lack of Product Interoperability

Standards for Fibre Channel connectivity have not been established. If companies purchased all of the components for a SAN from one vendor, then most of the connectivity problems will be eliminated. It is also likely that companies would want to purchase components for SAN from different vendors beyond storage hardware and software. If the hardware and software that make up SAN could not communicate, the businesses can experience very costly mistakes (Campbell 2000).

Interoperability is a problem when "(t)he company can't make some of its switches work with some of its servers ... which range from incompatible vendor implementations of the high-speed Fibre Channel standard to slow development of host-bus adapters by server vendor can have serious consequences" (Garvey 2000).

As previously highlighted, the issue organisations face in the deployment of SAN is in the interoperability of switches and servers. There are unstable and unpredictable connections of lines in the I/O chain from host-to-storage devices. Organisations are learning and experiencing the hard way that the promises of SANs are still a future knowledge management benefit. As previously stated, organisations are investing large amounts of money into SAN laboratories to locate the problems proactively. For example, Data Storage Institute has partnered with SNIA in order to ascertain problems of SAN.

However, in SAN promises, "a specialized high-speed network connects a diverse collection of storage devices and servers so that every server and application can access all the data" (Garvey 2000).

Once the multi-vendors comply with SAN standards set by the American National Standards Institute, one problem will be minimised. When standards have been legislated and complied with by organisations, then there will be guidelines for suppliers to abide by the standard. Therefore, this problem should be ameliorated.

In order to overcome this major drawback, the year 2000 saw several vendor alliances established and numerous open testing events held in an attempt to bring vendors together (Rapaport & Baltazar 2001). Many of the largest SAN vendors have invested in interoperability labs. IBM has dedicated 80,000 square feet of space and $500 million worth of equipment to its interoperability lab. The lab includes equipment from all major server vendors including Compaq, IBM and Sun; switch vendors such as Ancor, Brocade and Gadzoox; routers from Chaparral and Cross Roads; and software from Computer Associates, Hewlett Packard, Legato and Veritas. Their aim was to help clients design a foolproof system and test their planned solutions. Other companies such as EMC have also started to dedicate millions of dollars to labs similar to IBM's, in an attempt to give clients experience in deploying SAN technology and to eliminate the fears about incompatibility issues and rising costs.

Interoperability is perhaps one of the most important issues for determining why a total SAN solution is not easy to achieve. Vendors are yet to develop a universal SAN solution, and it is unlikely that one vendor will ever be able to achieve this. The fibre channel landscape has a plethora of vendors selling products in storage and network spectrums. These products function as a synergistic and cohesive system; vendors must agree on a common set of implementation guidelines and standards for the solution to be effective. The FCIA and SNIA have addressed interoperability issues with ongoing vendor plug and play compatibility and certification programs. According to Ferrarini (2002), until products have plug and play compatibility, systems integrators will have to deal with these issues as best they can.

In a test of four different SAN systems conducted by Internetweek.com, interoperability was highlighted as both a significant issue and a limitation of the solution. Compaq products offered traded inflexibility for simplicity, supporting only a limited variety and quantity of hardware (Zeichick 2000). Interestingly, 49 out of 160 IT managers cited interoperability as their biggest concern about SAN implementations in a Computerworld survey of IT managers published in 2000 (Zeichick 2000). "If the vendors agreed on a set of functions for SAN management

interoperability, that would give customers more flexibility in putting in equipment from different vendors" (James 2001).

To advance interoperability, individual storage and system vendors have set up interoperability labs to test storage switches, hubs, hot bus adapters and disk arrays with their own equipment. EMC, StorageTek, Brocade Communications and Compaq are among those participating. While the labs are focused on proving interoperability between the vendors' storage equipment and other devices, none of the labs is open to testing any server operating system with any storage device that has an interconnected router or switch (Connor 2000).

Amro Information Technology Services Co and Showtime Networks Inc have failed to experience the positive side of interoperability, as SAN is not a plug and play device at this stage (Garvey 2000). It is necessary for vendors to demonstrate a cooperative attitude if open standards are ever to be implemented consistently (Webster 2000). Good service and support are crucial once a SAN is implemented (Solomon 2003).

Since Amro Information Technology Services Co and Showtime Networks have implemented SANS, the Fibre Channel Industry Association's SANmark qualification and trademark licensing program has gone some way in assuring interoperability. The SANmark program is designed to ensure conformance to common network operations that promote robust, heterogeneous Fibre Channel networks (Ottem 2002). According to Ohlson and Lais (2000), "The SAN interoperability issue is a double-edged sword for vendors...They all agree they need to propel the interoperability issue forward". However, allegiances are still divided between the two pre-standards bodies, the SNIA and the EMC Corp, led by FibreAlliance, and the vendors may never agree on standards proposals (Ohlson and Lais 2000).

Things can become even more complicated once a SAN implementation is under way. E-business organisations implementing SAN face initial challenges that include

incompatible switches from multiple vendors, a lack of robust network management software and inadequate technical support.

Interoperability standards, which are being worked on by vendor organisations such as the SNIA, are expected to support storage virtualisation, the ability for users to pool together physical storage on devices made by different vendors.

One result of the lack of previous cooperation among vendors is that security is almost nonexistent in storage installations, according to Hubert Yoshida, Vice-President of data networking solutions at San Jose-based Hitachi Data Systems Corp. "That is one area that we have to work on", he told about 150 vendor representatives at a conference (Mearian 2001).

SAN can be seen as a risky, immature and expensive technology with interoperability problems (Ohlson & Lais 2000). Large outlays of money and time are needed to establish SANs, which can be a deterrent to employing such storage techniques. The time taken to introduce the system to the point of deployment has been estimated between six and nine months for an individual customer (Cook 2000).

3.18.7 Security

Organisations are informing vendors that there is a lack of security barriers in SAN systems, such as failure to prevent unauthorised access to company knowledge. The security issue could be avoided during the building and implementing of SANs. Enterprise Storage Group of Milford in Massachusetts claimed that "concern about security is the chief impediment to widespread implementation of SANs" (Kranz 2001).

Furthermore, Bill Van Emburg, Chairman of Piscataway, New Jersey-based systems integrator Quadrix Solutions Inc. also believed "security safeguards should be built into a SAN" (Kranz 2001).

Since the SAN is, in essence, a network, SAN security issues mirror those of any network of file servers, in that there is a need to control access and prevent damage. Security capabilities must be built into the fabric of the SAN. At present, SAN administrators have only two rudimentary security techniques: LUN (logical unit number) masking and zoning.

- LUN masking creates subsets of storage within the SAN virtual pool and allows only designated servers to access the storage subsets.
- Zoning, also called partitioning, achieves a similar result at the switch by limiting access from a given port to given data.

SAN fabrics are only as secure as their weakest point; consequently either the entire network is secure or the network is open to corruption (Brocade 2001). SANs allow for common pools of storage, which can theoretically be accessed by anyone from anywhere. It is necessary to consider who should have access and what level of access each individual should have when implementing and managing a SAN (Ferrarini 2002).

It is imperative that organisations are aware of potential points for breach when implementing and designing a SAN. Reliable security solutions highlighting these vulnerabilities are necessary to manage security risks created by SANs. These risks include:

- unauthorised and/or unauthenticated SAN access;
- insecure management access;
- World Wide Name (WWN) spoofing; and
- management controls allowed from different access points.

The identification of these risks are useful tools for containing security breaches and to ensure end-users cannot cross between specified storage areas (Radding 1992).

3.18.8 Expensive Maintenance

According to Friedman (2001), "It is not the storage hardware that is costing so much; it's the management of the storage system. Only 9% of total storage expenditures go toward actual storage hardware. The rest, according to Cahners In-Stat, is consumed by management, software and support. And as the cost of hardware continues to drop, this ratio will only increase".

This above statement is particularly true for SAN, a networked storage configuration. Implementing and maintaining a SAN involves new levels of expertise and support that introduce complexities into traditional IT systems support organisations. A different brand of knowledge is required than that demanded by traditional storage. New expenses occur as supports for SAN availability are required. According to Friedman (2001), areas for supporting activities are: the server and network administration, the application environments, the storage, and the storage interconnect environment.

Overall these issues prove that SAN knowledge management systems are an expensive infrastructure for an enterprise to acquire, install, trust and manage. Therefore, if an organisation has confidence in SAN's implementation costs, apart from believing in its security aspects, it must ascertain the cost benefits against the time and expense of implementing and managing a SAN system. For this reason SAN systems are slow to thrive and only larger stable organisations have taken the plunge.

Large vendors such as IBM and Hitachi can only guarantee the hardware they sell, but not the connectivity of the entire network. In addition, when it comes to the integration of products from several different vendors, the mission is critical.

3.18.9 Difficult in Developing a Business Case to Client Needs

It is critical to the success of SAN applications that a clear business-goal-oriented plan is established by the business implementing SAN as part of their operations

(Schuchart 2002). Without this planning, the decisions made about which SAN solution is right for the business are destined to failure. The problems that SAN purports to solve are not clear or easily remedied (Schuchart 2002). Amro Information Technology Services Co, Showtime Networks Inc, Fidelity Investments Systems Inc and Blue Cross Blue Shield all undertook extensive planning with the companies implementing their SAN and had set goals they wanted to achieve prior to contacting the associated vendors. This makes all the difference.

The publicity surrounding the SAN market outweighed actual sales of this technology. In fact, there is still plenty of growth predicted for SAN technology as companies continue to wrestle with the best methods to manage data. The majority of companies are still relying on server-attached storage systems. Necessity, however, will force e-business organisations to transition to newer systems.

There is a threshold that users should be aware of before they consider SAN technology. If a company has 500GB of storage or more, then there is a cost justification and a management justification to move toward a SAN. There is a definite cut-off. A company with 50GB to 100GB does not need to be investigating a SAN solution. Once the company is in the 400 GB to 500 GB range, however, then a SAN solution starts to make a lot of sense (Hess 1999).

3.18.10 Storage Management Tool Inadequacies

Many users are still hesitant to deploy a SAN because the software tools needed to knit together and centrally manage such installations are not fully in place. Different storage vendors all have some software tools, but they don't have the full range (Mearian 2001).

A number of leading storage device manufacturers are pushing hard on the software front. However, storage resource management is still made up of disparate products, developed by disparate vendors. Most notably missing are tools that can handle enterprise storage management tasks such as SAN administration and control of

media and tape libraries. The opportunity for vendors is there, but there are very few products on the market addressing the needs.

Of about 300TB of data stored in three separate storage area networks (SAN) at the Boeing Co. around 2000, only 2TB to 3TB could be shared in a SAN with products from different vendors because the software available to manage them is unreliable. Every vendor is deploying their own flavour, and they are not interoperable (Mearian 2001). At the same time, while storage vendors continue to promote storage manageability and open standards, users say the applications they have seen fall far short of what they need, such as automated load balancing and storage virtualisation or the pooling of storage capacity from mixed vendor environments.

One company is taking action to address the problem of incompatibility. IBM sells Tivoli Storage Network Manager, but the company plans to improve interoperability with other vendors' products with its Storage Tank software (Mearian 2001).

Storage solutions such as SAN may seem to be cost-effective, but it isn't until a company purchases and implements one that they realise the hidden inadequacies.

This may force e-business to spend more money on interoperability, resulting in the cost-saving benefits being an empty promise for the e-business organisation or even making it cost more than some other alternative solution. While vendors are certainly willing to be open with server platforms and switches, they are not necessarily willing to extend this openness to their storage. SANs are not revolutionary and need to mature in the industry as has any other technology that has been developed in the past, before the real benefits come to hand (Mearian 2001).

3.19 IP SANs

IP SAN is a SAN technology without the complexity of Fibre Channel (FC) utilising the standard IP infrastructure. As majority of the infrastructures are IP networks, then the infrastructure change are usually not necessary when implementing an IP SAN solution. While FC is still the leading storage switch mechanism, IP-based SANs are becoming popular. IP SANs essentially harness the IP and iSCSI protocols to establish a SAN. As a result, IP SANs are now making their way up (Robb 2006).

CHAPTER 4

LITERATURE SURVEY

This chapter reviews the related topics in SAN and CSFs literature, such as CSF studies on system success and information centres, as fundamental for IT, IS and SAN implementation success.

As far as the author is aware, no empirical studies had been done which have examined the CSFs of SAN implementation at the start of this research study. Numbers of authors have researched CSFs and only few have studied SAN; none has combined the two. This study fills that void by combining both CSFs and SAN implementation theory and research. There are empirical studies on CSFs involved in IT and IS planning and implementation. It was also accepted that the IT/IS-related literature on CSF studies could be useful with careful adjustment and necessary extensions of this research foundation in order to incorporate it into this study on CSF of (in this case SAN) implementation. The researcher of this study has carefully studied the literature in order to extract the factors that are suitable for SAN implementation, in order to establish a research model which is useful for identifying the CSFs of SAN implementation.

4.1 General

SAN is a dedicated, centrally managed, secure information infrastructure, which enables any-to-any interconnection of servers and storage systems (Zeisler 2001). SANs allow businesses to move, store and access as well as manage information from one or more data centres.

SAN is being rapidly deployed in the large enterprises around the world (Mearian 2001; eMarketer 2000; Greenstein & Feinman 2000; Evans & Wurster 1999). The rapid growth of SANs over the years since the introduction of the Fibre Channel and the attention paid to it in the business press have greatly increased interest in storage systems (Garvey 2000).

Implementation of IT is critically dependent on the business or the sector on which IT is applied. Early work on IT implementation suggested that sector differences were significant (Earl 1989). Although SAN systems have many advantages and benefits, it is true to say that there are some drawbacks. The given difficulties must be assessed when reviewing the implementation of a SAN system as the solution to a firm's data storage difficulties (Babcock 2000; Moore 2001; Mier & Percy 2001).

According to Toigon (2001), SANs would help to make business processes more efficient by enabling greater access to data for decision makers. It is a reality that investments in innovative IT applications are risky and expensive. The managerial decision to adopt a SANs system early or wait for the technology to become more established is not trivial. Early adoption poses significant demand and technological risks, but the rewards could be great. Firms that deploy SANs technology may observe competitors' success in using this channel to attract customers and generate revenue and profits. Besides, technology vendors such as IBM, SUN, EMC, Veritas, ClearLogic and Open Market may persuade potential firms to adopt the SAN technology.

Companies both large and medium have been deeply affected due to massive storage needs as the result of online transactions and Enterprise Resource Planning (ERP). Research shows that even though there have been numerous success stories about benefits obtained from implementing SAN, it is not as straightforward and simple as is suggested by the Storage Network Industry Association (SNIA) and the solution providers, as there are examples of business failures or disappointments obtained from deploying SANs in e-business organisations. Therefore, deploying SANs requires a more in-depth organisational learning process, knowing the most CSFs for implementation, implementational effectiveness, and management commitment and support.

Although the demand for more sophisticated network infrastructure and storage is increasing day by day, there was no published work on CSFs study of SAN implementation in the literature at the time of this study. However, the proposed

research model uses most relevant CSF studies in the field of information systems IT/IS. Papers on CSFs that were consulted include Rockart (1982), Martin (1982b), Miller et al. (1987), McCredie and Updegrove (1999), Kuang et al. (2001), and Nelson and Somers (2001).

Past research has often focused on forecasting the future trends in SANs in terms of the cost per gigabit of storage and or the expected capacity of data in future years (Mohebbi 2000; Isakovich 2001; Inrange 2002; Hoard 2001). Others such as Werner et al (2000) have conducted research on the perception of users of their implemented SAN system. Similarly, Brocade (2001) conducted a census of the percentage of SAN-attached network storage, and it was estimated that 72% of that storage would be SAN-attached.

SANs offer the means to increase data sharing and reliability, and to lower costs and scalability. However, the challenge for organisations is to understand how to change the organisations and processes to take full advantage of the benefits offered by SANs.

Gartner research director Robert Passmore suggested that large enterprises that have implemented SANs have seen productivity improvement of three to ten times in their IT organisations (Schwartz 2002). More than 50 percent of all storage systems were networked-up from 23 percent a year ago, and by 2005, 90 percent of all storage would be networked (Schwartz 2002).

Another area that is rapidly deploying network storage solution is web usage mining. In recent years, there has been an increase in web usage mining (Wu, Yu & Ballman 1998; Masseglia, Poncelet & Cicchetti 1999). Web usage mining is the type of web mining activity that involves the automatic discovery of user access patterns from one or more web servers. The main motivation of these studies was to get a better understanding of the reactions of customers who shop through the electronic premises of a company on the worldwide web (www) or of users who are simply browsing these premises. Some studies also applied the mining results to improve the

design of websites, analysed system performance and network communications or even built adaptive websites. In general, there are two main goals in the application of the knowledge discovered in web usage mining: a) general access pattern tracking for understanding access patterns and trends, and b) customised usage tracking for adapting and personalising the browsing experience for users. Due to the large capacity of data generated in web usage mining, numbers of companies have already implemented SAN, and others are about to implement SAN in the near future.

The web creates glorious storage problems. The rapid pace of web application development and deployment consumes infrastructure at an alarming rate. In this frenzied world, several constants emerge: vast quantities of data need to be instantly and reliably available to servers and applications across the enterprise. Decoupling storage and servers by employing a SAN can alleviate capacity bottlenecks by allowing for dynamic reconfiguration of storage resources and the systems that access them. These were the problems faced by iSearch, a company that specialises in maintaining resume databases for employers and job-search websites in Los Angeles. With 3 million resumes in dozens of databases and the performance demands of intelligent web-based search applications, the company would have faced a nightmare if they had not chosen the right storage the first time (Hammond 1999).

Nowadays, digital information is relatively easy to capture and fairly inexpensive to store. The digital revolution has seen collections of data grow in size, and the complexity of the data therein increase. Advances in technology have resulted in our ability to meaningfully analyse and understand the data we gather lagging far behind our ability to capture and store these data (Fayyad et al. 1996).

It is generally accepted that the reason for capturing and storing large amounts of data is due to the belief that there is valuable information implicitly coded within it (Fayyad et al. 1996). Companies that specialise in data mining and ERP that have not implemented SAN yet will be among those will be considering SAN implementation

to cope with their massive data, unless newer technology becomes available in near the future.

According to Zaino in 2000, a survey from Enterprise Management Associates (EMA) showed that some IT professionals preferred not to implement SANs, at least not immediately. More than half of the 187 IT professionals EMA surveyed at companies with median annual revenue of $225 million said they were using, evaluating or planning to use a SAN soon. Yet considering the benefits of these architectures for data-intensive e-business, increased availability of data to a wider array of users, faster information access via a separate high-speed network, and better scalability and failover protection, it may come as a surprise that 46% of those queried said they had no plans to install a SAN (Zaino 2000).

Companies evaluating SANs have a lot of data on their plates. According to Zaino (2000), the EMA survey reported that 55% of these users either stored or planned to store at least 500 Gbytes of data on their first SAN, and 36% of the respondents were looking at having to store, manage and track more than 1 terabyte of data. But some companies were simply making sure they were well prepared for the future. EMA said 10% of the survey respondents expected to store 50 to 100 Gbytes, while 12% said they would store less than 50 Gbytes, at least in their initial implementations (Zaino 2000).

The power, reliability and extensibility of SANs are driving significant interest in this solution as companies rush to implement e-business in every industry segment. However, the level of complexity typical of e-business and SAN systems results in major implementation challenges for management. Even more important, managers are discovering that being able to see and manage their entire solution's performance is a major factor when it comes to realising the benefits that a reliable, redundant SAN can bring them. As a result, today's managers are beginning to learn that deploying a SAN is just the beginning. The ability to see all of the SAN components and to tune it to achieve optimal performance and response times represents the next major step in SAN implementation.

Managing data storage is a continuing challenge for storage administrators. They must steadily improve availability, quality and performance of storage services in order to support their company's business objectives. According to Koclanes (2001), now their task is even more challenging, as they must manage an ever-increasing amount of physical data in the face of flat headcount and shrinking resources. Consolidating to network storage, SAN and NAS can improve operational efficiencies that can significantly reduce this management burden, especially as part of an active, integrated storage resource management (SRM) solution.

According to Koclanes (2001), effective SRM solutions are based on:

- a holistic data model that incorporates the logical and physical relationship of the storage elements from the application, through file systems, volume managers and databases, through the fabric, to the storage array and down to the spindle;
- a well-defined application centric policy and rules;
- service-level agreement enablers;
- service-level objective (SLO) executors;
- a well-defined managed element (devices, file systems, databases, volume managers) characterisation, policy and rules for provisioning and managing these resources;
- best-practice workflows that enforce the policies, and rules that ensure SLO adherence within the known characteristics based on a holistic data model and competing application service level objectives; and
- automation of the workflow steps to enable consistent performance and operational efficiencies in analysis and provisioning of storage.

According to a survey conducted by RBC Capital Markets and the Computing Technology Industry Association published in 2001 (Betts 2001), 46% of companies with more than $1 billion in annual revenue had already deployed a SAN. Among companies with revenue of $250 million to $1 billion, 25% had deployed a SAN, and 14% of small enterprises ($50 million to $250 million) had implemented a SAN. The

RBC study predicted that initial SAN deployments would grow at a compound annual growth rate of 37% over the next two years and that SAN-attached storage would account for more than 50% of total storage capacity in 2003.

An MIT Media Lab venture looking to find out how babies develop the ability to talk began in March 2006. The project began using 14 microphones and 11 cameras mounted on ceilings throughout the house to record everyday life of a baby boy. The required storage area was expected to be 1.4 petabytes, or 1,400TB, of data compiled over the span of the three-year project (Mearian 2006). "This is a great marriage between industry and the academic world," said Frank Moss, director of the MIT Media Lab at a press conference (Mearian 2006). It was believed that 350GB of video would be processed during every 12-hour analytical run. The project had been amassing several terabytes of audio and video data per week of early-childhood learning and socialization data to model human language acquisition, Roy said, "If you take all parallel tracks of data over three years, you'll have 400,000 hours of video and audio data" (Mearian 2006).

In March 2006, the Credit Union Journal reported that with more than two terabytes of available storage space, 70 servers, and 10,000 check images every day, SANs have become an attractive storage device for the mountains of data that are spilling from new high-byte technologies at University of Wisconsin CU (Jepson 2006).

Not all businesses have a real need for a SAN. E-business organisations with limited data transfer and storage requirements would have no need to implement SAN. Even with a single site, size is also an issue, with a rule of thumb suggesting that only once an organisation needs to store 500GB of data or more will a SAN become cost-effective (Orubeondo & Apicella 2001).

Although Zasman (2002) highlighted the significant benefits of SANs to organisations, they are not without their shortcomings. As a result of the drive for scalability, the construction of vastly larger databases and the increased use of enterprise-wide networks, the number and complexity of multi-vendor SANs have

increased. Security poses a major concern. Lack of security increases the vulnerability of commercial applications environments. Zasman (2002) also noted that a well-designed SAN builds upon an enterprise's existing storage devices to produce significant returns on investment (ROI). His findings did not consider that although a well-designed SAN is an important part of the implementation, it alone is not enough to guarantee a ROI. The important goals of SANs include:

- managing the storage system;
- facilitating disaster recovery; and
- simplifying and providing fast backup operations by leveraging the greater bandwidth available over Fibre Channel.

Scientists now regularly use medical imaging techniques such as magnetic resonance imaging (MRI) to study brain function. While most MRIs create a static record of the body, in vivo studies map brain functions over time. Such functional MRIs require costly equipment as well as appropriate subjects. They generate huge amounts of data: in vivo functional magnetic resonance imaging (fMRIs) are typically 5 GB and can go up to 45GB. With better equipment and techniques, file sizes keep growing (Storage Management conference in Chicago 2003).

The data generated by one study can be of immense value to other scientists and educators who are studying the same or similar topics. Unfortunately, while studies are published in scientific journals with a couple of illustrations, much of the valuable raw functional imaging data isn't available to other researchers. The secondary role of SAN implementation is its capacity for data archiving. Archive data will be used as a fossil record in the field of MRI. In years to come, scientists can look back and see how much has been achieved.

SANs are high-speed storage networks that rely on hubs, switches and gateways rather than on traditional storage methods that use the legacy SCSI architecture, such as online disk and tape library systems (Weils 1999). According to IBM (2001), a SAN "simplifies and centralises resource management" and also "enhances security and data integrity of new computing architectures".

One of the most powerful driving forces for the business organisation implementation of SANs is the ability to simplify and speed up backup operations by using the greater bandwidth available over Fibre Channel.

E-business organisations implement SANs for numerous reasons. The transfer to SANs has been motivated by the requirement to manage the dramatically rising volume of business data, information and knowledge to mitigate its effect on network performance.

The industry publicity about SANs has been widespread. McArthur's 2001 study showed that vendors had amassed at least 1,460 press releases about SANs in 18 months - surpassing even the 'wireless web' with 1,056 releases during the same period (McArthur 2001). Yet many corporate IT managers see SANs as a risky, immature, expensive technology with interoperability problems.

According to an article by Ottem (2002), experts suggested that about 5% of SAN failures are not easy to diagnose. It is these few intractable problems that cause major difficulties for those who use multi-vendor SANs.

An estimated 25% of all SANs were heterogeneous systems consisting of mixed servers, switches, disk drives, host bus adapters and cabling all linked together in an intricate network fabric, according to Ottem in 2002. When the growing complexity of these fabrics results in a SAN failure, the cause is sometimes difficult to diagnose. One way to minimise the need for troubleshooting is by doing a better job of setting up SANs in the first place, that is, by implementing it correctly.

SAN has potential; however, it has some limitations (Hammond 1999).

- The first limitation is that Fibre Channel devices from different vendors may not operate well on the same network.
- The second interoperability issue is on the server side. Not all servers support native Fibre Channel connections.

- Third, interoperability with desktop operating systems, as well as many third-party applications, do not support SAN-attached storage.
- The fourth limitation of today's SAN is the distance over which a Fibre Channel connection can be made. The current limit on this type of connection is around 10 kilometres. However the ability of companies' SAN to spread from city to city could be required a few years from now. As the result of this limitation, disaster recovery across large cities such as Sydney and Melbourne is not feasible at this stage.

Manchester, Mier and Percy (2001) indicated that data transfers are slowed down when using SANs for small files. They also stated that as a result there is a need for more servers to collectively access disk storage for SANs.

In a survey of 100 SANs IT professionals, Enterprise Management Associates Inc. (EMA) found that 80% had a major problem with SANs that was holding back their purchase or deployment of the technology: 'the act of implementing the technology at this stage is daunting enough to give IT professional's serious pause' the EMA study said (Zaino 2000, p. 1).

The typical SAN server has high needs in the area of very large storage capacities (tens of terabytes) and/or high performance. These servers are also, typically, database servers. Initial SAN implementations were able to address input and output (I/O) performance issues. Unfortunately, over time databases have developed I/O bottlenecks that the initial SAN deployment could fully handle. Daytime processing could not keep up with user requests, and night-time batch cycles (large reports, database refreshes, data loads etc.) exceeded the nightly windows. Usually, one or two areas of the database called "hot spots" caused these I/O bottlenecks (McKinstry 2000). It quickly became evident that the hot spots often resulted from very large amounts of random I/O. With the very large host systems that run these databases, it is very easy to overpower a traditional disk subsystem with random I/Os causing the host to sit idle while waiting for the disks to respond.

Although SAN solutions predicted the fact that access over a distance of 10 kilometres is realisable, for the modern global organisation this may not be enough. Fibre Channel's basic range of 10 km was overcome by substituting WAN links using dedicated dark fibre, which could reach 100 km, or DWDM which could reach 320 km (Robb 2006). Then multi-gigabit IP transport for both FC and iSCSI was developed, this can span a few thousand km, depending on the bandwidth and application. Essentially the need for a SAN is to ensure that disaster recovery systems can be generated in case of an emergency – as demonstrated by the September 11 attack on New York's World Trade Centre.

Many initial SAN implementations are reaching the end of their life cycle. Managers are faced with very costly upgrades or complete overhauls. Both options are risky and expensive.

As organisations in the future build upon the success of their initial SAN implementations, the security threat will undoubtedly increase. Given that the ultimate SAN objective is to create enterprise SANs capable of handling all of an organisation's information assets, the organisation must throw open the SAN to the entire enterprise and beyond. When this happens, good fundamental security practice alone requires that managers plan specific security measures.

Val Bercovici, the chief technical architect of a major manufacturer in a trade show in Toronto US earlier this decade, warned his audience, 'deploy carefully … poor security is one of the storage networking industry's …dirty secrets' (Solomon 2003).

According to Kranz (2001), SAN allows for common pools of storage, which can theoretically be accessed by anyone from anywhere. So the questions that need to be asked are:

- Who should have access?
- What level of access should each individual have?
- How should the company secure the SAN?

Security has been a major concern for organisations that have implemented SAN. Enterprise Storage Group of Milford in Massachusetts claimed that "concern about security is the chief impediment to widespread implementation of SANs" (Kranz 2001).

The SNIA is already addressing the SAN security issue. Managers can expect improved SAN capabilities by the time most organisations are ready to deploy enterprise-wide SANs.

The very capacities that make SANs ideal for storage networking, the ability to make any-to-any connections, make it possible for application servers to see all storage devices on the SAN at the same time, and even to overwrite each other on the same disks. This is generally considered a bad thing, so storage administrators must protect against it. In spite of real security threats from ignorance or malice, Fibre Channel security against external attacks is not as mature as messaging network security.

Chudnow (2002) explained, "Security for storage networks is new because most people, three or five years ago, didn't know about them. New networks are hard to hack because you don't know how". As more people find out how to hack into storage networks, they publicise vulnerabilities over the internet and other hackers attempt to exploit that knowledge. Storage administrators may not have even known about the original intrusion because the hacker left no traces, but suddenly find the network is suffering thousands of attempts.

The word interoperability can have either a positive or a negative connotation. The positive is that entities on the storage network do interoperate seamlessly. Unfortunately, the word 'interoperability' when used in a storage context is usually preceded by 'problem with' or followed by 'issues'. Interoperability is a problem when "the company can't make some of its switches work with some of its servers ... which range from incompatible vendor implementations of the high-speed Fibre Channel standard to slow development of host-bus adapters by server vendor can have serious consequences" (Garvey 2000).

Interoperability is perhaps one reason why finding a total SAN solution is very difficult. No one vendor has yet to develop a universal SAN solution, nor does it seem probable that one vendor will ever be able to pull off this feat. For example, the Fibre Channel landscape has multiple vendors selling products up and down the storage and network spectrum. For these separate products to function as a synergistic and cohesive system, vendors must agree on a common set of implementation guidelines and standards. Organisations must work closely with SAN key suppliers in their interoperability labs to ensure everything will work together, and this is a costly and time-consuming exercise for organisations.

It is interesting to note that some vendors are trying to steer clear of interoperability problems by introducing interoperability labs in addition to their product lines. According to McFadden in 2000, Hewlett-Packard had recently announced it would invest US$300 million in two SAN integration centres, one in Atlanta and the other in Cupertino, California. The idea was to have a place where vendors can test and validate interoperability between SAN offerings. HP was not alone in trying to address the perceived failure to commit to interoperable SAN offerings; IBM and EMC have also set up their own interoperability labs. EMC has invested more than US$200 million in an interoperability-testing laboratory, where it certifies systems and parts from partners and competitors alike (McFadden 2000).

In order to overcome this major drawback, the year 2000 saw several vendor alliances established, and numerous open testing events held in an attempt to bring vendors together (Rapaport & Baltazar 2001). Many of the largest SAN vendors have invested in interoperability labs. IBM has dedicated 80,000 square feet of space and $500 million worth of equipment to its interoperability lab. The lab includes equipment from all major server vendors including Compaq, IBM and SUN; switch vendors such as Ancor, Brocade, Gadzoox, routers from Chaparral and Cross Roads and software from Computer Associates, Hewlett Packard, Legato and Veritas. Their aim is to help clients design a foolproof system and test their planned solutions. Other companies such as EMC have also started to dedicate millions to labs similar

to IBM's, in an attempt to give clients experience in deploying SAN technology and to eliminate fears about incompatibility issues and rising costs.

In 2002, Schwartz cited Nancy Marrone, analyst, Enterprise Storage Group, saying that SANs had come a long way, but there was still a great need to verify interoperability (Schwartz 2002).

Mark Teeter, director of Enterprise Storage Solutions, Advanced Systems Group, stated: "Don't miss and match switches if you don't have to: even if there was complete compatibility, customers would have the extra burden of using and maintaining multiple management tools, along with increased complexity with maintenance and support. I'm not a big supporter of intermixing multiple switch-vendor products in a ..." (Schwartz 2002).

According to Sullivan (2000), companies Pyxis and Nth Generation have learned that SANs from different vendors still don't interoperate easily. "Combining EMC's and Compaq's SANs proved impossible. We couldn't run EMC and Compaq in the same Fibre Channel network," said Richard Baldwin, president and CEO of Nth Generation, also in San Diego. At the time of this research, Pyxis operates the SANs separately, managing them with utilities from EMC and Compaq. The interoperability issue is not unique to EMC and Compaq. All SAN vendors are grappling with Fibre Channel standards and resolving compatibility problems. Compatibility among switch ports, multiple-switch fabrics, name services and registered state-change notification are among the interoperability issues vendors are now wrestling with. Because SANs are not universally interoperable, most early users are forced to stick with a single vendor's solution.

However, for some companies with increasing storage demands, interoperability issues may not outweigh SAN's benefits. In the case of Pyxis, the high data access rate afforded by SANs made maintaining separate systems worthwhile. Pyxis' network supported more than 1,400 users, half of whom were field-based engineers and application specialists serving more than 3,300 customers. With the SANs, Pyxis

maintained about 8 terabytes of disk storage. Pyxis had developed an application that provided automated medicine dispensing at hospitals and pharmacies. The SANs architecture allowed Pyxis to guarantee 24x7 operations through disk mirroring and disk snapshotting, a technique that lets backups be done without interrupting online operations (Sullivan 2000).

Not long ago, only the largest of enterprises were deploying SANs, primarily to bridge the storage of large, mission-critical systems that were generating massive amounts of transaction-oriented data. According to Schwartz (2002), the role of SANs is actively expanding from storage networks centred around homogenous systems or applications into core components of enterprise systems, due to the improvements in interoperability. He also stated that the SANs today represent one of the largest growth opportunities for solution providers offering system, network and storage-integration services. Although there has been growth in SAN, the interoperability is still the main issue facing organisations. The growth in SAN has been more due to the fact that organisations tend to purchase the solutions from one vendor, to avoid interoperability.

Interoperability is perhaps one of the most important issues for determining why a total SAN solution is not easy to achieve. Vendors are yet to develop a universal SAN solution, nor will one vendor ever be able to achieve this. The Fibre Channel landscape has a plethora of vendors selling products in storage and network spectrums. These products function as a synergistic and cohesive system, and vendors must agree on a common set of implementation guidelines and standards for the solution to be effective. The FCIA and the SNIA have addressed interoperability issues with ongoing vendor plug fests and certification programs. Until products have plug and play compatibility, systems integrators will have to deal with these issues as best they can (Ferrarini 2002).

Early SANs had many interoperability problems, even in mainly homogeneous environments, so mixing operating systems was generally not something users undertook.

The FCIA and the SNIA have attacked the interoperability issue, undertaking ongoing vendor plug fests and certification programs. However until products have plug and play compatibility, companies, along with systems integrators, will have to deal with these issues with whatever means possible to deliver a true SAN solution.

The early days of SANs were very problematic. The market was flooded by a plethora of products and vendors, hardware and software, hubs and switches, with an extensive array of different features and functions. Early SANs had tremendous interoperability issues. The main problem has been products coming to market before standards. This created problems for consumers to sort through promotional material, understand what they needed, and find products that had interoperability. The result was that early SAN adopters put in a great deal of time and effort to get their SANs working. Interoperability was perhaps the number one issue for these early users. Only the brave dared to tackle the task, with lots of vendor involvement and frustration. The sentiment of the early adopters was that building your own SAN and trying to piece things together from various vendors was extremely difficult.

Analysts are optimistic that SAN interoperability issues will eventually be resolved. Storage vendors recognise that interoperability will increase the value of SANs to end-users.

The researcher of this study has carefully studied the literature in order to extract the factors that are suitable for SAN implementation, so as to establish a research model which is useful for CSFs of SAN implementation.

The conceptual framework of this research includes literature review in thirteen contexts:

- studies on the development, effectiveness of and the reliability of CSF;
- studies on use of CSF empirical studies for measuring performance;
- studies on use of CSF empirical studies for measuring implementational effectiveness;
- outlines of the studies that relate to selection of SAN system;

- outlines of the studies that relate to the organisation's technical support;
- outlines of the studies that relate to the management commitment and support;
- outlines of the studies that relate to users' training;
- outlines of the studies that relate to implementation's effectiveness;
- outlines of the studies tat relate to users' appreciation;
- outline of the studies that relate to technological competence;
- outlines of the studies and literature that relate to IT/IS and SAN implementation success;
- outlines of the studies that relate to change management; and
- studies of CSF for the implementation of IT or SAN.

4.2 Critical Success Factors (CSFs)

According to Rockart (1979), CSFs can be defined as "those few critical areas where things must go right for the business to flourish"; in other words, if these components fail, the system fails. CSFs for any information systems project have been a topic for research in the IS research community for quite some time (Bacon 1993).

The idea of identifying CSFs as a basis for determining the information needs of managers was proposed by Daniel (1961) but popularised by Rockart (1979). The idea is very simple: in any organisation certain factors will be critical to the success of that organisation, in the sense that if objectives associated with the factors are not achieved, the organisation will fail - perhaps catastrophically so. Rockart (1979: 85), by referring to Daniel (1961), gave the following as an example of the CSFs: "new product development, good distribution, and effective advertising for the food processing industry - factors that remain relevant today for many firms" (Bergeron & Begin 1989; Boynton & Zmud 1984; Goldsmith 1991; Leidecker & Bruno 1984; Pollalis & Frieze 1993).

4.3 Development, Reliabilities and Limitations of CSFs

The CSF approach was begun by Rockart (1979) and has since being popularised. Rockart (1979) defined CSFs as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation. They are the few key areas where things must go right for the business to flourish". According to Robson (1997) CSFs are used to identify the most important components of IS strategy for businesses' success.

Rockart (1979) outlined a procedure by which interviews between an analyst and a CEO result, first, in a set of CSFs and, then, in performance measures that represent these CSFs. Rockart (1979) did not specifically advocate using the CSF method to develop a detailed set of requirements specifications, but rather to identify critical areas of concern and to provide initial descriptions of information measures that reflect these critical areas. Rockart stressed two points: CSFs provide a focal point for directing a computer-based information system (CBIS) development effort, and the CSF method should result in an information system useful to a CEO as it pinpoints key areas that require a manager's attention.

Zmud (1979) argued that the success of IS implementations could be influenced by the following:

1. *organisational factors;*
2. *IS usage;*
3. *top management's support;*
4. *decisions performance;*
5. *personal and interpersonal characteristics;*
6. *users' attitude;*
7. *IS staff characteristics; and*
8. *IS policies.*

Zmud (1979) suggested that those implementing IS should also examine the system usages, user satisfaction and system performance for IS success.

The usefulness of CSFs was criticised by Davis (1979, 1980) due to constraints of human behaviour, in that the managers might unintentionally overlook CSFs. Davis's views led to further research on the use of explicit models and implicit models to elicit information requirements. Several other researchers have responded to Davis's comments and suggested a general approach to identify CSFs within the context of corporate planning as a way to minimise the weakness (Munro & Wheeler 1980; Munro 1983; Boynton & Zmud 1984). Hamilton and Chervany (1981a) reported the need for a performance measure for (IS). Boynton and Zmud (1984) argued that the weakness identified by Davis (1980) may largely overcome by careful planning and engaging an appropriate technique.

Munro and Wheeler (1980) analysed the process of determining information requirements for organisational control purposes by interviewing senior managers in a training seminar:

1. *to understand the business unit objectives*;
2. *to identify the CSF*;
3. *to identify the performance measures and standards for each CSF*;
4. *to identify data required to measure performance; and*
5. *to identify decisions and information required for implementing the business plan.*

Munro and Wheeler (1980) concluded that the CSF method and the performance measures and standards for each CSF help managers by providing the required management information.

Ginzberg (1981) identified the management approaches that can increase the effectiveness of the IS development process as follows:

1. *identification of those variables that are both especially important to the success of IS development and controllable by the users or IS designers; and*
2. *management of the development process of the IS designers and users by utilising the development tools and procedures.*

Rockart (1982) identified the CSFs from nine IS executives, and found that CSFs differed from one company to another. Rockart concluded that the CSFs can be grouped as a set of generic CSFs as follows:

1. *the IS service for the operations and development*;
2. *the communication between users and IS staff*;
3. *the IS human resources; and*
4. *repositioning the IS functions.*

Martin (1982a, 1982b) interviewed the chief information officers (CIO) of a number of business and government departments, and found the following factors to be critical to the success of IS:

1. *the development of human resources*;
2. *the management control of IS organisation*;
3. *the systems development*;
4. *the data processing operations*;
5. *the support of the organisation objectives*;
6. *the priorities of the parent organisation; and*
7. *the relationships with the management of the parent organisation.*

Munro (1983) examined articles of both Rockart (1982) and Martin (1982b) in detail and concluded that the results from both studies are interrelated and that the CSF methods are reasonable and the CSF approach is also a reliable technique. Munro (1983) also stressed that unless the interviewers are quite skilful, the CSF approach could not be completely free from the bias. These findings were also examined and

supported by Boynton and Zmud (1984) in that unless the interviewer is skilful, the CSF approach could be challenging.

A number of studies attempted to offer structural designs which would overcome the weaknesses attributed to CSFs by Boynton and Zmud (1984), and apply the concept to a number of areas, such as information requirement and planning as Boynton and Zmud suggested (1984). According to Boynton and Zmud (1984) CSF method has been cited for weaknesses in three principal areas:

1. *It has been asserted that the CSF method is difficult to use and is, therefore, not appropriate for organisations whose analysts do not possess the capability to successfully apply the method.*

2. *The validity of the CSF method has been questioned because of the threat of analyst and manager bias introduced through the interview process. However, Munro's (1983) study showed that two independent CSF analyses yielded comparable results, thus indicating that these potential biases can be overcome.*

3. Lastly, *Davis (1979) raised several concerns regarding the applicability of the CSF method as an appropriate requirements analysis methodology.*

The analysis of Boynton and Zmud (1984) suggests several guidelines on where, when and how to use CSFs. They concluded that CSFs are flexible and do not require a rigorous format in their use of interpretation. The following six guidelines are intended to direct an effective application of the CSF method (Boynton & Zmud 1984):

1. *CSFs are an excellent tool for information resource planning. The CSF method seems particularly useful for organisations considering a more aggressive information technology posture, as identified CSFs locate key business thrusts. CSFs are also very useful in prioritising potential*

information system projects by identifying those information services that address critical organisational concerns.

2. *When attempting to translate CSFs into specific information needs for a manager, except for a small cadre of top managers, the use of a prototype is recommended as a means of product development.*

3. *The individual managing the CSF effort should have a thorough understanding of the organisation or should, at least, be literate in the organisation's principal area of business. The analyst must manage this dialogue if it is to be successful.*

4. *Because it is desirable to access managers throughout the organisation in some CSF projects, it is useful to identify and cultivate a senior-level manager to champion the project.*

5. *It is preferable not to make an overt attempt to identify CSFs with information technology when conducting interview.*

6. *Planning efforts can be enhanced by conducting CSF interviews on multiple levels of the organisational hierarchy. However the analysts should not expect individuals throughout an organisation to readily relate to the CSF concept.*

Boynton and Zmud (1984) concluded that the weaknesses attached to CSFs can be largely overcome through a careful application of the CSF method, and the CSF method has numerous strengths. They also concluded that if the method is applied correctly, reliability should not be a problem with CSFs. Alongside and complementing the work on success factors is the body of work on IS failure (Sauer et al. 1993; Keil 1995; Sauer Southon & Dampney 1997; Lyytinen & Mathiassen 1998; Lyytinen & Robey 1999; Irani et al. 2001; Lemon et al. 2002).

Wetherbe and Leitheiser (1985) found that the most important CSFs for IS implementations are as follows:

1. *competent staff*;
2. *communication with the users*;
3. *top management support*;
4. *co-ordination of end-user computing*;
5. *facilitation of end-user computing*;
6. *role clarity*;
7. *commitment to the information centre concept; and*
8. *quality of information centre support services.*

Reliability is a quantifiable measure useful in the control and management of IS. It provides an early warning about the quality of the IS, and identifies the areas where trouble lies (Zahedi 1987). CSFs vary in nature and quantifiability. For those critical factors which have quantifiable performance and standard measures, one can combine such measures to arrive at the reliability of the factor (Zahedi 1987). Zahedi (1987) presented a model for formalising the reliability measure of the information system by synthesising the CSFs and system reliability concepts. It was argued that CSFs may have double significance. That is, if these factors are crucial for the success of the system, then their failure would lead to the failure of the information system (Zahedi 1987). The reliability measure derived in the research work of Zahedi (1987) contains the simplifying assumptions of probability independence of compounds.

Slagle and Wick (1988) listed the CSFs for the development of IS technology as follows:

1. *user involvement and agreement that the system has high payoff value*;
2. *the presence of a champion capable of promoting and defending the system in*

the institutional environment;

3. *the availability of a co-operative expert*;
4. *a high degree of management commitment to the systems development*;
5. *system utilisation and maintenance*;
6. *user commitment to learn how to use the system; and*
7. *user commitment to generate suggestions for continual improvement.*

Raghunathan et al. (1989) found the following CSFs using a sample of 1,000 randomly selected IS executives with a 20 percent response rate:

1. *the relationship with and support of the objectives of the organisation*;
2. *the development of human resources*;
3. *the data processing operations*;
4. *the management control of IS organisations*;
5. *the performance measurements; and*
6. *the development of information systems.*

Hylas et al. (1989) reported the following success factors for IS implementation:

1. *a good candidate for the IS implementation is the application of a single department or user group*;
2. *the user departments should participate in implementation projects*;
3. *the strong senior management involvement is needed to sponsor the IS implementation*;
4. *the business professionals should be trained to develop and maintain their own implemented systems; and*
5. *the active and continued support of the IS department is essential.*

Hylas et al. (1989) concluded that organisations can face problems during the IS implementation if no senior executive were especially assigned to develop and maintain the IS implementation.

Klein (1990) reported the biggest implementation obstacles that are to be avoided for an effective and successful IS implementation as follows:

1. *no management commitment*;
2. *inadequate understanding of the existing IT infrastructure*;
3. *inappropriate organisational structure and resources*;
4. *trying too much too quickly; and*
5. *no controlling framework or infrastructure.*

Later Klein (1991) reported that IS implementation decisions should be based on an application-by-application basis, not on a political basis, and that IS implementations should take into account the following factors:

1. *the involvement of senior management and line management*;
2. *responsiveness to change*;
3. *the IS strategy*;
4. *user satisfaction*;
5. *the technical background of users and IS staff*;
6. *the response time*;
7. *the database size and access requirement*;
8. *the number of users*;
9. *the development costs*;
10. *the competitive benefits; and*
11. *the development flexibility.*

Dagenais (1991) identified the critical issues for the success of IS implementation as follows:

1. *a cost-effective analysis is conducted*;
2. *the appropriate hardware to assure the adequate response time and system performance is selected*;
3. *the chosen software can be implemented on the hardware platform or can be*

developed within a reasonable time at an acceptable cost;

4. *the users and IS staff understand the implemented system*;
5. *the standards and constraints on the IS management are defined*;
6. *implementation objectives are defined*;
7. *the appropriate applications for implementation are selected; and*
8. *IS implementation issues such as the system development life cycle concepts are dealt with.*

Radding (1992) examined more than ten US firms that implemented the IS projects, and found that these firms faced the following implementation issues:

1. *people*;
2. *application development*;
3. *administration*;
4. *integration; and*
5. *networking*.

Fosdick (1992) suggested the following approaches to avoid the pitfalls of IS implementation:

1. *research and maintain compatibility issues carefully*;
2. *handle the organisational issues up front; and*
3. *understand the business problem that the application is supposed to solve*.

Soliman (1997) listed the main elements of the successful information system as follows:

1. *the selection of a suitable problem domain*;
2. *realistic expectations of what the system can and should do*;
3. *the unwavering commitment and support of top management for the IS technology; and*

4. *thorough testing of the product before integrating it into the operational environment.*

He argued that taking shortcuts in satisfying any of these elements could lead to the product failure.

Based on the strengths of the CSF research approach mentioned above and methods for dealing with critical comments, there appears to be some confidence and support for obtaining CSFs for SAN implementation.

4.4 Implementation Success

DeLone and McLean's model (1992) is one of the most referenced frameworks related to implementation success. The paper incorporates six main success factors as measurements for success. The study included an analysis of the literature in connection with practitioners' and academics' views on information system success and how it was achieved. The authors found that there is no one measure in order to view an information system success and thus developed six different factors.

The six success categories identified are as follows:

1. *system quality*;
2. *information quality*;
3. *system usage*;
4. *user satisfaction*;
5. *individual impact; and*
6. *organisational impact.*

System quality concerns the desired characteristics of the system itself which produces the information, while information quality stresses characteristics of the information and its desired form (DeLone & McLean 1992). Systems usage and user

satisfaction were found relevant from studies that attempted to analyse and measure the interaction of the information product with its recipients. The individual impact factor relates to what influence the information product has on management decisions. Finally, the organisational impact factor derives from research that has investigated the effect of the information product on organisational performance.

The relationships between system quality and information quality are such that they singularly and jointly affect both use and user satisfaction. The amount of use can influence the degree of user satisfaction and vice versa. Use and user satisfaction offer the background to individual impact, and this individual impact was found to eventually have some organisational impact (DeLone & McLean 1992). It is worthwhile to note that DeLone and McLean's (IS) model (1992) shows the actual dependencies between the relationships of the different success factors as well as recognising and grouping the factors into categories.

4.5 Selection of the SAN System (Hardware, Software and Network)

Borthick and Scheiner (1988) applied factor analysis to aggregate hardware attributes from Datapro Report on Minicomputers into three factors:

1. *satisfaction of met expectations, recommend to user expectations others, ease of conversion, reliability of manufacturer's application programs;*
2. *user's perceived user education, software on schedule, competence with system user documentation; and*
3. *constraints on program and data compatibility effective operations problems, late delivery problems.*

According to Borthick and Scheiner (1988), many system attributes could affect a manager's evaluations of an information system. As the discussion immediately following will indicate, the literature suggests five interrelated attributes as being key:

1. *importance of the system to the business unit*;
2. *investment in the system*;
3. *technical quality of the system*;
4. *level of use of the system; and*
5. *perceived management value of the system.*

The importance of a system for assisting the business unit in meeting its goals is a key attribute of any system. A system is more likely to be perceived as important if it is aligned (Earl 1989; Floyd & Wooldridge 1990; Broadbent & Weill 1993; Henderson & Venkatraman 1993) with the business goals of the business unit. How important a system is to the business has been suggested to be one of the factors that determine how much will be invested in the system and how often it is used.

According to Weill (1999), the technical quality of each system is a multifaceted construct designed to capture how the system performs from a technical perspective. Weill (1999) identified six aspects of technical quality as follows:

1. *Source Code Quality. How easily the source code can be understood and maintained is fundamental to a system's technical quality (Sprauge & McNurlin 1986, p. 217).*

2. *Data Quality and Reliability. The degree to which its data is accurate (Ives et al. 1980), reliable (Davis & Olson 1985, p. 604), and current (Kim 1986) is fundamental to a system's technical quality.*

3. *System Reliability. How well a system performs its expected function is partly dependent on its reliability (Perry 1992). Reliability, an important component of technical quality (Kim 1986), encompasses response time, uptime and availability (Alter 1992, p. 66).*

4. *Ease of Use. Ease of learning and use of a system is a fundamental aspect of its technical quality (Davis & Olson 1985). How easy it is for a new user to become proficient depends on a number of design issues including the help facilities, menus, user documentation, screen prompts (Burch & Grudnitski 1989, p. 262) and the general system complexity (Alter 1992, p. 67).*

5. *Output Quality. Screen-based and printed output is often the major product of an information system, and its quality and understandability (Srinivasan 1985; Burch 1992, p. 279) are vital.*

6. *Portability. Lack of compatibility with other systems is a major cause of problems in the technical quality of information systems (Alter 1992, p. 69). The extent to which the systems were portable (Perry 1992) was assessed during this study.*

The importance of acquiring the right system and expertise has been highlighted by Gable (1989, 1991) and Kole (1983). Previous researchers (Yap et al. 1992) have also provided empirical evidence of positive relationships between IS effectiveness and the level of consultant effectiveness. Selection of suitable computer hardware, software and infrastructure is an important factor in implementation of IS. The importance of good vendor support has been highlighted by Farhoomand & Hrycyk (1985), Garris & Burch (1983) and Heintz (1981). There is also empirical evidence that IS effectiveness is significantly associated with good vendor support (Wong 1986; Lees 1987; Yap et al. 1992). The duties of a vendor generally include providing the computer hardware, software packages, technical support and users training.

A review of vendor support literature (Wong 1986; Lees 1987; Lucas et al. 1988; Heikkila et al. 1991; Yap et al. 1992) reveals the following important attributes of vendor support:

1. *adequacy of technical support during IS implementation;*
2. *adequacy of technical support after IS implementation;*
3. *quality of technical support;*
4. *adequacy of training provided;*
5. *quality of training provided; and*
6. *relationship with other parties in the IS implementation project.*

Lucas et al. (1988) found that although active vendor support during systems installation was highly correlated with satisfaction variables, vendor support after installation was even more highly correlated with satisfaction variables.

4.6 Organisations' Technical Support and Technological Competence

The main function of a technical support department is to provide sufficient and necessary technical support, trouble shooting and training on both hardware and software within the organisation. According to Mougayar (1997), education is the key for successful implementation, when all employees and managers are well trained and informed of the implementation.

Other studies by Magal et al. (1988) also found that a more efficient support could be provided by technical staff if they have a better understanding of the user's business and problems. Their study produced a consolidated list of 26 CSFs relevant for Information Centres (IC), and categorised IC by staff, size, user group size, IC age and type of hardware supported. Of these, the three most important as determined by the mean ratings were a competent staff, communication with the users, and top management support. Their study indicates a clear association between organisations' technical support and implementation success.

The 26 CSFs variables applicable to IC according to Magal et al. (1988) are as follows:

1. control procedures to ensure standards, policies, etc are adhere;
2. competent staff;
3. support right software packages;
4. end-user training;
5. monitoring and coordination of end-user applications development;
6. top management support;
7. response to applications requests;
8. promotion IC services;
9. communication with users;
10. cost-effective solutions;
11. atmosphere for users;
12. system performance;
13. understanding of users' business and problems;
14. organisational acceptance of IC concept;
15. management of end-user expectations;
16. provision of services to distributed sites;
17. definition of IC mission;
18. users' understanding of data processing;
19. reliability of applications developed;
20. commitment of end users to the IC concept;
21. career paths for IC staff;
22. priority criteria for work;
23. charge back criterion;
24. standardised hardware and software;
25. training for IC staff; and
26. liaison function with end-user departments.

According to Raymond (1990), smaller firms look to external sources for technical support, such as small business consulting centres operated by government agencies,

universities or computer vendors. They could potentially rely on the same external sources for training. Consultants and vendors provide consultancy services specifically to help small firms successfully introduce and implement information systems. They can assist in analysing requirements, selecting the hardware and software, user training, technical support and project management.

Gable (1991) and Kole (1983) found that the experience and capabilities of the consultants played an important role in IS success in small firms. Raymond and Bergeron (1992) also proposed that personal computing success could be determined by the support provided by external sources. This was empirically supported by Yap et al. (1992), who found that IS success was positively associated with the level of vendor support, including training and technical support, given to small firms. Thong et al. (1993) concluded that the level of IS effectiveness was higher in firms with a high level of vendor support than those with a low level of vendor support. They concluded that smaller firms with external support, mainly consultants, had higher levels of system success.

4.7 Management Commitment and Support

In recent decades, there has been a considerable research focus on top-management behaviour. Traditionally, the top-management involvement has been stressed as an important determinant of success (Bass 1990), although some writers have questioned the direct correlation between management involvement and outcome variables (Anderson 1994). According to Beer et al. (1990) it is usually enough if top-management approves the changes and that has a positive outcome on the implementation. However, depending on the implementation, top management involvement may not always be essential in the implementation process.

Management commitment and support refer to the extent to which information technology implementation efforts are promoted by the top management in an organisation (Rai & Bajwa 1997). Top management support is a widely accepted CSF in the MIS literature. As Jarvenpaa and Ives (1991, p. 205) stated, "few

nostrums have been prescribed so religiously and ignored as regularly as executive support in the development and implementation of management information systems". Past innovation studies have also reported a positive association between top management support and observed innovation behaviour in organisations (Kimberly & Evanisko 1981; Meyer & Goes 1988; Rai & Bajwa 1997).

The CSF literature recognises top management support as an important factor for ensuring implementation success (Brown & Vessey 1999; Davenport 2000; Esteves & Pastor 2000; Nah et al. 2001; Smyth 2001; Dong 2001; Al-Mashari 2003). From an historical perspective, the IS management literature has also reinforced the importance of top management support (Schein 1992; Bassellier & Reich 2001). Equally, IS implementation literature (Ginzberg 1981) and general top management literature (Finkelstein & Hambrick 1996; Hambrick & Mason 1984) recognise its importance.

If the top management become aware of technical problems associated with SAN implementation well in advance, they would be in a better position to understand issues and assist in avoiding some of the pitfalls associated during SAN implementation.

The evidence in the literature suggests that top management commitment and support are critical to the success of system implementation (Vollman et al. 1992, p. 410). Without such support and commitment to invest in the implementation of SAN system, it is impractical for SANs projects to be approved. Top management support is essential to develop confidence and respect for the implementation team (Hoopes 1995).

According to the findings of Magal et al. (1988) one of the three most important CSFs as determined by the mean ratings was the top management support of the implementation. Top management IT knowledge was one of the nine IT implementation success variables presented by DeLone (1988).

Other researchers such as Abdul-Gader (1990) stated that one of five profiles needed for the success of IT applications in organisations is the "Top management involvement in IT implementation system".

4.8 Communications and Training

According to Abdul-Gader (1990), an '*extensive user training program*' is one of the key areas in which it guarantees for success of IT applications in organisations. Prakash (1996) and Laudon and Laudon (1997) have stated that there is a high demand to train employees on a regular basis, as the result would have significant impact on implementation success.

Nath (1989) conducted research on "*associations between user training and Information Systems success*". Data were collected from 98 IS users in 16 different departments of 12 organisations. The results indicate that there exist positive associations between the various types of computer-related training/educational programs an organisation provides to IS users and the perceived success of IS. Specifically, the availability of a resident computer expert in the organisational functional area of users has the most significant positive relationship with success.

Brady (1967) noted that with adequate computer training for middle and top managers, computers could positively affect the organisation. Empirical research by Benson (1983) and Rockart and Flannery (1983) also indicated the strong need for computer-related training for end-users. According to Rockart and Flannery (1983), IS policies in areas such as computer-related education needed strengthening. According to Nelson and Chaney (1987), "... managers do not feel they possess the necessary computer skills to do their jobs effectively".

The analysis shows that the availability of a resident expert within the functional area to help users has the strongest positive association with success. This supports the findings reported by Nelson and Chaney (1987). By studying a sample of 100 end

users in 20 firms, these researchers reported that the most frequent and effective form of training came from the availability of resident experts (Nelson & Chaney 1987).

4.9 Users' Appreciation

Users of the SAN system will be more satisfied and appreciate the system if they have a good knowledge understanding of the system. The feeling of being in control has been found to lead to increased self-efficacy beliefs (Gist et al. 1992; Tafarodi, Milne & Smith 1999), less stress (Amirkhan 1998), and higher satisfaction (Judge, et l. 2000). Lack of control, however, produces stress and lower perceived competency (Amirkhan 1998; Judge et al. 2000).

The concept of user satisfaction is relatively direct and rooted in the works of Cyert and March (1963), who suggested that if an IS/IT met the needs of users, the system would produce user satisfaction.

Empirical research has found a positive relationship between user satisfaction with an information system and the system's overall success. For example, Swanson (1974) found a relationship between a user's appreciation of a system and the user's utilisation of the system's outputs.

The underlying assumption is that if users are not satisfied with a system, it is not an effective system. Conversely, an information system will be considered effective in meeting users' needs if these users are satisfied. Powers and Dickson (1974) concluded that user satisfaction was the most critical factor for system success. It is also argued that user satisfaction is an indicator of system usage and effectiveness (Baroudi et al. 1988; Igbaria & Nachman 1990).

According to other researchers the importance of user participation in a system's implementation has been widely recognised in the literature (Ives & Olson 1984; Kappelman & McLean 1991).

Employee involvement is a broad concept that encompasses a wide scope of practices. It is taken here to be "the exercise, by employees of influence over how their work is organised and carried out" (Fenton-O'Creevy 2001, p. 28).

Table 4.1: Relationship between user participation and user satisfaction by other researchers

User participation		
Improve system quality	Improve systems quality	Ives and Olson (1984)
	Provide a more accurate and complete assessment of user information requirements	Norton and McFarlan (1975); Robey and Farrow (1982)
	Provide expertise to the organisation	Lucas (1981)
	Avoid development of unimportant features	Robey and Farrow (1982)
	Improve user understanding of the system	Lucas (1981); Robey and Farrow (1982)
Increase user acceptance of systems	Develop realistic expectations about system capabilities	Gibson (1977)
	Provide an arena for bargaining and conflict resolution about design issues	Keen (1981)
	Foster system ownership by users	Robey and Farrow (1982)
	Decrease user resistance to change	Lucas (1981)
	Commitment of users to the system	Lucas (1981); Markus (1983)

User satisfaction helps to produce system utilisation, which helps to produce desirable results. Ives et al. (1983) stated that user information satisfaction is not simply an objective measure of the technical quality of a system, but rather measures how users perceive the system. Ives et al. (1983) held that if system users regard a 'technically good system' as being poor, then it is effectively a poor system.

4.10 System Performance and Effectiveness

This study, therefore, tries to combine previously published IT/IS implementation-related research studies with a very limited number of SAN-related publications in order to incorporate the CSFs of SAN implementation model.

To evaluate an information system's success, one should measure systems performance and effectiveness. Organisations have come to rely on technological innovations as a central component of their competitive strategy (Reddy 1990). While new technologies (i.e. SAN) hold tremendous promise for enhancing an organisation's efficiency and effectiveness, much of this potential is never realised (Kwon & Zmud 1987).

According to Lucas (1981) and Zmud (1983) the successful implementation of IS in organisations remained a challenge. The problems involved were accentuated by numerous past IS implementation failures.

Broader models of implementation focus on the problematic human and organisational components of technology implementation success (Griffith & Northcraft 1993). Zmud (1979) suggested that research should examine system usage, user satisfaction and user performance for IT/IS success. He also suggested that organisational factors, such as management's support, decisions performance, personal and interpersonal characteristics, users' attitude and IT/IS staff characteristics as well as policies, influence the success of system implementation.

In a field study, Ginzberg (1981) concluded that "there is degree of realism of user's pre-implementation expectations which is positively correlated to success ... of both attitudinal and behavioural". In his study he then examined the IT/IS manager's view in relation to implementation success. As a result of his study, this research will examine IT/IS managers' input. Ginzberg suggested viewing the development process as three major stages and eight sub-stages. Others have suggested different numbers of stages. However, the specific number is of little importance. The stages are outlined in table 4.2. Definition of stages focuses on what the new system will do and how it will look to the user.

Table 4.2: Davis's outline of stages and sub-stages

STAGES	SUB-STAGES
Definition stage:	Feasibility assessment Information analysis
Physical stage:	System design Program development Procedure development
Implementation stage:	Conversion Operation and maintenance Post audit

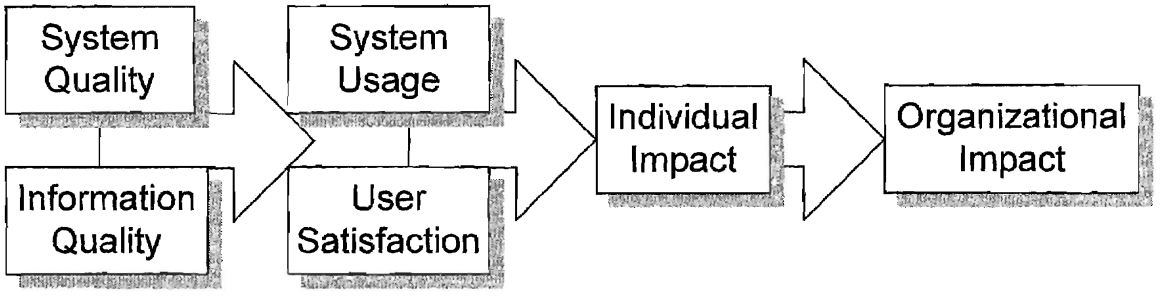
The purpose of Ginzberg's (1981) study was the initial exploration of MIS user pre-implementation expectations, to determine if they could serve as the basis for a tool to help guide and manage the MIS development process. The result of the study is quite encouraging. The degree of realism of users' pre-implementation expectations was positively correlated with a range of project success, both attitudinal and behavioural. Further, while some other pre-implementation measures were correlated with attitudinal measures of project outcome, they were not highly correlated with the behavioural measure of system usage. The results of this study also suggest that user management and system development personnel who played an active role during system definition can provide the benchmark expectations against which the realism of users' expectations can be judged.

Yaverbaum (1988) researched the importance of the factors affecting end-users. These factors were organisational factors (management support, management activity and training programs) and user factors (cognitive differences, users' characteristics [attitude, age, past training, education, job experience] and user participation) affecting user satisfaction, and are crucial to the success of information systems. The study did not refute prior research, but rather added to it by analysing the motivating potential of a task and job satisfaction, and by identifying places where improvement is needed. The approach used provides a convenient method for focusing on end-user problems. The results support Zmud's (1979).

DeLone and McLean's model (1992) is one of the most referenced frameworks related to implementation success. The paper incorporates six main success factors as measurements for success. Their study (DeLone & McLean 1992) included an analysis of the literature in connection with practitioners' and academics' views on information system success and how it was achieved. The authors found that there is no one measure of information system success, and thus they developed six different factors:

- system quality;
- information quality;
- system usage;
- user satisfaction;
- individual impact; and
- organisational impact.

Figure 4.1: IS Success Model Adapted from DeLone and McLean (1992)



This model has been found to be very relevant to IS researchers (Bowtell et al. 1999), and with a selected mix of SAN success factors, this IS success model will be a basis for the proposed theoretical framework adapted.

In reviewing 180 empirical studies (articles) during the period 1981-1987, DeLone and McLean (1992) identified 16 different empirical measures of system quality, 18 measures of information quality, 32 measures of system usage, 32 measures of user satisfaction, 47 measures of individual impact, and 25 measures of organisational impact.

The model above was developed so that the authors (DeLone & McLean 1992) could 'predict' future IS success and analyse the diverse research previously conducted on IS success to show their compatibility.

The study Li (1997) undertook was on IS success factors, indicated by ISS. His study revealed that the rankings of ISS factors between IS staff and IS managers and between user staff and user managers were not significantly different. However, the rankings of IS personnel and user personnel were significantly different. Based on these, the most and the least important ISS factors are identified. The top five important ISS factors indicated by the IS managers are:

- accuracy of output;
- reliability of output;
- relationship between users and the IS staff;
- users' confidence in the systems; and
- timeliness of output.

4.11 Information Requirements

Organisations situations will change form time to time, and factors that are dealt with by executives as commonplace at one time may become CSFs at another time. According to Rockart (1982) the key is "for the executive to clearly define at any point in time exactly those factors that are crucial to the success of his particular organisation in the period for which he is planning". The four generic CSFs identified by IT/IS executives are summarised as follows:

1. service;
2. communication between users and IT/IS staff;
3. IT/IS human resources;
4. re-positioning the IT/IS function;
    - technical;
    - organisational;
    - psychological; and

- IT/IS managerial.

Ferguson and Dickinson (1982) suggested the following seven CSF for directors:

1. the need to improve productivity;
2. the need to make better use of resources;
3. the need to improve the product or the product line;
4. the need to strengthen and develop management;
5. the need to be more attractive to lenders and inventors;
6. the need to increase the value added; and
7. the need to become less vulnerable to inflation.

Martin's (1982b) analyses led him to identify the following CSFs, which characterise most MIS/DP organisations. In other words, if typical MIS/DP organisations are to be successful, things must go well in the following areas:

1. system development (reliable, timely and cost-effective application systems);
2. data processing operations;
3. human resources development;
4. management control of the IT/IS;
5. relationships with the management of the parent organisation;
6. support of the objectives and priorities of the parent organisation; and
7. management of change.

4.12 Users' Appreciation and Satisfaction

The evaluation of tangible benefits associated with User-Developed Applications (UDA) services is a critical issue for IT/IS managers. There is a positive relationship between user involvements and IS implementation success (Rivard & Huff 1984; Ives & Olson 1984).

However, other studies indicate that the end-user has become crucial to the success or failure of a system. Franz and Robey (1987) defined user involvement as "the amount of users' perceived influence during the design and implementation stage".

Rivard and Huff (1988) in a follow-up study reported CSFs for end-user computing via a two-phase study based on their 1984 study. They had a 25 percent response rate to their questionnaire survey. The following CSFs were found:

- quality of IT/IS support
- user satisfaction with support from IT/IS;
- user satisfaction with environmental set-up;
- perception of user friendliness of software tools; and
- users' attitudes.

In order to find potential factors for End-User Computing (EUC) success, Bergeron et al. (1993) reviewed 67 studies and judged 30 questionnaire items from these articles. A return of 263 questionnaires represented a response rate of 14.3% for individuals and 19.7% for organisations. Using a factor analysis with varimax rotation, the 30 success variables that were investigated can be merged into five factors. These five success factors, listed in order of decreasing importance, are:

- organisational effectiveness;
- user appreciation;
- efficiency of applications;
- quality of applications; and
- adequacy of applications.

Table 4.3: Dimensions and Factors for User Involvement Measurement (after Bergeron et al. 1993)

Description of factors	
Organisational Effectiveness:	***Efficiency of Application:***
1. Increase in the quality of decision making	1. More work accomplishment by users
2. Improvement in the decision-making quality	2. Time savings
3. Improvement in organisational performance	3. Reduction in users' work effort
4. Improvement in organisational effectiveness	4. Cost-benefits of applications
5. Attainment of organisational objectives	5. Low cost applications
	6. Cost effectiveness of EUC as compared to other possibilities
Adequacy of Applications:	7. Savings in the development of applications by users
1. User autonomy	8. Effective execution of tasks
2. Balance between local autonomy of applications and their integration to organisational systems	
3. Competitive advantage	***User Appreciation:***
4. Information systems applied to major organisational problems	1. Quicker access to information
	2. Easier access to information
	3. User satisfaction
Quality of Application:	4. Increase in the quality of information
1. No data redundancy	5. Increase in the use of existing information systems
2. No duplication of applications	6. Better communication capacity
3. Quality of information	7. Increase in data processing capacity
4. Quality of user database	8. Efficient use of tools by the users
5. Error free applications	

CHAPTER 5

RESEARCH METHODOLOGY

To address the research problem mentioned, the researcher reviewed the literature extensively, as shown in chapter 4, for the appropriate CSFs and research instrument to be used in this study. As there is no published work found on CSFs of SAN implementation in the literature at the time of this study, the proposed research model uses most relevant CSF studies in the field of information systems IT/IS. Papers on the CSFs that were consulted include Rockart (1982), Martin (1982b), Miller et al. (1987), McCredie & Updegrove (1999), Gide (1999), Kuang et al. (2001) and Nelson & Somers (2001).

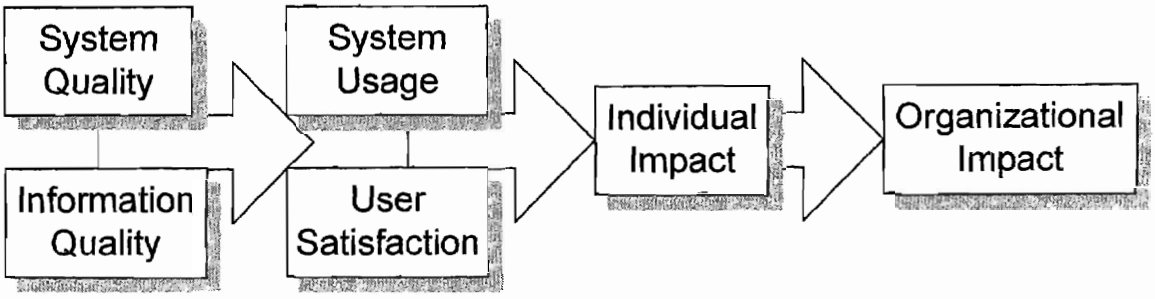
5.1 Theoretical Framework

As there have not been any surveys published attempting to link the use of SAN-based systems with the performance of organisations, a new approach for establishing guidelines for constructing the research instrument needs to be identified.

The development of a theoretical framework is part of the research strategy that the researcher has adopted. The proposed framework has been formed by merging three theoretical perspectives: DeLone & McLean's (1992) model of IS success, Eldon Y. Li's (1997) perception of the importance of IS success factors and Drury and Farhoomand's (1999) hierarchical structural model of IS success. Other papers consulted were Croteau et al. (2003) on critical success factors of CRM technological initiatives, Soliman et al. (2001) on critical success factors of implementation of CAD/CAM in ERP environment, Nelson & Somers (2001), one of the most extensive reviews of critical success factor in ERP implementations that exists at the time of this research, and Gide's (1999) model for successful implementation of internet e-commerce in business operations.

DeLone and McLean (1992) incorporated six main factors as measurements for success. Their study includes an analysis of the literature in connection with practitioners' and academics' views on information system success and how it was achieved. The authors found that there is no 'one measure' in order to determine the success of an information system and thus developed six different factors (see figure 5.1 below) in an 'IS Success Model'.

Figure 5.1: IS Success Model Adapted from DeLone and McLean (1992)



The six success categories identified are system quality, information quality, system usage, user satisfaction, individual impact and organisational impact.

This model has been found to be very relevant to IS researchers (Bowtell et al. 1999), and with a selected mix of SAN success factors, this IS success model will be a basis for the proposed theoretical framework adapted.

In reviewing the 180 empirical studies (articles) during the period 1981-1987, DeLone and McLean (1992) identified 16 different empirical measures of system quality, 18 measures of information quality, 32 measures of system usage, 32 measures of user satisfaction, 47 measures of individual impact, and 25 measures of organisational impact.

The model above was developed so that the authors (DeLone & McLean 1992) could 'predict' future IS success and analyse the diverse research previously conducted on IS success to show their compatibility.

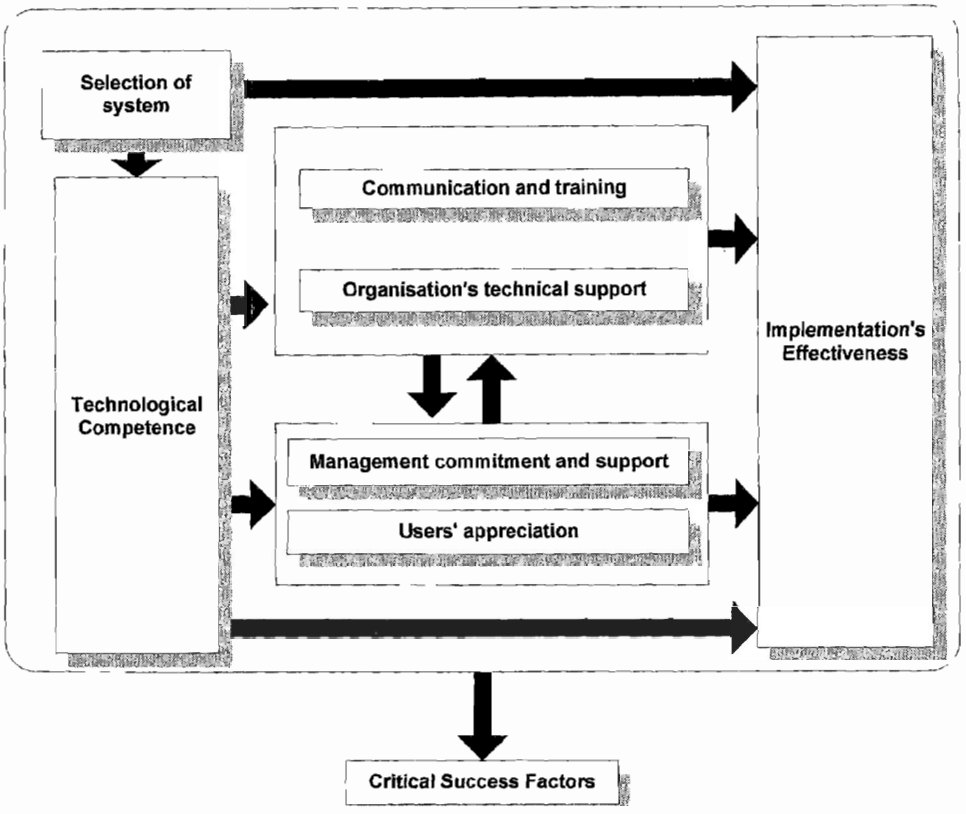
Huberman and Miles (1994) argued that a theoretical framework should be used to explain the main issues to be studied. The development of a theoretical framework is part of the research strategy that the researcher has adopted.

The framework (figure 5.2) is represented by these factors: selection of system, organisations' technical support, management commitment and support, communication and training, organisational effectiveness, users' appreciation and technological competence.

The author chose to define a boundary in this context in the same way as Reynolds and Stair (2001), where the boundary represents a limitation from the rest of the environment that the researcher will focus on. The theoretical framework offers the possibility of grouping complex issues of investigation together in a more manageable research overview.

The arrows in the framework refer to how DeLone and McLean (1992) viewed the different factors influencing each other. The researcher found it important to be aware of the relationship between the factors; thus the proposed arrows (interdependencies) are shown. CSFs are represented at the lower edge of the framework, representing the fact that all of the factors will be considered when evaluating the success factors. The figure below (figure 5.2) outlines the proposed theoretical framework developed for this research project.

Figure 5.2: Proposed Theoretical Framework



The theoretical framework was developed after an extensive literature review on existing quality frameworks and existing CSF models of IS implementations. The theoretical framework developed consists of seven factors.

The proposed theoretical framework will be used to address the existing gap in the literature. Therefore, the proposed theoretical framework will be a basis model for future research in the SAN area. The proposed framework incorporates the ideal in-built model of SAN implementation, which can also be a framework for further research and studies in this area.

Due to the newness and lack of theory and prior empirical study of CSFs for SAN implementation success, this study adopted a two-phased field research approach using focus groups to collect research data. The variables included in the model have been derived from previous CSFs studies (Rockart 1982; Martin 1982b; Magal et al. 1988; Bergeron et al. 1993; Cavaye 1995; Gide 1999) and focus groups.

Common philosophical assumptions underlie much of the IS research current at the time of this study (Baroudi & Orlikowski 1989). A number of different paradigms exist in the IS field (Fitzgerald & Howcroft 2000; O'Donovan & Roode 2002). Iivari's notion of paradigms (1991), which is based on Burrell and Morgan's work (1979), distinguished four major areas of research assumptions, namely ontology, epistemology, ethics and methodology.

5.2 Ontological Assumptions

According to Burrell and Morgan (1979), ontological assumptions deal with the nature of science and have been referred to as the subjective-objective dimension. According to Iivari (1991), the view of information/data, the view of information systems, the view of technology and the view of organisations and society are assumptions that are confined to ontological assumptions.

5.3 Epsitemological Assumptions

Epistemological assumptions mainly concern the *grounds of knowledge*. According to Burrell and Morgan (1979), the grounds of knowledge relate to how knowledge can be obtained. Other researchers such as Ivari (1991) classified epistemological assumptions into two opposite approaches:

1. positivism; and
2. anti-positivism.

5.3.1 Positivist Assumptions

Positivists believe that a final truth, even about social phenomena, can be reached through the methods of science, where science is understood as expressed in measurements. The term "positivism" derives from the belief that society will become ever more perfect as a result of advances in science, including the social sciences.

5.3.2 Anti-Positivist Assumptions

The opposite of positivism is anti-positivism. Anti-positivism maintains that the social world can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied (Hirschheim & Iivari 1992).

The researcher would rather take an anti-positivist view and assume that one can only understand by researching into the individuals who are directly involved in the activities to be studied (Burrell & Morgan 1979).

5.3.3 Ethics of Research

The main ethical issues related to this research will be to maintain the confidentiality and anonymity of respondents (Frey & Fontana 1994).

5.3.4 Empirical Versus Non-Empirical

According to Schwandt (1997), empirical research involves observation, or direct fact-finding about issues (Kling 1991).

According to Alavi et al. (1990), non-empirical methods are those that focus on ideas, frameworks and speculation rather than on observation. The data utilised within this method is almost always of a secondary nature.

According to Sekaran (1992), Brittain (1992), Soar (1997), Zikmund (1997) and Gide (1999) the use of two focus groups can be an effective tool in validating and establishing guidelines for this type of research, especially if the concept under investigation is relatively new.

The researcher conducted two-step focus group discussions for reviewing issues such as the success factors and the proposed model generated from the previous literature in the area of CSFs and IT/IS.

5.4 Focus Group

A focus group of a team of academia, experts and managers/technical managers (mainly SAN-experienced) can be extremely valuable in providing guidance to the researcher. Brittain (1992), Clark (1992) and Gide (1999) used a similar approach for research. The use of a focus group in this situation is warranted for the following reasons.

1. A focus group provides a non-biased formulation of the research instrument.
2. Published results suggest that a focus group approach is an appropriate choice of research method for this type of problem (Brittain 1992; Sekaran 1992; Soar 1997; Zikmund 1997; Soliman 1997; and Gide 1999).
3. The results from this study are likely to be of wider interest, and hence a method to ensure the creditability of the outcome needs to employed. The use of an independent, non-biased focus group with industry experience as well as academia will enhance the creditability of the outcome.
4. There is no published research on this topic, and hence a focus group is likely to provide the guidance and in-depth analysis that are not found in the literature.

5.5 The Role of the Researcher

Although the researcher planned the research design and instrument and organised the meetings, the researcher did not take part in the focus group discussions. In this case the role of the researcher in relation to the focus group was that of observer. The researcher collected views of the members in the brainstorming sessions of the focus group. The researcher made efforts to counter potential bias and/or the Hawthorn Effect (Soar 1997).

5.6 Research Model

Since there has been no published work found on CSFs for SAN implementation in the literature at the time of this study, the proposed research model uses some of the

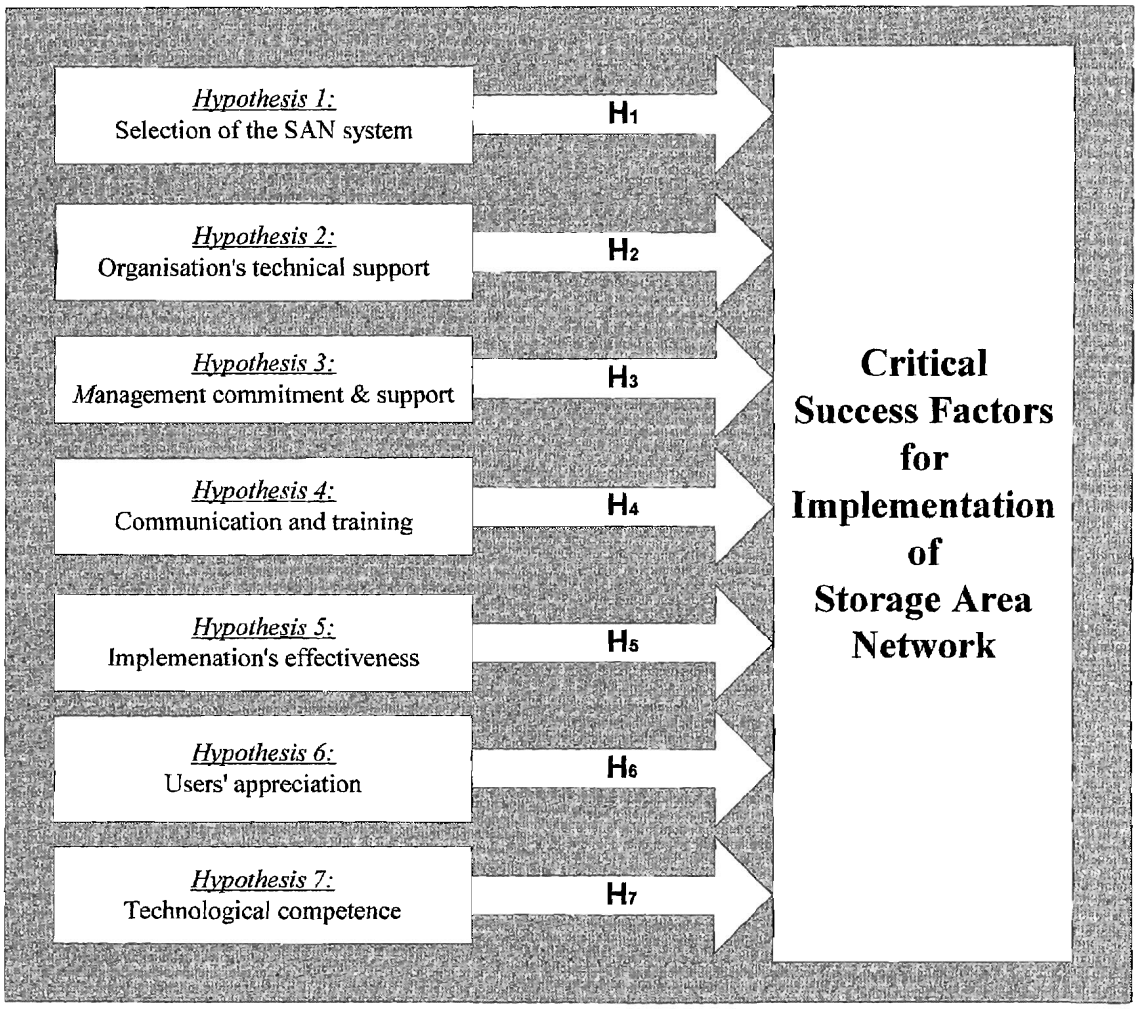
important, well-known and internationally recognised previous CSF studies in information systems (IS). Papers on CSFs study which were consulted were Rockart (1982), Martin (1982b), Miller and Doyle (1987), McCredie and Updegrove (1999), Gide (1999), Kuang et al. (2001) and Nelson and Somers (2001).

In this study, seven sets of hypotheses that are likely to impact on the success or otherwise of SAN implementation are identified. The independent variables were selected from various IT/IS related literature.

The hypothesised factors are briefly as follows:

1. selection of the SAN system (hardware, software and network);
2. organisation's technical support;
3. management commitment and support;
4. communication and training;
5. implementation's effectiveness;
6. users' appreciation; and
7. technological competence.

Figure 5.3: The Proposed Conceptual Research Model and Hypotheses for Successful Implementation of SAN systems



The proposed conceptual research model consisting of seven hypotheses for this research is presented in figure 5.3.

The researcher of this study adopted a research approach using two-phased focus groups to guide the research data collection. The variables included in the model have been derived from previous CSFs studies (i.e. Rockart 1982; Martin 1982b; Magal et al. 1988; Bergeron et al. 1993; Cavaye 1995; Gide 1999) and focus groups.

Two separate focus groups were formulated to assist the researcher by providing input into the model as well as questionnaires. The use of focus groups is appropriate

when the concepts being investigated are relatively new (Sekaran 1992, Zikmund 1997).

The research involved a very comprehensive review of the literature including journal articles, papers, business magazines, books, conference proceedings and emails related to IT/IS and SAN, followed by two-step focus group discussions for reviewing issues (i.e. proposed model and success factor items) generated from the previous literature by the researcher of this study.

In order to make a preliminary validation of the instrument, a pilot test was also undertaken with the second focus group participants. Morgan (1991, p. 43) recommended a range from six to eight participants for a focus group. Accordingly, eight participants were chosen for the first focus group. The participants of the focus group were from various industry sectors and consulting firms, all with a number of years of experience in SAN implementation. The selection of the members was based on their involvement in SAN implementation and expertise in the field.

The researcher acted as an observer during the two focus group meetings, as this was necessary to ensure non-bias of the research outcome. The researcher organised the meeting and designed the instruments. During the meeting, the researcher did not take part in the focus group discussion, but acted as an observer only and took notes.

The purpose of the focus group was to discuss and highlight the issues that face organisations that plan to implement SAN. The participants were informed of the purpose of the focus group before it took place. The first meeting lasted for approximately two hours. The focus group discussed various success factors in detail. Based on their discussion a research model was proposed. The ideas and comments made by the focus group were transcribed and, based on the literature review, a questionnaire was generated.

5.6.1 Scope of the First Focus Group

The first focus group was concerned with:

1. identifying the CSFs relating to IT/IS from the literature;
2. providing the researcher with an expert view on the appropriate CSFs for the implementation of the SAN system;
3. identifying which, if any, of the traditional CSFs for IT/IS should be considered for the SAN implementation;
4. established a preliminary research model that links implementation success factors;
5. identifying and examining the SAN implementation success factors;
6. identifying set of hypothesis based on the CSFs for SAN implementation; and
7. constructing the initial survey questionnaire based on the hypothesis.

5.6.2 Scope of the Second Focus Group

The second focus group was concerned with:

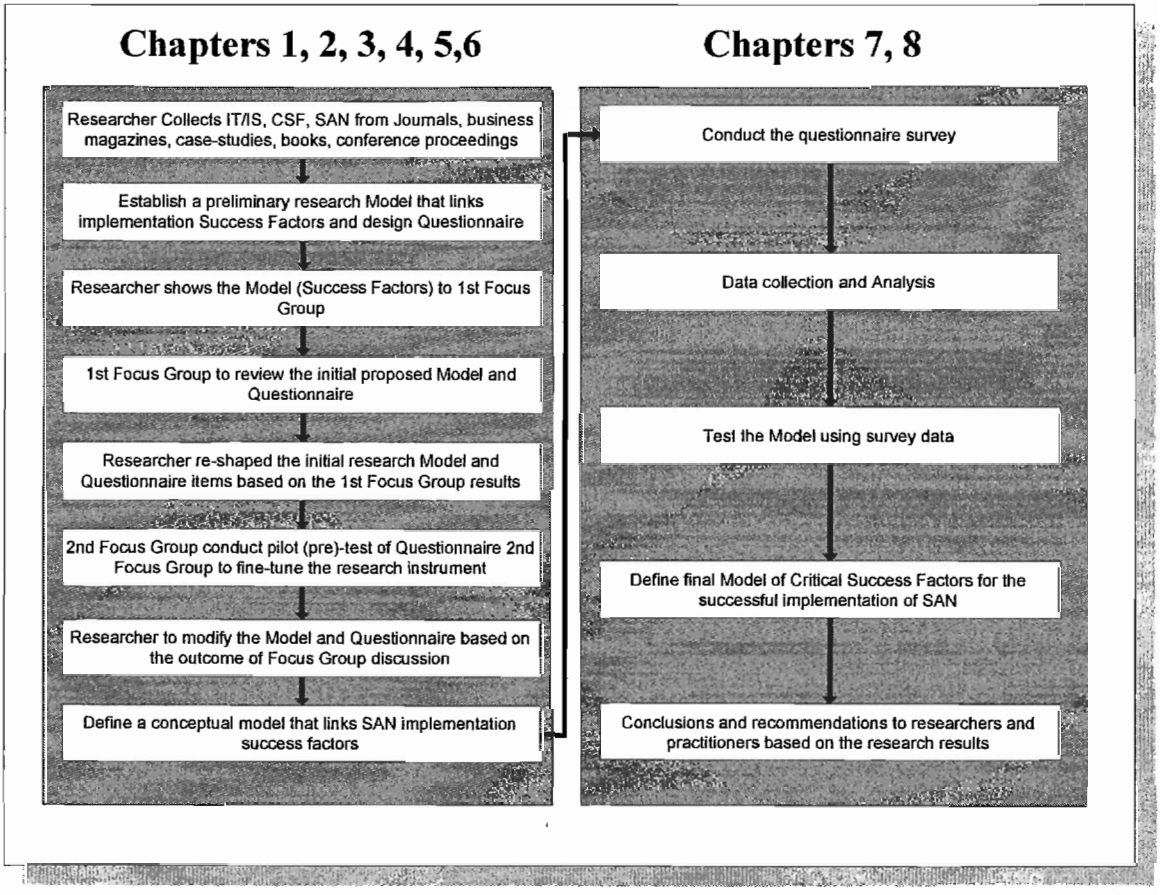
1. discussing and reshaping the survey questionnaire based on the first focus group results;
2. reviewing and criticising the set of hypotheses developed by the first focus group;
3. assessing the significance of each of the CSFs developed by the first focus group;
4. conducting a pilot-test of the survey questionnaire;
5. finetuning the research instrument;
6. defining a conceptual model that links SAN implementation success factors;
7. testing the model using survey data; and
8. identifying the CSFs for the successful implementation of SAN.

The second focus group consisted of seven participants from different industry sectors and consulting firms, all with number of years of experience in SAN

implementation. In order to avoid any possible bias, the first focus group participants were not called in to attend the second focus group meeting discussions. The preliminary survey questionnaire was distributed to the second focus group members prior to the meeting. The participants were given enough time to review the questionnaire so that they could provide constructive feedback during the meeting. The second focus group conducted a pilot test of the survey questionnaire first. The participants then finetuned the survey questionnaire.

The second focus group meeting lasted for about four hours. The recommendations and their feedback were incorporated into the survey questionnaire.

Figure 5.4: Step-by-step Research Study



In order to protect the respondents' privacy, it was decided to send the survey by mail. A covering letter with instructions explained that the respondents should not

write any of their details on the questionnaire so that the respondents would remain anonymous.

The designed instrument should have taken less than 20 minutes to complete. As an incentive to complete the questionnaire, a copy of the results from the survey were also offered to the respondents upon their request.

5.7 Questionnaire Design

The questionnaire design was based on the research model described above which employed selected appropriate CSF items from Rockart (1982), Martin (1982b), Magal et al. (1988), Bergeron et al. (1993), Gide (1999) and other important studies related to IS implementation success.

Consistency of the attributes was achieved by dividing the instrument into different sections, and special attention was paid to validity and linearity issues during the design and testing stages of the instrument development. Likert scales (1-7) were used to measure the criticality of different attributes, with 1 being least critical and 7 representing maximum criticality. This scale is frequently used for measuring people's opinions (Han & Noh 2000; Usoro 1999) and opinions are what this instrument set out to measure.

This research used seven major factors, which have been discussed as the most important criteria from different dimensions of the literature.

Table 5.1: The Relationship with other CSF Studies

ROCKART's CSF	MARTIN's CSF	GIDE's CSF	THIS STUDY'S CSF
Service (operations and development)	Data Processing operations System development	E-Commerce System Application E-Commerce System Integration	Selection of SAN system (hardware, software and network)
Communications between users and IS Staff	Relationships with the management of the parent organisation	Communication, Training and Facilitation E-Commerce User Appreciation	Communication and training Users' appreciation
Human resources	Human resources development	E-Commerce Department's Service	Organisations technical support
Re-positioning the IS function ▪ Technical ▪ Organisational ▪ Psychological ▪ IS Managerial	Support of the objectives and priorities of the parent organisation Management of change -Technological Management control of the IS/DP organisation	Top Management Commitment and Support Organisational Effectiveness Technological Competence Change Management Internet/E-Commerce Security and Reliability	Management commitment and support Implementation's effectiveness Technological competence

5.8 Items of the Questionnaire

The first section of the questionnaire identified:

- how long the companies have been using the SAN; and
- the level of their satisfaction with the SAN system in e-business operations.

The second section of the questionnaire measured:

- the improvements in performance resulting from SAN implementation. These questions used a 7-point Likert-type scale for measurement.

The third section of the questionnaire measured the seven CSFs from this study:

- Each potential CSF had a general question for the purpose of validating the construct.
- These questions used a 7-point Likert-type scale for measurement

Table 5.2: Description of the Questionnaire

Questionnaire		CSF	Measurement Variables	Scale used
Section	**Question Number**			
1	1-3		Organisations' SAN level of satisfaction with SAN, number of years implemented SAN	Various scale
2	4-17		SAN implementation performance and success.	7 - point Likert-type
3	18-26	1	Selection of SAN system (hardware, software and network)	7 - point Likert-type
	27-33	2	Organisations technical support for the SAN implementation	
	34-40	3	Top management commitment and support for the SAN implementation	
	41-44	4	Communication and training	
	45-50	5	Organisational effectiveness	
	51-56	6	Users' appreciation	
	57-64	7	Technological competence for SAN implementation	

5.9 Data Analysis Procedures

In order to achieve the objectives of this study, five statistical steps and procedures were used.

The five-step data analysis procedures used in this research to develop the prediction model are as follows:

a) calculation of descriptive statistics (mean, standard deviation, and the distribution of the collected data);
b) examination of the non-response bias (Demographics Chi-square Analysis);
c) check of reliability and validity (Cronbach's Alpha Factor Analysis);

d) testing of the hypotheses (Factor Analysis and Canonical Correlation Analysis); and
e) development of a prediction model (Multiple Regression Analysis).

This study used the SPSS (Statistical Package for the Social Science) for data analysis.

5.9.1 Non-Response Bias

When a mail questionnaire is used to collect data, non-response bias can be a concern; that is, respondents could differ in some fundamental way from non-respondents. This difference can cause the data that are received to be biased toward the respondents, thus not representative of the population that is being sampled. One way to decrease the potential of non-response bias is to increase the response rate from the sample frame.

A high response rate reduces the potential for non-response bias. As the percentage of study responses increases, the validity of the data is expected to increase; i.e., the data received become more representative of the population of interest and non-response bias is therefore decreased. For this reason, response rate is considered an important metric in determining the validity of results obtained from mail questionnaires. Aaker et al. (1998) lists the following six factors as having the greatest influence on survey participation:

1. perceived amount of work required;
2. intrinsic interest of the topic;
3. characteristics of the sample;
4. credibility of the sponsoring organisation;
5. level of induced motivation (incentives); and
6. increased unethical use of marketing research to sell products.

The "perceived amount of work required" directly relates to questionnaire length. By comparison, a shorter questionnaire would require less work than a longer one. However, the effects of questionnaire length on response rate have been debated in the literature for some time.

Heberlein and Baumgartner (1978) reported that each additional question added to the questionnaire effectively reduced responses by approximately 0.05 percent. The efficiency of survey research could be increased if it can be proven that shorter questionnaires result in higher response rates and, thereby, increased validity of data obtained through mail questionnaires (Smith et al. 2003).

Mailed questionnaire surveys often have problems of non-response bias (Emory & Cooper 1991). In order to minimise or avoid this problem, several steps were taken:

1. limiting the number of items in the questionnaire;
2. a guarantee of confidentiality and anonymity to respondents in the cover letter; and
3. a summary of the survey results to be offered to the respondents upon request, as an incentive.

A question in regard to the number of employees in the firm was used to test non-response. The chi-square test was used to test the differences between groups. If the differences were not significant, the inference would be that data obtained from the respondents may not be significantly different from the whole sample; thus there would be no significant response bias. However, if the differences were significant, there would be a response bias. Chi-square tests ascertain whether a significant difference exists between two groups (Emory & Cooper 1991).

5.9.2 Reliability

Reliability is the consistency and stability of a score from a measurement scale. There must be reliability for there to be validity or accuracy. Reliability is the degree

of consistency, precision and repeatability. Scores on reliable measures are not greatly influenced by random error.

The reliability of a scale (factor or construct) is found by examining its internal consistency, by calculating Cronbach's alpha. This method indicates the extent to which items (elements) within a scale are homogenous or correlated (Saraph et al. 1989; Wong & Aspinwall 2005).

According to Yin (1994, p. 33) reliability has been defined as the "....demonstration that the operations of a study - such as the data collection procedures - can be repeated, with the same results". Yin (1994, p. 36) also suggested that "the objective is to be sure that, if a later investigator followed exactly the same procedures as described by an earlier investigator and conducted the same case study all over again, the later investigator should arrive at the same findings and conclusions. ... The aim of reliability is to minimise the errors and biases in a study."

While reliability reflects the consistency of test scores, validity refers to how well the test measures what it purports to measure. The main concern of this research was with content validity and predictive validity.

A research instrument can be evaluated by two criteria (Allen & Yen 1979; Emory & Cooper 1991; Gide 1999):

1. reliability; and
2. validity.

Churchill (1979) suggested that reliability can reflect the validity of the measure and that the *coefficient alpha* should be the first measure to be calculated.

This study calculated *Cronbach's coefficient alpha* for the reliability test. Cronbach's alpha (α) is a formula for determining reliability based on internal consistency; it has the most utility for multi-item scales at the interval level of measurement (Emory &

Cooper 1991). Nunnally (1978) suggested that reliability of 0.50 and 0.60 should suffice and that reliability beyond 0.80 is wasteful, while Churchill (1979) suggested a cut-off point of 0.70. In this study a cut-off point of 0.6 was used. Factors below the 0.6 cut-off point were eliminated from further analysis and calculations.

5.9.3 Validity

While reliability reflects the consistency of test scores, validity refers to how well the test measures what it purports to measure. Validity refers to the extent to which an instrument evaluates what it is intended to measure. For a scale to be valid, it must also be reliable. Validity is differentiated from reliability in that the former relates to accuracy, while the latter relates to consistency.

Validating and refining the CSFs are important before any further analysis is conducted. Reliability and validity tests were carried out following the approach taken by Saraph et al. (1989); Yusof and Aspinwall (2000).

Two types of validity will be tested in this study:

1. content validity; and
2. construct validity.

5.9.4 Content Validity

Content validity reflects how adequately the test samples represent the content domain. It is not measured statistically, but instead is judged by expert opinion on the representativeness of the items.

Content validity is a subjective assessment of how appropriate the instrument seems to a group of reviewers (i.e. a focus group) with knowledge of the subject matter. It typically involves a systematic review of the survey's contents to ensure that it includes everything it should and nothing that it shouldn't.

There is no content validity statistic. Thus, it is not a scientific measure of a survey instrument's validity. Nonetheless, it provides a good foundation on which to base a rigorous assessment of validity. Since we are developing a new survey instrument in a SAN area that has not previously been researched, it is the only valid form of preliminary validation available. According to Emory and Cooper (1991), content validity provides a careful and systematic examination of the instrument.

An instrument has content validity if it has measurement items that adequately cover the content domains or aspects of the concept being measured (Ahire et al. 1996; Wong & Aspinwall 2005). It is not assessed numerically, but can only be subjectively judged by researchers (Saraph et al. 1989; Wong & Aspinwall 2005). The survey instrument used in this study was the outcome of an iterative process of checking and refinement by the focus group.

The focus group participants carefully reviewed the items to determine content validity.

5.9.5 Construct Validity

Construct validity concerns how an instrument "behaves" when used. Construct validity is an operational concept that examines whether the measurement scales represent and act like the attributes being measured (Nunnally & Bernstein 1994). Assuming that the total score of a scale is valid, the extent to which an individual item measures the same thing as the total score is an indicator of the validity of that item. In addition, factor analysis is considered to be a powerful and indispensable method of construct validation. Thus, as well as item-total correlations, the construct validity of the scales in the measurement instrument was assessed using factor analysis.

The construct validity of the seven measurement scales was evaluated by analysing the items of each of the scales using principal components analysis. However, this

analysis, as with all factor-analysis procedures, includes subjective judgement when it comes to determining the number of factors and their interpretation (Spector 1992).

Several guidelines have been developed to assist in deciding how many factors to extract. The two most widely used criteria are the eigenvalue rule and the scree test. The scree test is based on a subjective examination of the plot of eigenvalues for each successive factor. The eigenvalue rule is based on retaining only factors that explain more variance than the average amount explained by one of the original items.

Construct validity refers to the extent to which an instrument measures a theoretical construct; that is, it evaluates the theory on which the construct is based, as well as the measuring instrument used (Emory & Cooper 1991). Two common methods of evaluating construct validation are:

1. examining the correlations between total scores and item score; and
2. conducting a factor analysis.

The idea of correlation is one of the most important and basic in the elaboration of bivariate relationships. Measures of correlation indicate both the strength and the direction of the relationship between a pair of variables.

The first method assumes the total score is valid, and if the item scores correlate with the total score, then this implies the whole construct is valid. The second method, factor analysis, is considered as another approach to examine construct validity because factor analysis provides for examination of the underlying structure of the overall measure (Ives et al. 1983).

5.9.6 Factor Analysis

Factor analysis is a multi-variate statistical technique and the primary purpose is data reduction and summarisation (Hair et al. 1998). The purpose of factor analysis is to

"explore the underlying variance structure of a set of correlation coefficients. Thus, factor analysis is useful for exploring and verifying patterns in a set of correlation coefficients. . . "(Brown 2001, p. 184). Factor analysis is used to study construct validity (Bachman 1990, p. 262-263; Brown 1996, p. 246).

Factor analysis is used for the following purposes:

- to reduce a large number of variables to a smaller number of factors for modelling purposes;
- to select a subset of variables from a larger set, based on which original variables have the highest correlations with the principal component factors;
- to create a set of factors to be treated as uncorrelated variables as one approach to handling multicollinearity in such procedures as multiple regression;
- to validate a scale or index by demonstrating that its constituent items load on the same factor, and to drop proposed scale items which cross-load on more than one factor.

Factor analysis must be distinguished from component analysis, since a component is an observable linear combination. "Factor" is also used in the sense of matrix factor in that one matrix is a factor of a second matrix if the first matrix multiplied by its transpose equals the second matrix.

Factor analysis refers to all methods of data analysis using matrix factors, including component analysis and common factor analysis. After the initial factor extraction, the common factors are uncorrelated with each other. Factors are then rotated by an orthogonal transformation, as well as an oblique transformation. The factors rotated by an orthogonal transformation are uncorrelated, whereas those rotated by an oblique transformation become correlated.

The purpose of *common factor analysis* (Mulaik 1972) is to explain the correlations or co-variances among a set of variables in terms of a limited number of

unobservable, latent variables. In common factor analysis, it is assumed that the variables are linearly related, except for uncorrelated random error or unique variation in each variable.

According to Rao, (1964) the purpose of *principal component analysis* is to derive a small number of linear combinations (principal components) of a set of variables that retain as much of the information in the original variables as possible. Principal component analysis can also be viewed as an attempt to uncover approximate linear dependencies among variables. The output includes all the eigenvalues and the pattern matrix for eigenvalues greater than one.

Principal component and common factor analyses are often followed by rotation of the components or factors. In this research, the principal component analysis model (Rao 1964) is used because of the ease of rotating the factors either orthogonally or obliquely. The rotation can make the factor differentiation easier. This research also uses the orthogonal factor rotation method (varimax) as it provides a better matrix construct.

5.9.7 Canonical Correlation Analysis

Hotelling (1936) developed canonical correlation analysis, and Cooley and Lohnes (1971) and Mardia et al. (1979) discussed the application of canonical correlation. The purpose of *canonical correlation analysis* (Mardia et al. 1979) is to explain or summarise the relationship between two sets of variables by finding a small number of linear combinations from each set of variables that have the highest possible between-set correlations.

Canonical analysis was adopted to show the interrelationships among sets of composite criterion variates and was used to analyse the relationships between the predictor and criterion sets of variables.

Hair et al. (1998) recommended three criteria to be used for interpreting the canonical function: (1) the canonical correlation; (2) the significance level of the F statistic; and (3) the redundancy index. The hypotheses were tested using the canonical correlation analysis, and the correlation between the dependent and canonical variables examined from the results. This research also examined several multi-variate F statistics that were provided by the results, using tests including Pillais' F-test for canonical function. For each dependent (criterion) variable, results from uni-variate F-tests and Roy-Bargman step-down F-tests were examined.

This study attempted to find the relationships between the expected CSF and SAN implementation success and to develop a model for the prediction of SAN implementation success.

5.9.8 Multiple Regression Analysis

Multiple regression analysis is used for analysing the relationship between a single dependent variable and several independent (predictor) variables (Gide 1999). Regression model also can measure the strength of the relationship among variables from multiple regression (Hair et al. 1998; Gide 1999). Sigma T was calculated to describe variability or to present the standard deviation of a dataset. Sigma T characterises the variability of the data relative to its average value. The larger the value of sigma, the larger the spread in data values about the dataset average.

5.10 Testing the Hypotheses and Identifying the CSF

Canonical correlation analysis was used to identify and test the hypotheses about the relationships.

The degree of linear relationship between SAN implementation and the success factors can be determined. Each hypothesis was then tested in terms of the significance of the relationship.

The factors extracted from the factor analysis results and the findings are discussed in detail in the later chapters.

Table 5.3: Hypotheses testing using Canonical Correlation Analysis

CSFs	Independent Variables (Section 3) 7-Point Likert type	Main Hypotheses	Dependent Variables (Section 2) 7-Point Likert type
1	X1 – X9	Selection of SAN system (hardware, software and network)	Y1-Y14
2	X10 – X16	Organisations technical support	
3	X17 – X23	Management commitment and support	
4	X24 – X27	Communication and training	
5	X28 – X33	Implementation's effectiveness	
6	X34 - X39	Users' appreciation	
7	X40 – X47	Technological competence	

5.11 Developing a Prediction Model

The regression has become one of the most widely used techniques in the analysis of data in the social sciences. The regression model identified the contribution of each factor and the relationship between SAN implementation success and the expected CSF. The regression model was also used to predict the strength of the relationship among the variables. This prediction model was then constructed based on the findings from these multi-variate analysis methods.

CHAPTER 6

STATEMENT OF RESEARCH HYPOTHESES

6.1 General

This chapter describes the development of the hypotheses based on the expected CSFs for SANs implementation.

Since no published work has been found on CSF study of SAN implementation in the literature at the time of this study, the proposed research model used some of the important, well-known and internationally recognised previous CSFs studies in IS (Rockart 1982; Martin 1982b; Miller & Doyle 1987; McCredie & Updegrove 1999; Kuang et al. 2001; Nelson & Somers 2001).

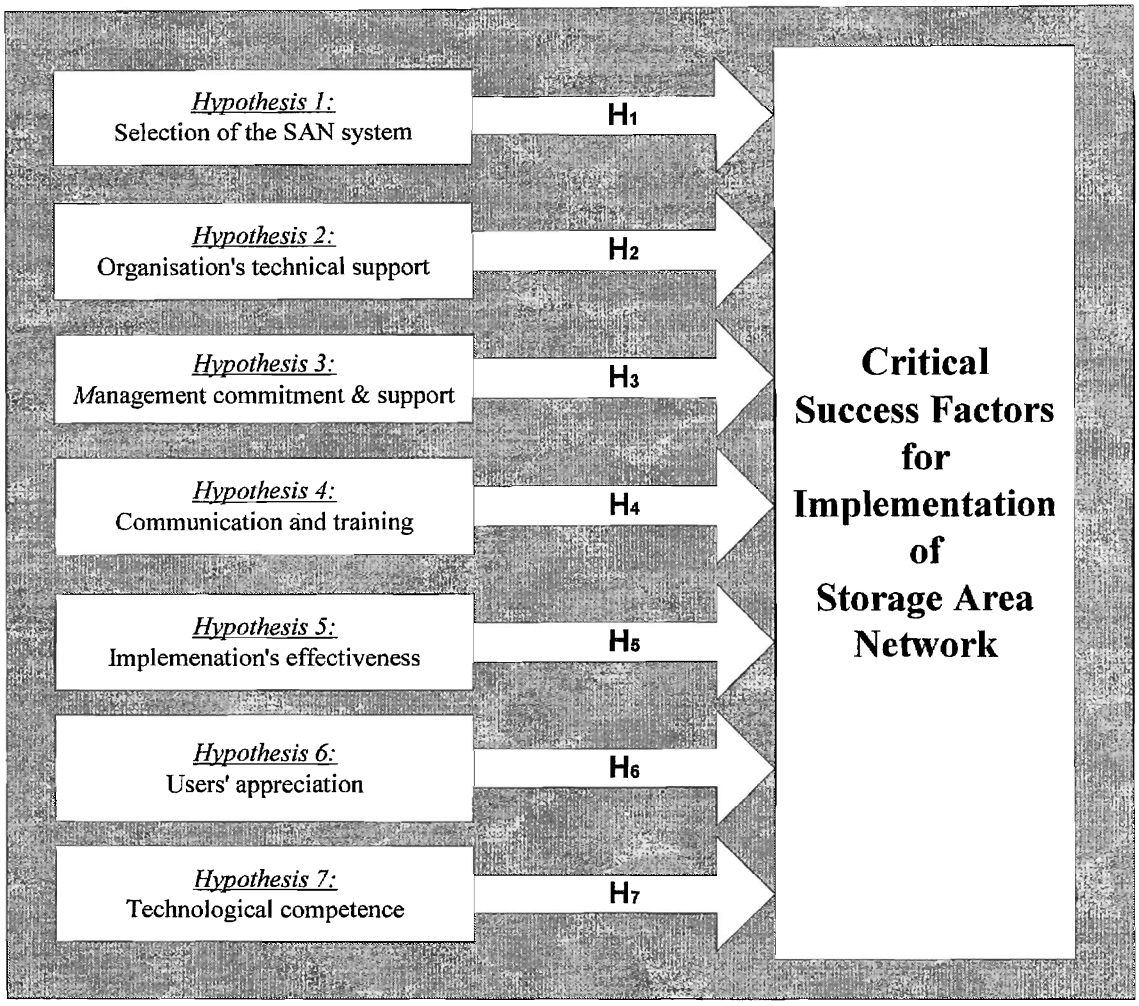
In this study, seven sets of hypotheses that are likely to impact on the success or otherwise of SAN implementation are identified. The independent variables were selected from various IT/IS-related literature.

The hypotheses are briefly as follows:

1. selection of the SAN system (hardware, software and network);
2. organisation's technical support;
3. management commitment and support;
4. communication and training;
5. implementation's effectiveness;
6. users' appreciation; and
7. technological competence.

The research model shown in figure 6.1 highlights the seven set of hypotheses for testing in this research.

Figure 6.1: The Proposed Conceptual Research Model for Successful Implementation of SAN systems



6.2 Hypothesis 1 (Selection of the SAN System)

The first group of hypotheses deals with the selection of the SAN system (hardware, software and network) for implementation. SAN systems are a combination of hardware, software and network components.

Gartner's research determined that in 2000, corporations spent 25 percent of their computer infrastructure budgets on storage and 75 percent on hardware (Isakovich 2001). Traditionally, creating a SAN was made possible only with the use of

extremely expensive proprietary hardware by a particular vendor. According to InfraStor (2001) organisations can select from a variety of hardware without being constrained and locked in by a particular hardware vendor, allowing businesses to have the desired level of performance scalability without a practical limit.

Interoperability is perhaps one explanation of why finding a total SAN solution is very difficult. No one vendor has yet to develop a universal SAN solution, nor does it seem probable that one vendor will ever be able to accomplish this feat. For example, the fibre channel landscape has multiple vendors selling products up and down the storage and network spectrum. For these separate products to function as a synergistic and cohesive system, vendors must agree on a common set of implementation guidelines and standards. Organisations must work closely with SAN key suppliers in their interoperability labs to ensure everything will work together, and this is a costly and time-consuming exercise.

It is interesting to note that some vendors are trying to validate interoperability claims by introducing interoperability labs in addition to their product lines. According to McFadden (2000), many of the largest SAN vendors have invested in interoperability labs. According to Nancy Marrone, analyst, Enterprise Storage Group, "SANs have come a long way, but I think there is still a great need to verify interoperability. If I were an integrator, I'd make sure I tested it before I installed it" (Schwartz 2002).

All SAN vendors are grappling with Fibre Channel standards and resolving compatibility problems. Compatibility among switch ports, multiple-switch fabrics, name services and registered state-change notification are among the interoperability issues vendors are now wrestling with. Because SANs are not universally interoperable, most early users have been forced to rely on a single vendor's solution.

According to Schwartz (2002), the role of SANs is actively expanding from storage networks centred around homogenous systems or applications into core components of enterprise systems, due to the improvements in interoperability.

Although there has been growth in SANs, interoperability is still the main issue facing organisations. The growth in SANs has been more due to the fact that organisations tend to purchase the solutions from one vendor, to avoid the interoperability problems.

As large vendors can only guarantee the hardware they sell but not the connectivity of the entire network, it makes it very important to choose the right hardware, software and network for the implementation of SAN. In addition, when it comes to the integration of products from several different vendors, the mission is critical. The focus group held the view that selection of the SAN system (hardware, software and network) is related to the implementation success of the SAN system. Accordingly, this study hypothesised that a positive relationship exists between selection of the SAN system (hardware, software and network) and the SAN system's implementation success.

This positive relationship is hypothesised as:

H_1: The selection of the SAN system for implementation is positively related to SAN success.

H_{1a}: The appropriateness of the SAN system is positively related to SAN implementation success.

6.3 Hypothesis 2 (Organisation's Technical Support)

The second group of hypotheses deals with the organisation's technical support provided for the SAN implementation system. The function of the technical support department is to facilitate and manage hardware, software, network and system upgrade (hardware and software) as well as managing resources within the organisation to maintain and support the SAN system.

An effective SAN technical support department provides sufficient and necessary available storage, supports applicable and efficient software, provides troubleshooting and trains and assists users, as well as having competent SAN technical support staff who support the SAN implementation system on a daily basis.

According to Prakash (1996), the success of the implementation is based on employee morale and productivity, which are the result of the constant training and support received in the organisation. Laudon and Laudon (1997) also concluded that the organisation's technical support has a significant role to play in increasing productivity and, as a result, the possibility of SAN implementation success. The focus group held the view that organisation's technical support for the SAN implementation is related to the implementation success of the SAN system. Accordingly, this study hypothesised that a positive relationship exists between organisation's technical support for the SAN implementation and the SAN system's implementation success.

This positive relationship is hypothesised as:

H_2: An organisation's technical support for the implementation of the SAN system is positively related to SAN success.

6.4 Hypothesis 3 (Management Commitment and Support)

The third group of hypotheses deals with management commitment and support for the SAN implementation. It is understood that without the full commitment and support of top management in the organisation, it is very difficult to achieve a successful implementation (Ruth & Schware 1996). Therefore top management involvement would be necessary to achieve the objectives of the SAN implementation.

Management commitment and support refer to the extent to which information technology implementation efforts are promoted by the top management in an

organisation (Rai & Bajwa 1997). Top management support is a widely accepted CSF in the MIS literature. As Jarvenpaa and Ives (1991, p. 205) stated, "few nostrums have been prescribed so religiously and ignored as regularly as executive support in the development and implementation of management information systems". Past innovation studies have also reported a positive association between top management support and observed innovation behaviour in organisations (Kimberly & Evanisko 1981; Meyer & Goes 1988; Rai & Bajwa 1997).

Traditionally, management involvement has been stressed as an important determinant of success (Bass 1990). Management commitment and support during the planning phase help organisations to overcome any unforeseen problems during the implementation and, as result, facilitate good communications among SAN system users.

If the top management become aware of technical problems associated with SAN implementation well in advance, they would be in a better position to understand issues and assist in avoiding some of the pitfalls associated with SAN implementation.

According to Ginzberg (1981) the technical support department may be required to provide a detailed plan of the SAN implementation to management. Providing detailed planning to management is important in determining what the users' response to the SAN implementation will be.

The importance of management is, of course, considerable although some researchers have questioned the direct correlation between management involvement and outcome variables. Beer et al. (1990) indicated that it is usually enough if top management approves of the changes and has a positive attitude. Nevertheless, top management involvement may not always be an essential feature of the outcome of a change process. In recent decades, there has been considerable research focus on top management behaviour.

The evidence in the literature suggests that top management commitment and support are critical to the success of system implementation (Vollman et al. 1992, p.410). Without such support and commitment to invest in the implementation of SAN system, it is impractical for SAN projects to be approved. Top management support is essential to develop confidence and respect for the implementation team (Hoopes 1995).

The focus group held the view that organisations' technical support for SAN implementation is related to the implementation success of the SAN system. Accordingly, this study hypothesises that a positive relationship exists between an organisation's technical support for SAN implementation and the SAN system's implementation success.

H_3: Commitment and support from management are related to SAN implementation success.

6.5 Hypothesis 4 (Communication and Training)

The fourth group of hypotheses deals with the communication and training of users for the SAN implementation. Technical support staffs need to be trained on a regular basis to keep up with the hardware and software changes as part of the system upgrade. As well as the technical staff members, SAN users may also need to be trained in order to be able to use the system properly and more efficiently. In order to gain full support from users of the SAN, the users need to have a very good understanding of the implications of the new SAN system. Users of the system need to be well trained on some of the system changes, such as access to data, security issues and new procedures as the result of the SAN implementation.

While the SAN system is implemented and after the completion of the implementation, the technical staff and users of the SAN system may need to receive training on the hardware and software, so that they could be more efficient in their daily tasks. As the result of the training received, the users will feel more confident

with the new system, and therefore their attitude towards the implementation could be more positive (Rainer et al. 1992).

According to Rainer et al. (1992) and Turban et al. (1996), good training for the users of the system will improve communication between users and reduce their fear of the system. This is more likely to improve users' satisfaction with the SAN implementation.

The focus group held the view that users' training for the SAN implementation is related to the implementation success of the SAN system. Accordingly, this study hypothesises that a positive relationship exists between users' training for the SAN implementation and the SAN system's implementation success.

H_4: Users' training is positively related to SAN implementation success.

6.6 Hypothesis 5 (Implementation's Effectiveness)

The fifth group of hypotheses deals with the effectiveness of SAN implementation. As there are examples of business failures or disappointments from the implementation of SAN, there is a need for a more in-depth organisational learning process, knowing the most critical success factors for implementation of SAN systems and in particular the implementation's effectiveness from implementation of SANs.

Increased competitive pressure due to globalisation and rapid enhancements in enabling technologies demand that organisations adopt and implement new technologies and storage systems (like SAN) rapidly to accommodate the high demand for storage. Those who fail to meet this challenge may lose opportunities to enhance productivity and their competitive position, which may even threaten their survival.

IT/IS effectiveness is interpreted as the change in organisational effectiveness resulting from the introduction and use of IT/IS (Iivari & Ervasti 1994). Cameron and Whetten (1983) characterised the assessment of implementation effectiveness through seven critical questions: the purpose of assessing effectiveness, the level of analysis, the perspective according to which effectiveness is assessed, the domain of activity on which the assessment is focused, the time frame being employed, the types of data being used in the assessment, and the reference against which effectiveness is being judged.

On the other hand, in their study, Hamilton and Chervany (1981a) determined the need for performance measures for IT/IS. Hamilton and Chervany (1981b) also described and compared the effects of evaluator viewpoints about system effectiveness on resources-oriented perspectives (or efficiency) and influences-oriented perspectives (or effectiveness). Some of their evaluation items - for example, IT/IS personnel productivity, computer performance, service and users' attitude - are identical to the components of CSFs from the studies of Rockart (1982), Martin (1982b) and later CSF researchers.

Adding value due to SAN implementation can be made possible through alignment of SAN goals and objectives with the organisation's goals and objectives (Cockburn & Wilson 1996; Cronin et al. 1994 1996; Quelch & Klein 1996). Ginzberg (1981) suggested that there are two management approaches that can increase the effectiveness of the system development process. One approach is to identify those variables that are both especially important to the success of system development and controllable by the user or the system designer. The other approach is to manage the development process of the system designer and user by utilising development tools and procedures.

The focus group held the view that effectiveness of SANs in organisations is related to the implementation success of the SAN system. Accordingly, this study hypothesises that a positive relationship exists between implementation effectiveness for SAN implementation and the SAN system's implementation success.

H5: The implementation's effectiveness is positively related to SAN implementation success.

6.7 Hypothesis 6 (Users' Appreciation)

The sixth group of hypotheses deals with the users' appreciation of SAN implementation.

The following items are derived from an instrument used to measure success criteria for users' appreciation after implementation (Bergeron et al. 1993):

- quicker and easier access to information;
- user satisfaction;
- increase in the quality of information;
- increase in the use of existing information systems;
- better communication capacity;
- increase in data processing capacity; and
- efficient use of tools by the users.

Extensive studies have been conducted on the importance of user appreciation in IS success (Barki & Hartwick 1994; Cavaye 1995).

Users of a SAN system will be more satisfied and appreciative of the system if they have a good knowledge understanding of it. The feeling of being in control has been found to lead to increased self-efficacy beliefs (Gist et al. 1992; Tafarodi, Milne & Smith 1999), less stress (Amirkhan 1998) and higher satisfaction (Judge et al. 2000). Lack of control, however, produces stress and lower perceived competency (Amirkhan 1998; Judge et al. 2000).

Although Schewe (1976) found no significant relationship between a user's involvement and his/her attitude toward the system, other studies (Montazemi 1988;

Baroudi et al. 1986) have drawn a parallel relationship between user involvement and user satisfaction.

The concept of user satisfaction with SAN systems is relatively direct and rooted in the works of Cyert and March (1963), who suggest that if an IS/IT meets the needs of users, the system will produce user satisfaction. Empirical research has found a positive relationship between user satisfaction with an information system and the system's overall success. For example, Swanson (1974) found a relationship between a user's appreciation of a system and the user's utilisation of the system's outputs. User satisfaction helps to produce system utilisation, which helps to produce desirable results. Ives et al. (1983) stated that user information satisfaction is not simply an objective measure of the technical quality of a system, but rather measures how users perceive the system. Ives et al. (1983) held that if system users regard a "technically good system" as being poor, then it is effectively a poor system. The underlying assumption is that if users are not satisfied with a system, it is not an effective system. Conversely, an information system will be considered effective in meeting users' needs if these users are satisfied. Powers and Dickson (1974) concluded that user satisfaction is the most critical factor for system success. It is also argued that user satisfaction is an indicator of system usage and effectiveness (Baroudi et al. 1988; Igbaria & Nachman 1990).

Others also viewed users' satisfaction as a likely factor for evaluating systems success (DeLone & McLean 1992). Numbers of researchers highlighted the importance of user involvement and participation on end-user satisfaction with the system (Harwick & Barki 1994; Beeler & Hunton 1997).

Employee involvement is a broad concept that encompasses a wide scope of practices.
It is taken here to be "the exercise, by employees of influence over how their work is organized and carried out" (Fenton-O'Creevy 2001, p. 28).

According to Lucas (1981) if users are not informed about the implementation of the new system, in this case SAN systems, then their attitudes towards the

implementation become unfavourable. As a result, the new implementation will not be embraced, and is more likely to increase the risk of failure.

A participatory approach can often be seen in projects that involve new, innovative workplace concepts. The benefits of broad-based user involvement in planning and design have been documented in several studies. They include enhancing the users' sense of commitment and increasing user satisfaction and trust (Granath et al. 1996). Furthermore, user involvement may create more realistic expectations of outcomes as users become aware of the physical and financial constraints of the project.

Ives and Olson (1984) classified users' involvement and participation into 6 groups. Table 6.1 lists the 6 groups of users' involvement.

Table 6.1: Users' Involvement Classified by Ives and Olson (1984)

1. No involvement	Users are either unwilling or not invited to participate.
2. Symbolic involvement	Users' input is requested but ignored.
3. Involvement by advice	Users' advice is solicited through interviews or questionnaires.
4. Involvement by weak control	Users have "Sign-off" responsibility at each stage of implementation.
5. Involvement by doing	Users are active members of the implementation team.
6. Involvement by strong control	Users' overall organisational performance evaluation depends on the outcome of the development effort.

The focus group held the view that users' appreciation of the SAN implementation is related to the implementation success of the SAN system. Accordingly, this study hypothesises that a positive relationship exists between users' appreciation of the SAN implementation and the SAN system's implementation success.

H6: Users' appreciation is positively related to SAN implementation success.

6.8 Hypothesis 7 (Technological Competence)

The seventh group of hypotheses deals with technological competence for SAN implementation. Technological competence enables a company to become a market pioneer through new product development and the use of new production processes.

According to Malerba and Marengo (1995), companies with a high level of technological competence will have greater innovation success than companies with only a low level of technological competence. Information technology (IT) is referenced in the literature as an enabler of the change. IT can be the enabler of change but it can also be a potential constraint as most firms have existing IT infrastructures built up over many years (Taylor & Todd 1995).

Technological competence refers to the level of technological resources that are available to an organisation. SAN technological initiatives are generally considered to be costly and complex innovations that demand advanced technological skills, integrated information sources, and costly information systems infrastructures. Therefore, organisations with a higher balance of IT sophistication, technological skills, and resources are more prone to achieve actual benefits from implementing SAN (Iacovou et al. 1995; Kettinger & Hackbarth 1997; Croteau et al. 2003).

Numbers of other studies have looked at the content or types of competency (e.g. Malerba & Marengo 1995). Although other researchers (Carlsson & Eliasson 1991; Dosi & Teece 1993; Malerba & Marengo; 1995 Sanchez & Heene 1997) been investigating managerial competencies, the focus of this research is on technological competencies and their impact on organisations' success. According to Broadbent and Weill (1995) the state of the IT infrastructure can influence the choice of either a radical or an incremental implementation plan. Nord and Tucker (1987) stated that organisations lacking technical readiness are unable to recognise their inadequacies.

The focus group held the view that technological competence for SAN implementation is related to the implementation success of the SAN system. Accordingly, this study hypothesises that a positive relationship exists between technological competence for SAN implementation and the SAN system's implementation success.

H_7: The organisation's technological competence for implementing the SAN system is positively related to SAN implementation success.

CHAPTER 7

DATA ANALYSIS AND RESULTS

This chapter presents the results of the data analysis. This study used a survey-based instrument to test if the seven hypotheses developed in chapter five can be supported. The research instrument was a questionnaire, composed of four sections (see Appendix-A) with a total of 64 questions. The first section of the questionnaire contained three questions and was designed to measure the level of satisfaction with the SAN system, the number of employees in the organisation and the number of years the SAN system has been implemented. The second section was composed of fourteen variables measuring improvements in performance of the SAN system's implementation. The third section of the questionnaire was designed to measure the impact of the SAN system's implementation on the performance of the company. This chapter will discuss the results of the 64 questions measured in the questionnaire.

Instructions explaining to the respondents how to reply were included in a covering letter. The letter indicated that individual responses would be confidential and would remain anonymous, and that the survey was part of a PhD research study identifying the critical success factors for the implementation of SAN systems.

7.1 Introduction

The design of the questionnaire was based on the seven hypotheses developed and described in the previous chapter. The aims of the questionnaire were to measure variables for testing the seven hypotheses, which in turn were used to determine whether or not the seven success factors are critical to the success of SAN implementation.

The first section of the questionnaire comprised 3 questions to identify the SAN implementation status, number of years using SAN, the level of satisfaction and the number of employees in the companies which had implemented SANs.

The second section was composed of 14 questions to measure the improvements in performance and success of the SAN systems' implementation. This section employed a 7-point Likert-type scale for the measurement.

The third section of the questionnaire contained 47 questions measuring the seven potential success factors for SAN system implementation. These questions also used a 7-point Likert-type scale for measurement.

The following Table (Table 7.1) illustrates the layout of the questionnaire:

Table 7.1: Description of the questionnaire

Questionnaire		CSF	Measurement Variables	Scale used
Section	**Question**			
1	1-3		Organisations' level of satisfaction with SAN, number of years implemented SAN and number of employees	Various scale
2	4-17		SAN implementation performance and success.	7-point Likert-type
3	18-26	1	Selection of SAN system (hardware, software and network)	7-point Likert-type
	27-33	2	Organisation's technical support	
	34-40	3	Management commitment and support	
	41-44	4	Communication and training	
	45-50	5	Implementation's effectiveness	
	51-56	6	Users' appreciation	
	57-64	7	Technological competence	

7.2 Response Rate

The chosen sample size was 440. Thus, 440 questionnaires were mailed to SAN-based user companies in June 2004. The results are based on the assumption that 440 questionnaires reached the sample subjects. From these, 103 were returned for an initial response rate of 23.41 percent. From the 103 returned questionnaires, 96 answered all questions to represent a complete response, yielding a useable response rate of 21.82 percent.

7.3 Descriptive Statistics

The first section discusses duration, organisational size and satisfaction with SAN implementation. The second section provides the mean values and the standard

deviations of the 14 SAN implementation success (performance) items and those of the 47 SAN implementation activities.

7.3.1 Number of Years of SAN Implementation

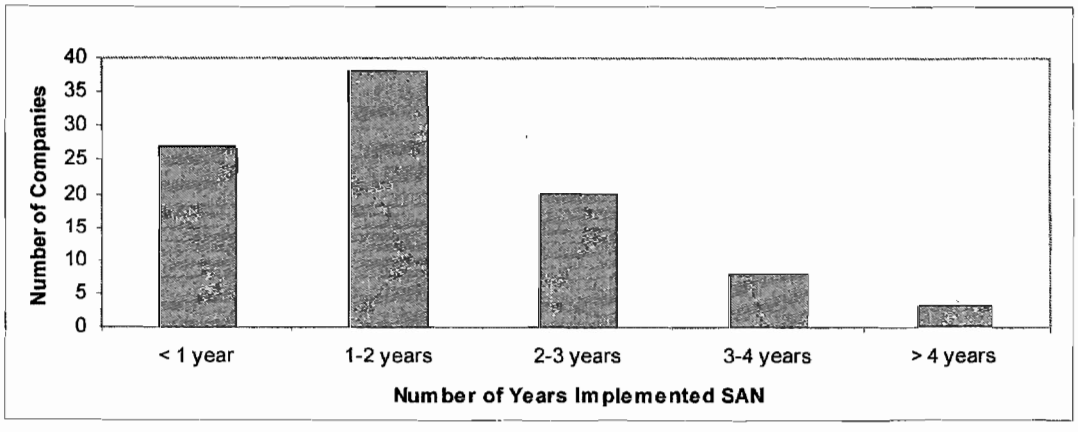
The first section of the questionnaire contains 2 questions (see Appendix-A) which are related to the length of time and overall business operations satisfaction.

Table 7.2 shows that 28.13 percent of the respondents had implemented SAN for less than one year. The majority of the respondents, about 39.58 percent, had implemented SAN for between one and two years. 20.83 percent of the respondents had implemented SAN for between two and three years. 8.33 percent had implemented SAN for between three and years, and only 3.13 percent had implemented SAN for more than four years. The results indicate that majority of the respondents, 39.58 percent, had implemented SAN for between one and two years.

Table 7.2: Number of years of SAN implementation

Years of SAN Implementation	Number of Companies	Percentage (%)
Less than 1 year	27	28.13
Between 1 to 2 years	38	39.58
Between 2 to 3 years	20	20.83
Between 3 to 4 years	8	8.33
More than 4 years	3	3.13
Total	96	100.00

Figure 7.1: Number of years of SAN implementation



7.3.2 Overall Business Satisfaction with SAN Implementation

Table 7.3 shows the rates of respondents' overall satisfaction with SAN system implementation. The Table shows that only 3.13 percent of the respondents were very dissatisfied with SAN implementation. The results indicate that majority of the respondents, 43.75 percent, were satisfied with SAN system implementation. The results also show that 19.79 percent were very satisfied with SAN system implementation.

Table 7.3: Overall satisfaction rate with SAN implementation

Overall Satisfaction Rate with SAN Implementation	Number of Companies	Percentage (%)
Very dissatisfied	3	3.13
Dissatisfied	9	9.38
Neutral	23	23.96
Satisfied	42	43.75
Very satisfied	19	19.79
Total	96	100.00

Figure 7.2: Overall Business Satisfaction Rate with SAN implementation

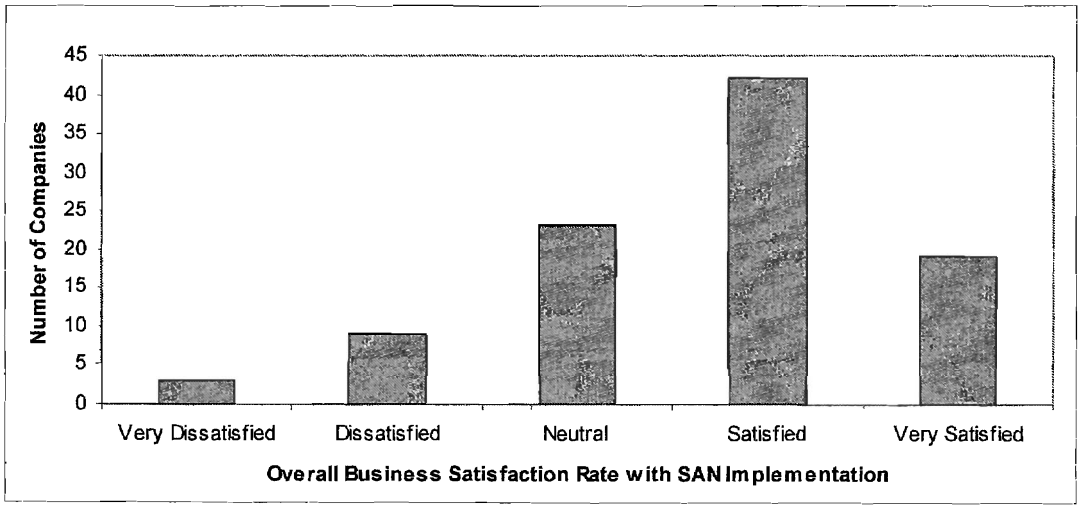


Table 7.4 shows that the majority of the companies that had implemented SAN, about 47.92 percent, had more than 500 employees. Only 4.17 percent of respondents had between 21 and 50 employees'. Companies with between 101 and 500

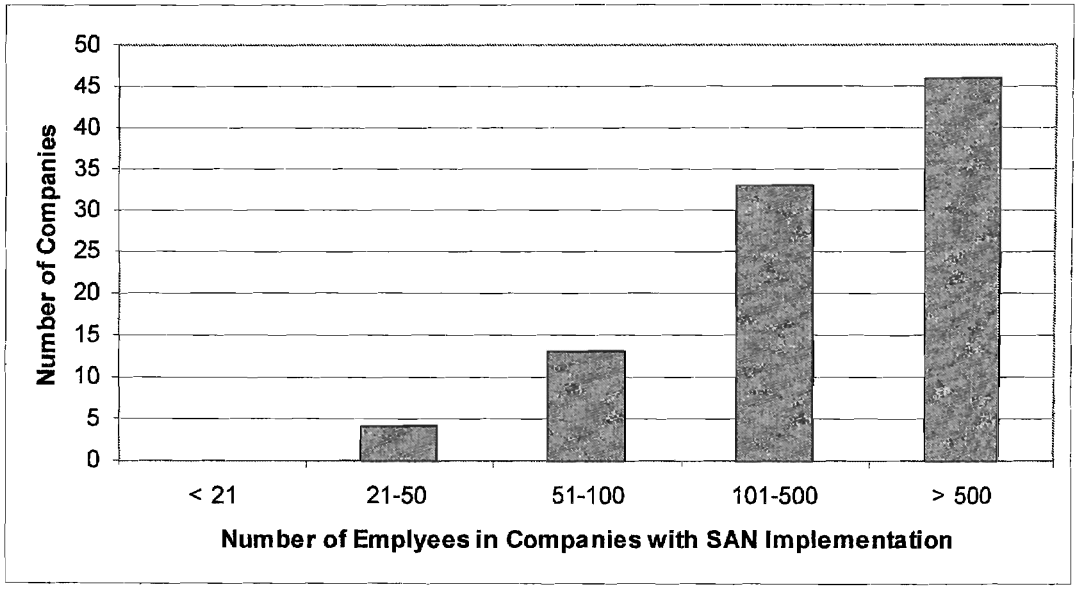
employees form a quite a large percentage of those that have implemented SAN, about 34.38 percent.

The results also indicate that companies with 20 employees or fewer have not implemented SAN.

Table 7.4: Number of Employees in Companies which had implemented SAN

Number of Employees	Number of Companies	Percentage (%)
< 21	0	0.00
21-50	4	4.17
51-100	13	13.54
101-500	33	34.38
> 500	46	47.92
Total	96	100.00

Figure 7.3: Number of Employees in Companies which had implemented SAN



7.4 SAN Implementation Success Items

In the second section of the questionnaire, 14 items were used to measure the improvements in performance after SAN implementation. The measurements of

SAN implementation success are made on a Likert type scale of 1 (Strongly disagree) to 7 (Strongly agree).

The 14 items of the questionnaire in the second section are shown in Table 7.5 as Y1 to Y14.

Table 7.5: The 14 items of the questionnaire in the second section

Y1	SAN implementation has improved systems' availability.
Y2	SAN implementation has improved systems' response time.
Y3	SAN implementation has improved systems' scalability (ability to upgrade the hardware in future).
Y4	There have been overall cost savings as the result of SAN implementation.
Y5	SAN implementation has reduced the overall systems' administration.
Y6	SAN implementation has improved overall productivity.
Y7	SAN implementation has improved the overall efficiency of users.
Y8	SAN implementation has led to higher user/customer satisfaction.
Y9	SAN implementation has increased revenue and market share.
Y10	SAN implementation has led to overall time saving in business operations.
Y11	Communication with other staff has improved because of the SAN implementation.
Y12	The SAN system has improved organisational effectiveness.
Y13	The SAN system is effective because of its high quality, efficiency, adequacy and security.
Y14	The security of the SAN system has enabled me to perform my tasks better.

Table 7.6 shows the means and standard deviations of the 14 items measuring implementation success.

Table 7.6: Descriptive Statistics for the SAN Implementation Success Items

	Mean	Std. Deviation
Y1	5.21	1.095
Y2	5.18	1.114
Y3	5.17	1.130
Y4	4.82	1.248
Y5	5.34	.950
Y6	5.26	.954
Y7	5.05	1.040
Y8	5.18	1.095
Y9	5.26	1.069
Y10	5.33	1.043
Y11	5.53	1.123
Y12	5.23	1.071
Y13	5.27	.957
Y14	5.27	.989

The mean values for the 14 items ranged from 4.82 to 5.53 on a scale of 1 (Strongly disagree) to 7 (Strongly agree). The standard deviation ranged from .950 to 1.248. Item Y11, "Communications with other staff has improved because of the SAN implementation", has the highest mean value of 5.53, while item Y4, "There has been overall cost saving as the result of SAN implementation", has the lowest mean value of 4.82. Item Y5, "SAN implementation has reduced the overall systems' administration", has the lowest standard deviation value of .950, while item Y4, "There has been overall cost saving as the result of SAN implementation", has the highest standard deviation value of 1.248.

7.5 SAN Implementation

The third section of the questionnaire consists of 47 questions. The items in the third section measure the impact of SAN implementation. The 47 items of the questionnaire in the third section are shown in Table 7.7 from X1 to X47.

Table 7.7: The 47 items of the questionnaire in the third section

X1	The SAN system used in the company is suitable for the company's intended use.
X2	The SAN system used in the company fully met users' expectations.
X3	The chosen SAN system is right for the company.
X4	The chosen SAN system is sufficient for users' needs.
X5	The chosen SAN system provided ample storage for users.
X6	The chosen SAN system is easy to operate.
X7	The response time of the SAN system satisfies my expectations.
X8	The selected SAN system is useful for my intended use.
X9	The use of the SAN system has streamlined my work.
X10	The company provided a satisfactory level of technical support for the implementation of the SAN system.
X11	The technical support for the implementation of the SAN system fulfilled users' requirements.
X12	The technical support for the implementation of the SAN system is sufficient.
X13	The technical support made the implementation of the SAN system easier.
X14	The response time for providing technical support for the implementation of the SAN system is good.
X15	The technical support was useful for the implementation of the SAN system.
X16	The company streamlined the technical support for the implementation of the SAN system.
X17	Top management thoroughly understood the goals and objectives of SAN implementation.
X18	Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.
X19	Top management made available for the implementation of SAN a wide range of resources.
X20	Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.
X21	Top management promoted users' commitment and support for the SAN system implementation.
X22	Top management were continuously involved in the SAN implementation efforts and processes.
X23	The success of the SAN implementation was due to the effort of the top management leadership.
X24	The implementation of the SAN system was communicated to all users and technical staff.
X25	The implementation of the SAN system was publicised to all organisational units.
X26	Users were provided with a good understanding of the implemented SAN system.
X27	Training resources for the SAN system were managed effectively and efficiently.

Table 7.7: Continued ...

X28	The implementation of the SAN system has improved system availability.
X29	The implementation of the SAN system has improved the speed of the product/service cycle.
X30	The SAN implementation has resulted in time savings in business operations and management.
X31	The SAN implementation has resulted in cost savings in business operations and management.
X32	The SAN implementation has resulted in improved productivity and efficiency of users.
X33	The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).
X34	The implementation of the SAN system increased users' confidence.
X35	The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.
X36	The implementation of the SAN system increased users' utilisation of IT systems.
X37	Users' expectations of the SAN system increased after the implementation.
X38	The implementation of the SAN system prompted users' participation in the SAN system implementation.
X39	Users' attitudes to the SAN system implementation are positive.
X40	Our company has competent SAN technical staff.
X41	There are reliable and qualified SAN services available.
X42	SAN technical staff have facilitated an increase in the productivity of users.
X43	SAN technical staff provide adequate control for SAN system implementation and maintenance.
X44	There is adequate SAN infrastructure in place.
X45	There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.
X46	There are adequate SAN-related knowledge and skills throughout the organisation.
X47	There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).

Table 7.8 below shows the means and standard deviations of the 47 items that measure the factors of importance in SAN implementation.

The mean values for the 47 items ranged from 4.51 to 5.35 on a scale of 1 (Strongly disagree) to 7 (Strongly agree). The standard deviation ranged from .580 to 1.376.

Items X29, "The implementation of the SAN system has improved the speed of the product/service cycle", has the lowest mean value of 4.51, while item X22, "Top

management were continuously involved in the SAN implementation efforts and processes", has the highest mean value of 5.35. Item X14, "The response time for providing technical support for the implementation of the SAN system is good", has the lowest standard deviation value of .580, while item X36, "The implementation of the SAN system increased users' utilisation of IT systems", has the highest standard deviation value of 1.376.

Table 7.8: Descriptive Statistics of the 47 SAN Implementation Items

	Mean	Std. Deviation
X1	4.80	1.120
X2	5.08	.660
X3	5.09	.727
X4	4.91	.952
X5	5.01	.900
X6	5.09	.809
X7	4.91	1.346
X8	4.96	1.368
X9	4.96	.857
X10	5.04	1.273
X11	5.04	.780
X12	5.19	.998
X13	5.00	.995
X14	5.15	.580
X15	5.04	.794
X16	5.09	.755
X17	5.13	.824
X18	5.29	1.025
X19	5.23	.989
X20	5.08	.763
X21	5.04	1.281
X22	5.35	1.086
X23	4.82	.918
X24	4.96	.870
X25	4.67	1.202
X26	4.92	1.111
X27	4.93	.885
X28	4.59	1.072
X29	4.51	1.124
X30	4.70	1.189
X31	5.07	.771
X32	5.16	.812
X33	4.71	1.205
X34	4.96	.857
X35	4.77	1.357
X36	4.65	1.376
X37	4.55	1.045
X38	5.15	.680
X39	4.81	1.324
X40	4.95	.999
X41	4.97	.814
X42	4.86	.866
X43	5.00	.681
X44	5.10	.840
X45	5.09	.755
X46	5.02	.882
X47	4.89	1.035

Table 7.9: The seven hypotheses and the related questionnaire items

Hypotheses		Items of Questionnaires
H1	Selection of the SAN system (hardware, software and network)	X1 – X9
H2	Organisation's technical support	X10 – X16
H3	Management commitment and support	X17 – X23
H4	Communication and training	X24 – X27
H5	Implementation's effectiveness	X28 – X33
H6	Users' appreciation	X34 - X39
H7	Technological competence	X40 – X47

6.6 Non-Response Bias Test

The survey results obtained from respondents were compared with the whole sample with regard to employee numbers to calculate the non-response bias.

The following two general hypotheses (null and alternative) were tested for non-response bias using a chi-square goodness-of-fit test.

H_0: The distributions of the number of employees for the 96 respondents that have implemented SAN are not different from the distribution of the entire 440 organisations.

H_a: The distributions of the number of employees for the 96 respondents that have implemented SAN are different from the distribution of the entire 440 organisations.

The purpose of a chi-square test is to tests the mathematical goodness of fit of an observed frequency distribution. In other words it is used to determine whether the observed values deviate significantly from the corresponding expected values.

Table 7.10: Number of Employees for both the Respondents and the Entire Sample

Number of Employees	Number of Respondents	Entire Sample
< 21	0	0
21-50	4	14
51-100	13	45
101-500	33	148
> 500	46	233
Total	96	440

From the chi-square results, the null hypothesis was accepted and the alternative hypothesis was rejected. Therefore, the respondents matched the employee size.

The chi-square statistic for the employee size is 1.799 (for degree of freedom 3, significance level .615). This shows that the variance is not large, and the group is not significantly different. The results indicate that the 96 respondents that have implemented SAN may not be different from the distribution of the entire 440 organisations. In this regard, the survey results may not be affected by response bias.

Table 7.11: Chi-square for non-response bias

	Attributes
Chi-Square	1.799
df	3
Asymp. Sig.	.615

7.7 Reliability Test

Reliability can be assessed by posting the following three questions (Easterby-Smith et al. 2002, p. 53):

1. Will the measures yield the same results on other occasions?
2. Will similar observations be reached by other observers?
3. Is there transparency in how sense was made from the raw data?

A measure is reliable if it provides consistent outcomes. Churchill (1979) suggested that reliability can reflect the validity of the measure and therefore the coefficient alpha should be the first measure to be calculated. Accordingly, this study calculated the Cronbach's coefficient alpha (α) to test the questionnaire's reliability. According to Emory and Cooper (1991), the Cronbach's alpha (α) is based on internal consistency and as such it is the most useful for multi-item scales at the interval level of measurement as used in this study. According to Nunnally (1978) reliability of .50 and .60 should suffice and reliability beyond .80 is wasteful. On the other hand, Churchill (1979) suggested a cut-off point of .70. In this study a cut-off point of .60 was considered.

Table 7.12 summarises the mean values and the coefficient alphas (α) for all the 14 success items (Y1 – Y14) and 47 implementation activities (X1 – X47).

Table 7.12: Mean values and Cronbach's alpha (α) for the success and implementation activities of the SAN

Hypotheses	Items Code	Items	Mean	Cronbach's coefficient alpha (α)
	X1-X47	All SAN implementation activities	4.964	.905
	Y1-Y14	All SAN implementing success items	5.222	.937
1	X1-X9	Selection of SAN system (hardware, software and network)	4.988	.817
1a	X4-X6	Appropriateness of the SAN System	4.965	.679
2	X10-X16	Organisations technical support	4.823	.751
3	X17-X23	Management commitment and support	5.040	.821
4	X24-X27	Communication and training	5.122	.747
5	X28-X33	Implementation's effectiveness	4.899	.717
6	X34-X39	Users' appreciation	4.903	.768
7	X40-X47	Technological competence	5.007	.837

The results from Table 7.12 indicate the following:

- The Cronbach's coefficient alpha values range from .679 for the *Appropriateness of the SAN System* (X4 – X6) to .837 for the *Technological competence for SAN implementation* (X40 – X47).

- The overall alpha for SAN implementation activities was found to be .905.

- The overall alpha for SAN implementation success was found to be .937.

- As the Cronbach's coefficient alpha values are all over .6, the cut-off point, no variable was dropped from further analysis.

- The results indicate that the questionnaires seem to be sufficient for the intended research purpose.

According to Emory and Cooper (1991), the construct validity test examines the extent to which the questionnaire measures the theoretical construct. In other words, it evaluates the theory on which the construct of the questionnaire is based. The two common methods of evaluating the construct validity of the questionnaire are:

- Correlation between total scores and item score: if the total score is valid, and if the item scores correlate with the total score, then this implies the whole construct is valid.
- Factor analysis: according to Ives and Olson (1984) factor analysis is one of the most powerful approaches to examine the construct validity of the questionnaire because factor analysis examines the underlying structure of the overall measure.

Therefore the two validity tests performed were:

- content validity to examine the sampling adequacy of the instrument; and

- construct validity which deals with the theoretical construct of the instrument.

7.7.1 Validity Test

One of the most important criteria for the suitability of any data set is measurement validity. Validity refers to the extent to which an instrument evaluates what it is intended to measure. Two types of validity, *content validity* and *construct validity* were investigated for all the 14-Y and 47-X items in this study:

7.7.2 Content Validity

Examines the sampling adequacy of the instrument or the appropriateness of the content. This was achieved by:

- an extensive search of literature in order to include all possible items in the measurement including research papers, journals, books, on-line articles etc.;
- a pilot-test using focus group members; and
- revisions of the questionnaire by the focus group and number of SAN experts.

7.7.3 Construct Validity

Construct validity refers to the extent to which an instrument measures a theoretical construct; that is, it evaluates the theory which the construct is based on, as well as the measuring instrument used (Emory and Cooper 1991). The purpose of factor analysis is to "explore the underlying variance structure of a set of correlation coefficients. Thus, factor analysis is useful for exploring and verifying patterns in a set of correlation coefficients. . . "(Brown 2001, p. 184). Factor analysis is used to study construct validity (Bachman 1990, p. 262-263; Brown 1996, p. 246).

Two common methods of evaluating construct validation are:

1. examining the correlations between total scores and item score; and

2. conducting a factor analysis. This method is considered as another approach to examine construct validity because factor analysis provides for examination of the underlying structure of the overall measure (Ives et al. 1983).

This study performed a factor analysis first to determine the set of CSFs by choosing a particular factor loading pattern to examine construct validity, and then eliminating the unnecessary items from the instrument.

Factor analysis was performed on the 14 SAN implementation success items to determine eigenvalues. The eigenvalues measure the amount of variation in the total sample accounted for by each factor. Note that the eigenvalue is not the percent of variance explained but rather a measure of "amount," used for comparison with other eigenvalues. A factor's eigenvalue may be computed as the sum of its squared factor loadings for all the variables. Note that the eigenvalues associated with the unrotated and rotated solution will differ, though their total will be the same.Two factors were found to have eigenvalues greater than 1.

A factor matrix by the items of SAN implementation success after rotation by the varimax method is presented in Table 7.14. The two factors are extracted and labelled as 1) user-oriented improvements 2) SAN system effectiveness.

Table 7.13 presents the eigenvalues, percentage variance and total cumulative percentage variance of the SAN implementation success items.

The first factor extracted, user-oriented improvements, is labelled as SUCCESS1 and has an eigenvalue of 7.990, and the second factor extracted, SAN system effectiveness, is labelled as SUCCESS2 and has an eigenvalue of 3.842. The total variance of 84.518 percent can be explained by the two extracted factors, SUCCESS1 and SUCCESS 2.

Table 7.13: Factor Statistics for SAN Implementation Success Factors

Factors	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1 User-Oriented Improvements	7.990	57.074	57.074
2 SAN System Effectiveness	3.842	27.443	84.518

Table 7.14 presents the factor statistics for the 14 SAN implementation success items after rotation by the varimax method.

The varimax is one of the most popular rotation method. For varimax a simple solution means that each factor has a small number of large loadings and a large number of zero (or small) loadings. This simplifies the interpretation because, after a varimax rotation, each original variable tends to be associated with one (or a small number) of factors, and each factor represents only a small number of variables.

Table 7.14: Factor Statistics for SAN Implementation Success Factors

	Component	
	1	2
Y6	.951	.171
Y8	.948	.091
Y9	.910	.192
Y14	.907	.174
Y13	.895	.358
Y5	.887	.269
Y7	.877	-.088
Y1	.214	.957
Y12	.219	.952
Y2	.187	.948
Y3	.192	.944
Y10	.110	.930
Y11	.244	.719
Y4	-.062	.690

The first factor extracted from the 14 implementation success variables is labelled as "user-oriented improvements" (SUCCESS1) and includes the following seven items:

1. SAN implementation has reduced the overall systems' administration (Y5).
2. SAN implementation has improved overall productivity (Y6).
3. SAN implementation has improved the overall efficiency of users (Y7).
4. SAN implementation has led to higher user/customer satisfaction (Y8).
5. SAN implementation has increased revenue and market share (Y9).
6. The SAN system is effective because of its high quality, efficiency, adequacy and security (Y13).
7. The security of the SAN system has enabled me to perform my tasks better (Y14).

The second factor extracted from the 14 implementation success variables is labelled as "SAN system effectiveness" (SUCCESS2) and includes the following seven items:

8. SAN implementation has improved systems' availability (Y1).
9. SAN implementation has improved systems' response time (Y2).
10. SAN implementation has improved systems' scalability (ability to upgrade the hardware in future) (Y3).
11. There have been overall cost savings as the result of SAN implementation (Y4).
12. SAN implementation has led to overall time saving in business operations (Y10).
13. Communication with other staff has improved because of the SAN implementation (Y11).
14. The SAN system has improved organisational effectiveness (Y12).

The second approach that is commonly used is to examine a scree plot of the eigenvalues plotted against the factor numbers. A scree plot for the data analysed in tables 6.13 is presented in figure 6.4. The number of factors appropriate for a

particular analysis is the number of factors before the plotted line turns sharply right. Thus the scree plot shown in figure 6.4 supports the results from Table 7.14.

The scree plot is a plot of eigenvalues. It provides a visual aid for deciding the number of factors. Only the first two components have eigenvalues greater than 1. On a scree plot, components 3 to 14 appear as scree at the base of a cliff composed of components 1 and 2. The first component has an eigenvalue of 7.990 and captures 57.074 percent of total variance, and the second component captures 27.443 percent of total variance. Components 1 and 2 account for 84.518 percent of the total variance.

Figure 7.4: Scree Plot of implementation success

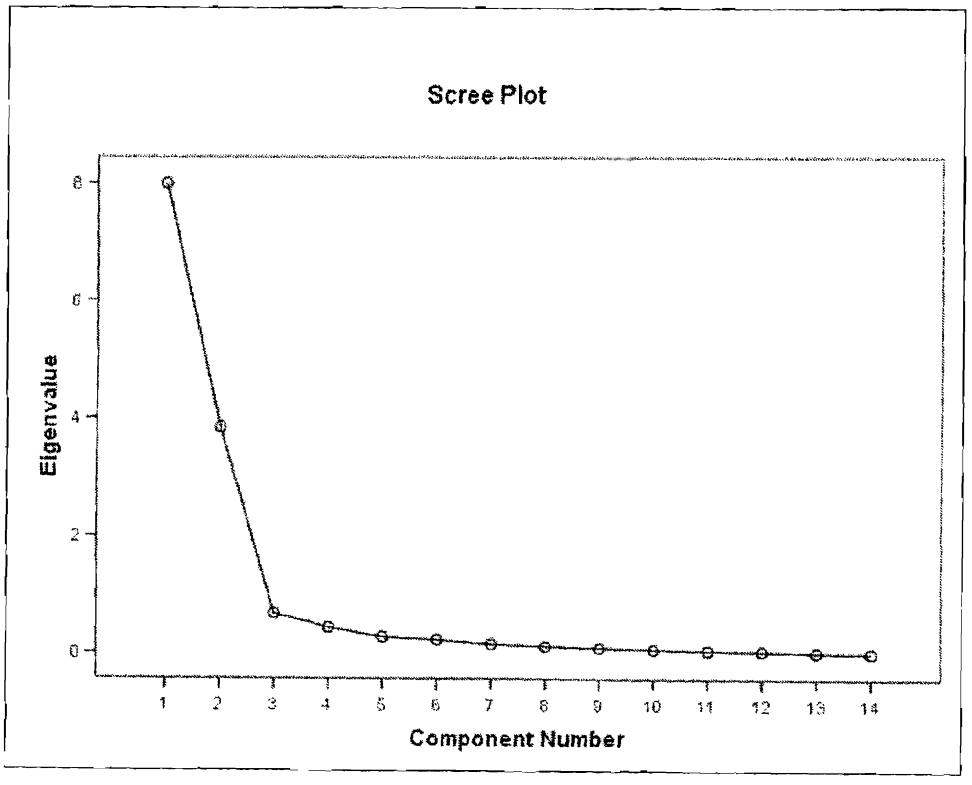


Table 7.15 presents the eigenvalues, percentage variance and total cumulative percentage variance of the SAN implementation activities.

Factor analysis was performed on the 47 implementation activities. The results indicate seven eigenvalues greater than 1. The eigenvalues range from 1.679 to

16.848. The first factor explains about 35.847 percent of the total variance, and the rest of the six factors each account for 12.059, 11.714, 9.014, 6.894, 5.49 and 3.573 percent of the total variance. Accordingly, 84.530 percent of the total variance can be explained by these seven factors.

Table 7.15: Factor Statistics for SAN Implementation Activities

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	16.848	35.847	35.847
2	5.668	12.059	47.906
3	5.505	11.714	59.620
4	4.237	9.014	68.634
5	3.240	6.894	75.528
6	2.552	5.429	80.958
7	1.679	3.573	84.530

Table 7.16 presents the factor statistics for the 47 SAN implementation activities after rotation by the varimax method.

Table 7.16: Factor Statistics for the 47 SAN Implementation Activities

	Component						
	CSF 1	CSF 2	CSF 3	CSF 4	CSF 5	CSF 6	CSF 7
X4	.911	.222	.029	-.157	.056	.044	.099
X5	.894	.340	.041	-.177	.044	.059	.088
X7	.893	.210	.008	-.177	.049	.052	.101
X30	.885	.255	.005	-.139	.033	-.034	.077
X32	.876	.320	.043	-.180	.051	.014	.048
X6	.867	.348	.056	-.148	.014	.032	.091
X3	.861	.343	.097	-.196	.022	.079	.067
X33	.858	.277	.032	-.204	.069	-.013	.002
X2	.848	.272	.088	-.216	.052	.107	.082
X29	.848	.246	.115	-.167	.076	.006	.181
X47	.324	.831	.129	-.120	.033	.088	.083
X45	.360	.825	-.001	.038	-.074	.028	-.110
X40	.383	.797	.104	-.136	.009	-.030	.113
X42	.365	.763	-.009	-.109	-.130	-.039	-.046
X39	.503	.756	-.020	-.163	-.054	.057	.136
X41	.251	.734	.160	-.009	.097	.186	.207
X38	-.112	.732	.152	-.018	.001	-.165	.504
X46	.540	711	.112	-.003	.096	123	-.091
X43	.462	.705	-.004	-.114	-.077	.154	-.108
X44	.625	.665	.058	-.121	.023	.070	-.054
X36	.576	.614	.069	-.152	.087	-.090	-.159
X37	.392	.591	-.081	-.070	-.075	-.023	.238
X34	.030	.071	.985	-.109	-.041	-.034	-.019
X21	.089	.060	.975	-.102	-.049	.055	.035
X26	100	.064	.970	-.099	-.038	.073	.039
X16	.065	053	.969	-.107	-.072	.017	.025
X24	.005	.088	.946	-.102	.003	-.065	-.058
X10	-.308	-.110	-.108	.903	-.097	-.080	.110
X27	-.314	-.133	-.104	.899	-.148	-.065	.059
X14	-.248	-.125	-.110	.896	-.084	-.025	.192
X25	-.295	-.128	-.093	.878	-.055	-.051	.143
X19	-.293	-.116	-.148	.868	-.038	-.099	.225
X31	-.143	.027	-.153	.507	.278	.224	.307
X35	.048	-.015	-.032	-.029	.988	-.036	.008
X23	.059	-.025	-.050	-.054	.988	-.021	-.034
X20	.057	-.011	-.027	-.012	.978	-.032	.016
X22	.071	-.030	-.042	-.094	.972	-.004	-.053
X18	.088	.002	-.052	-.050	.948	-.141	.031
X9	-.019	.164	.011	.067	-.050	.863	.018
X8	-.041	.024	-.134	-.036	.008	825	.098
X1	-.010	.016	.081	-.185	.081	796	.144
X15	.165	-.022	-.073	-.024	-.199	.751	-.271
X17	.200	.008	.382	.014	-.152	.625	.096
X12	.147	.008	-.098	.287	-.010	.044	.827
X13	.198	.181	.123	.006	-.040	-.016	.816
X28	.089	.117	.085	.393	.065	-.036	.722
X11	173	-.051	-.111	.296	-.062	.269	.618

All the variables in the factor statistics Table 7.16 have one loading (primary) of greater than .507. Only two variables have primary loading lower than .6. The first variable, X31, with loading of .507, and the other variable, X37, with loading of .591.

The first factor extracted from the 47 implementation success activities is labelled as "implementation's effectiveness" (CSF1) and includes the following ten items:

1. The chosen SAN system is sufficient for users' needs (X4).
2. The chosen SAN system provided ample storage for users (X5).
3. The response time of the SAN system satisfies my expectations (X7).
4. The SAN implementation has resulted in time savings in business operations and management (X30).
5. The SAN implementation has resulted in improved productivity and efficiency of users (X32).
6. The chosen SAN system is easy to operate (X6).
7. The chosen SAN system is right for the company (X3).
8. The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response) (X33).
9. The SAN system used in the company fully met users' expectations (X2).
10. The implementation of the SAN system has improved the speed of the product/service cycle (X29).

The second factor extracted from the 47 implementation success activities is labelled as "technological competence" (CSF2) and includes the following twelve items:

1. There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components) (X47).
2. There is a high level of technological competence of SAN system knowledge, experience and expertise in the company (X45).
3. Our company has competent SAN technical staff (X40).

4. SAN technical staff have facilitated an increase in the productivity of users (X42).
5. Users' attitudes to the SAN system implementation are positive (X39).
6. There are reliable and qualified SAN services available (X41).
7. The implementation of the SAN system prompted users' participation in the SAN system implementation (X38).
8. There are adequate SAN-related knowledge and skills throughout the organisation (X46).
9. SAN technical staff provide adequate control for SAN system implementation and maintenance (X43).
10. There is adequate SAN infrastructure in place (X44).
11. The implementation of the SAN system increased users' utilisation of IT systems (X36).
12. Users' expectations of the SAN system increased after the implementation (X37).

The third factor extracted from the 47 implementation success items is labelled as "users' appreciation" (CSF3) and includes the following five items:

1. The implementation of the SAN system increased users' confidence (X34).
2. Top management promoted users' commitment and support for the SAN system implementation (X21).
3. Users were provided with a good understanding of the implemented SAN system (X26).
4. The company streamlined the technical support for the implementation of the SAN system (X16).
5. The implementation of the SAN system was communicated to all users and technical staff (X24).

The fourth factor extracted from the 47 implementation success activities is labelled as "communication and training" (CSF4) and includes the following six items:

1. The company provided a satisfactory level of technical support for the implementation of the SAN system (X10).
2. Training resources for the SAN system were managed effectively and efficiently (X27).
3. The response time for providing technical support for the implementation of the SAN system is good (X14).
4. The implementation of the SAN system was publicised to all organisational units (X25).
5. Top management made available for the implementation of SAN a wide range of resources (X19).
6. The SAN implementation has resulted in cost savings in business operations and management (X31).

The fifth factor extracted from the 47 implementation success activities is labelled as "management commitment and support" (CSF5) and includes the following five items:

1. The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources (X35).
2. The success of the SAN implementation was due to the effort of the top management leadership (X23).
3. Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm (X20).
4. Top management were continuously involved in the SAN implementation efforts and processes (X22).
5. Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation (X18).

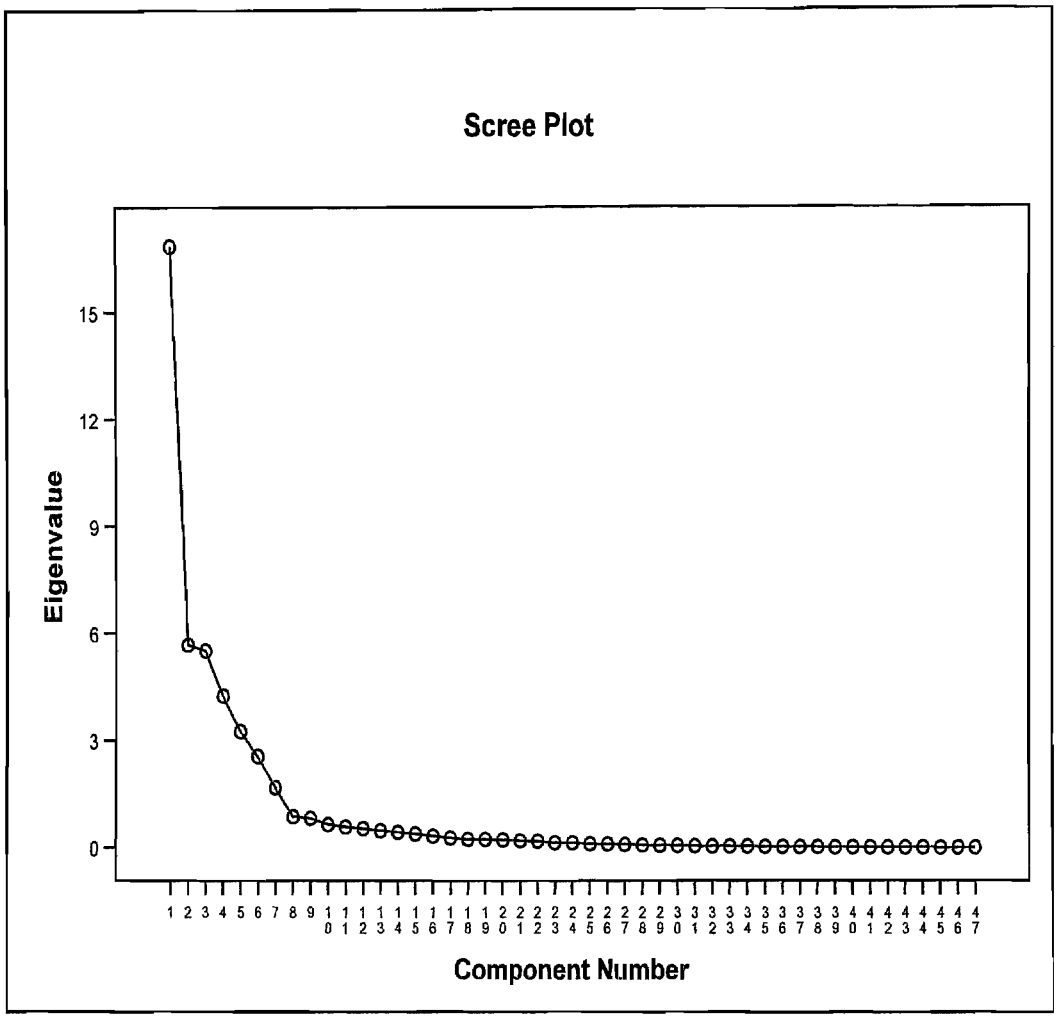
The sixth factor extracted from the 47 implementation success activities is labelled as "selection of the SAN system (hardware, software and network)" (CSF6) and includes the following five items:

1. The use of the SAN system has streamlined my work (X9).
2. The selected SAN system is useful for my intended use (X8).
3. The SAN system used in the company is suitable for the company's intended use (X1).
4. The technical support was useful for the implementation of the SAN system (X15).
5. Top management thoroughly understood the goals and objectives of SAN implementation (X17).

The seventh factor extracted from the 47 implementation success activities is labelled as "organisation's technical support" (CSF7) and includes the following four items:

1. The technical support for the implementation of the SAN system is sufficient (X12).
2. The technical support made the implementation of the SAN system easier (X13).
3. The implementation of the SAN system has improved system availability (X28).
4. The technical support for the implementation of the SAN system fulfilled users' requirements (X11).

Figure 7.5: Scree Plot of implementation activities



The scree plot is a plot of eigenvalues. It provides a visual aid for deciding the number of factors. Only the first seven components have eigenvalues greater than 1. On a scree plot components 8 to 47 appear as scree at the base of cliff composed of components 1 to 7. The first component has an eigenvalue of 16.848 and captures 35.847 percent of total variance. Components 1 to 7 account for 84.530 percent of the total variance.

The seven factors and their corresponding items have been grouped in Table 7.17.

Table 7.17: Components of the factors extracted from the 47 implementation activities

CSF1: Implementation's effectiveness	
X4	The chosen SAN system is sufficient for users' needs.
X5	The chosen SAN system provided ample storage for users.
X7	The response time of the SAN system satisfies my expectations.
X30	The SAN implementation has resulted in time savings in business operations and management.
X32	The SAN implementation has resulted in improved productivity and efficiency of users.
X6	The chosen SAN system is easy to operate.
X3	The chosen SAN system is right for the company.
X33	The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).
X2	The SAN system used in the company fully met users' expectations.
X29	The implementation of the SAN system has improved the speed of the product/service cycle.
CSF2: Technological competence	
X47	There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).
X45	There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.
X40	Our company has competent SAN technical staff.
X42	SAN technical staff have facilitated an increase in the productivity of users.
X39	Users' attitudes to the SAN system implementation are positive.
X41	There are reliable and qualified SAN services available.
X38	The implementation of the SAN system prompted users' participation in the SAN system implementation.
X46	There are adequate SAN-related knowledge and skills throughout the organisation.
X43	SAN technical staff provide adequate control for SAN system implementation and maintenance.
X44	There is adequate SAN infrastructure in place.
X36	The implementation of the SAN system increased users' utilisation of IT systems.
X37	Users' expectations of the SAN system increased after the implementation.
CSF3: Users' appreciation	
X34	The implementation of the SAN system increased users' confidence.
X21	Top management promoted users' commitment and support for the SAN system implementation.
X26	Users were provided with a good understanding of the implemented SAN system.
X16	The company streamlined the technical support for the implementation of the SAN system.
X24	The implementation of the SAN system was communicated to all users and technical staff.
CSF4: Communication and training	
X10	The company provided a satisfactory level of technical support for the implementation of the SAN system.
X27	Training resources for the SAN system were managed effectively and efficiently.
X14	The response time for providing technical support for the implementation of the SAN system is good.
X25	The implementation of the SAN system was publicised to all organisational units.
X19	Top management made available for the implementation of SAN a wide range of resources.

Table 7.17: Continued ...

X31	The SAN implementation has resulted in cost savings in business operations and management.
CSF5: Management commitment and support	
X35	The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.
X23	The success of the SAN implementation was due to the effort of the top management leadership.
X20	Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.
X22	Top management were continuously involved in the SAN implementation efforts and processes.
X18	Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.
CSF6: Selection of the SAN system (hardware, software and network)	
X9	The use of the SAN system has streamlined my work.
X8	The selected SAN system is useful for my intended use.
X1	The SAN system used in the company is suitable for the company's intended use.
X15	The technical support was useful for the implementation of the SAN system.
X17	Top management thoroughly understood the goals and objectives of SAN implementation.
CSF7: Organisation's technical support	
X12	The technical support for the implementation of the SAN system is sufficient.
X13	The technical support made the implementation of the SAN system easier.
X28	The implementation of the SAN system has improved system availability.
X11	The technical support for the implementation of the SAN system fulfilled users' requirements.

7.7.4 Posterior Reliability Test

After factor analysis, reliability tests were performed on the two composite factors of SAN implementation success and on the seven composite factors of SAN implementation activities. Table 7.18 presents coefficient alphas (α) for the two groups of factors. These factors provide a reliable and consistent measure of intended dimension and no further elimination of variables appeared necessary.

Table 7.18: Mean values and coefficient alpha for extracted factors

Factors (items)	Mean	Alpha
SAN Implementation Success		
User-oriented improvements (Y5, Y6, Y7, Y8, Y9, Y13, Y14)	5.234	.972
SAN system effectiveness (Y1, Y2, Y3, Y4, Y10, Y11, Y12)	5.210	.954
Impact of the SAN Implementation		
CSF1: Implementation's effectiveness (X2, X3, X4, X5, X6, X7,X29, X30, X32, X33)	4.906	.986
CSF2: Technological competence for SAN implementation (X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)	5.091	.958
CSF3: Users' appreciation (X16, X21, X24, X26, X34)	5.152	.991
CSF4: Communication and training (X10, X14, X19, X25, X27, X31)	5.125	.952
CSF5: Management commitment and support (X18, X20, X22, X23, X35)	4.994	.991
CSF6: Selection of SAN system (hardware, software and network) (X1, X8, X9, X15, X17)	5.169	.845
CSF7: Organisation's technical support (X11, X12, X13, X28)	4.971	.833

7.8 Hypotheses Testing

For the purpose of canonical correlation analysis, the criterion (dependent) variables are calculated from the SAN success variables. The predictor (independent) variables are represented by the SAN implementation activity variables.

Of all the major statistics packages, SPSS offers the least satisfactory built-in analysis for canonical correlation. However, the results and summary statistics usually called for can be elicited, albeit with some set-up.

The 14 SAN implementation success variables are grouped into two criterion variables according to the factor analysis results.

The first criterion variable, coded as SUCCESS1, is the weighted mean of the seven SAN implementation success variables that were extracted into the first factor by factor analysis. The first factor was labelled "user-oriented improvements". Table 7.19 shows the factor loadings for these seven variables. The factor loadings ranged from .877 to .951.

Table 7.19: Factor Loading for SUCCESS1

Code	User-Oriented Improvements Variables	Factor Loading
Y6	SAN implementation has improved overall productivity.	.951
Y8	SAN implementation has led to higher user/customer satisfaction.	.948
Y9	SAN implementation has increased revenue and market share.	.910
Y14	The security of the SAN system has enabled me to perform my tasks better.	.907
Y13	The SAN system is effective because of its high quality, efficiency, adequacy and security.	.895
Y5	SAN implementation has reduced the overall systems' administration.	.887
Y7	SAN implementation has improved the overall efficiency of users.	.877

The second criterion variable, coded as SUCCESS2, is the weighted mean of the seven SAN implementation success variables that were extracted into the second factor by factor analysis. This factor was labelled "SAN system effectiveness". Table 7.20 shows the factor loadings for these seven variables. The factor loadings ranged from .690 to .957.

Table 7.20: Factor Loading of SUCCESS2

Code	SAN System Effectiveness Variables	Factor Loading
Y1	SAN implementation has improved systems' availability.	.957
Y12	The SAN system has improved organisational effectiveness.	.952
Y2	SAN implementation has improved systems' response time.	.948
Y3	SAN implementation has improved systems' scalability (ability to upgrade the hardware in future).	.944
Y10	SAN implementation has led to overall time saving in business operations.	.930
Y11	Communication with other staff has improved because of the SAN implementation.	.719
Y4	There have been overall cost savings as the result of SAN implementation.	.690

According to Hair et al. (1998), the following three criteria may be used to interpret canonical function: (1) the canonical correlation; (2) the significance level of the F statistic; and (3) the redundancy index. The hypotheses are tested using canonical correlation analysis and the correlation between the dependent and canonical variables examined from the results. Firstly the original seven hypotheses were tested and then the seven factors extracted from factor analysis were examined.

7.8.1 Hypothesis One

The first hypothesis is the importance of selection of the SAN system (hardware, software and network) for the SAN implementation system.

The hypothesis statement is:

H_0: The selection of the SAN system for implementation is positively related to SAN success.

This hypothesis has one subset:

H_{1a}: The appropriateness of the SAN system is positively related to SAN implementation success.

The first subset hypothesis addresses the appropriateness of the selected SAN system.

a. The chosen SAN system is sufficient for users' needs (X4).
b. The chosen SAN system provided ample storage for users (X5).
c. The chosen SAN system is easy to operate (X6).

7.8.2 Hypotheses One – First Subset

The hypothesis statements are:

H_0: The appropriateness of the SAN system is not positively related to SAN implementation success.

H_{1a}: The appropriateness of the SAN system is positively related to SAN implementation success.

The three activity variables for testing this sub-hypothesis were:

(X4) The chosen SAN system is sufficient for users' needs.
(X5) The chosen SAN system provided ample storage for users.
(X6) The chosen SAN system is easy to operate.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and three predictor variables X4 - X6.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.21.

Table 7.21 shows the results of the canonical correlation analysis for the appropriateness of the SAN system. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .874 and .726, and the significance of the F-

statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites, SAN implementation success and the three activity variables X4 - X6 are high.

The total cumulative redundancy index is .807, indicating that 80.7 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the three predictor variables X4 - X6.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, the appropriateness of the SAN system is positively related to SAN implementation success.

Table 7.21: The Canonical Correlation for appropriateness of the SAN system.

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.874	.000	.411
SUCCESS2	.726	.000	.396
			Total: .807
Predictor			**Canonical Loading** 1 2
X4 The chosen SAN system is sufficient for users' needs.			.795 .398
X5 The chosen SAN system provided ample storage for users.			.693 .419
X6 The chosen SAN system is easy to operate.			.766 -.282

Next, the main hypothesis was tested. The hypothesis statements are:

H_0: The selection of the SAN system for implementation is not positively related to SAN success.

H_1: The selection of the SAN system for implementation is positively related to SAN success.

The nine activity variables for testing this hypothesis were:

(X1) The SAN system used in the company is suitable for the company's intended use.
(X2) The SAN system used in the company fully met users' expectations.
(X3) The chosen SAN system is right for the company.
(X4) The chosen SAN system is sufficient for users' needs.
(X5) The chosen SAN system provided ample storage for users.
(X6) The chosen SAN system is easy to operate.
(X7) The response time of the SAN system satisfies my expectations.
(X8) The selected SAN system is useful for my intended use.
(X9) The use of the SAN system has streamlined my work.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and nine predictor variables, X1 - X9.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.22.

Table 7.22 shows the results of the canonical correlation analysis for the selected SAN system. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .931 and .741, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the nine activity variables X1 - X9 are high.

The total cumulative redundancy index is .818, indicating that 81.8 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the nine predictor variables X1 - X9.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, the selection of the SAN system for implementation is positively related to SAN success.

Table 7.22: The Canonical Correlation for the selection of the SAN system

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.931	.000	.521
SUCCESS2	.741	.000	.297
			Total: .818
Predictor			**Canonical Loading** 1 2
X1 The SAN system used in the company is suitable for the company's intended use.			.721 .379
X2 The SAN system used in the company fully met users' expectations			.854 .509
X3 The chosen SAN system is right for the company.			.692 .626
X4 The chosen SAN system is sufficient for users' needs.			.683 .466
X5 The chosen SAN system provided ample storage for users.			.809 .584
X6 The chosen SAN system is easy to operate.			.753 .449
X7 The response time of the SAN system satisfies my expectations.			.659 .545
X8 The selected SAN system is useful for my intended use.			.582 -.232
X9 The use of the SAN system has streamlined my work.			.773 .238

7.8.3 Hypothesis Two

The second hypothesis is the importance of the organisation's technical support for the SAN implementation.

H_0: An organisation's technical support for the implementation of the SAN system is not positively related to SAN success.

H_2: An organisation's technical support for the implementation of the SAN system is positively related to SAN success.

The seven predictors for the canonical correlation are:

(X10) The company provided a satisfactory level of technical support for the implementation of the SAN system.
(X11) The technical support for the implementation of the SAN system fulfilled users' requirements.
(X12) The technical support for the implementation of the SAN system is sufficient.
(X13) The technical support made the implementation of the SAN system easier.
(X14) The response time for providing technical support for the implementation of the SAN system is good.
(X15) The technical support was useful for the implementation of the SAN system.
(X16) The company streamlined the technical support for the implementation of the SAN system.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X10 - X16.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.23.

Table 7.23 shows the results of the canonical correlation analysis for organisation's technical support. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .735 and .816, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the seven activity variables X10 – X16 is high.

Low redundancy index results from the great number of the variables in canonical correlation analysis, some having low component loadings. Negative loading indicates that a high score on the variable relates to a low score on the variate.

The total cumulative redundancy index is .792, indicating that 79.2 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the seven predictor variables X10 – X16.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, an organisation's technical support for the implementation of the SAN system is positively related to SAN success.

Table 7.23: The Canonical Correlation for Organisation's Technical Support.

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.735	.000	.174
SUCCESS2	.816	.000	.618
			Total: .792
Predictor			**Canonical Loading** 1 2
X10 The company provided a satisfactory level of technical support for the implementation of the SAN system.			.802 -.185
X11 The technical support for the implementation of the SAN system fulfilled users' requirements.			.788 .336
X12 The technical support for the implementation of the SAN system is sufficient.			.626 .312
X13 The technical support made the implementation of the SAN system easier.			.637 .443
X14 The response time for providing technical support for the implementation of the SAN system is good.			.721 -.185
X15 The technical support was useful for the implementation of the SAN system.			.430 -.261
X16 The company streamlined the technical support for the implementation of the SAN system.			.742 .209

7.8.4 Hypothesis Three

The third hypothesis is the importance of management commitment and support for SAN implementation.

H_0: Commitment and support from management are not related to SAN implementation success.

H_3: Commitment and support from management are related to SAN implementation success.

The seven predictors for the canonical correlation are:

(X17) Top management thoroughly understood the goals and objectives of SAN implementation.
(X18) Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.
(X19) Top management made available for the implementation of SAN a wide range of resources.
(X20) Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.
(X21) Top management promoted users' commitment and support for the SAN system implementation.
(X22) Top management were continuously involved in the SAN implementation efforts and processes.
(X23) The success of the SAN implementation was due to the effort of the top management leadership.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X17 – X23.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.24.

Table 7.24 shows the results of the canonical correlation analysis for management commitment and support. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .910 and .732, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the seven activity variables X17 – X23 is high.

The total cumulative redundancy index is .845, indicating that 84.5 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the seven predictor variables X17 – X23.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, commitment and support from management are related to SAN implementation success.

Table 7.24: The Canonical Correlation for Management Commitment and Support

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.910	.000	.456
SUCCESS2	.732	.000	.389
			Total: .845

Predictor	Canonical Loading 1	2
X17 Top management thoroughly understood the goals and objectives of SAN implementation.	.780	.265
X18 Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.	.751	.373
X19 Top management made available for the implementation of SAN a wide range of resources.	.539	.459
X20 Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.	.662	.799
X21 Top management promoted users' commitment and support for the SAN system implementation.	.719	.046
X22 Top management were continuously involved in the SAN implementation efforts and processes.	.620	.781
X23 The success of the SAN implementation was due to the effort of the top management leadership.	.456	.575

7.8.5 Hypothesis Four

The fourth hypothesis is the importance of communication and training for SAN implementation.

H_0: Communication and training are not positively related to SAN implementation success.

H_4: Communication and training are positively related to SAN implementation success.

The four predictors for the canonical correlation are:

(X24) The implementation of the SAN system was communicated to all users and technical staff.
(X25) The implementation of the SAN system was publicised to all organisational units.
(X26) Users were provided with a good understanding of the implemented SAN system.
(X27) Training resources for the SAN system were managed effectively and efficiently.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X24 – X27.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.25.

Table 7.25 shows the results of the canonical correlation analysis for communication and training. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .743 and .786, and the significance of the F-statistic is less than

.000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the four activity variables X24 – X27 is high.

The total cumulative redundancy index is .731, indicating that 73.1 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the four predictor variables X24 – X27.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, communication and training are positively related to SAN implementation success.

Table 7.25: The Canonical Correlation Communication and Training

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.743	.000	.359
SUCCESS2	.786	.000	.372
			Total: .731
Predictor			**Canonical Loading** **1** **2**
X24 The implementation of the SAN system was communicated to all users and technical staff.			.884 -.252
X25 The implementation of the SAN system was publicised to all organisational units			.647 .174
X26 Users were provided with a good understanding of the implemented SAN system.			.765 .583
X27 Training resources for the SAN system were managed effectively and efficiently.			.713 .428

7.8.6 Hypothesis Five

The fifth hypothesis is the importance of the implementation's effectiveness for SAN implementation.

H_0: The implementation's effectiveness is not positively related to SAN implementation success.

H_5: The implementation's effectiveness is positively related to SAN implementation success.

The six predictors for the canonical correlation are:

(X28) The implementation of the SAN system has improved system availability.
(X29) The implementation of the SAN system has improved the speed of the product/service cycle.
(X30) The SAN implementation has resulted in time savings in business operations and management.
(X31) The SAN implementation has resulted in cost savings in business operations and management.
(X32) The SAN implementation has resulted in improved productivity and efficiency of users.
(X33) The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X28 – X33.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.26. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .832 and .798, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the

two linear composites SAN implementation success and the six activity variables X28 – X33 are high.

The total cumulative redundancy index is .693, indicating that 69.3 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the six predictor variables X28 – X33.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, the implementation's effectiveness is positively related to SAN implementation success.

Table 7.26: The Canonical Correlation for Implementation's Effectiveness

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.832	.000	.435
SUCCESS2	.798	.000	.258
			Total: .693
Predictor			**Canonical Loading** 1 2
X28 The implementation of the SAN system has improved system availability.			.873 -.261
X29 The implementation of the SAN system has improved the speed of the product/service cycle.			.633 .409
X30 The SAN implementation has resulted in time savings in business operations and management.			.652 .528
X31 The SAN implementation has resulted in cost savings in business operations and management.			.773 .450
X32 The SAN implementation has resulted in improved productivity and efficiency of users.			.807 .460
X33 The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).			.733 .338

7.8.7 Hypothesis Six

The sixth hypothesis is the importance of users' appreciation for SAN implementation.

H_0: Users' appreciation is not positively related to SAN implementation success.

H_6: Users' appreciation is positively related to SAN implementation success.

The six predictors for the canonical correlation are:

(X34) The implementation of the SAN system increased users' confidence.
(X35) The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.
(X36) The implementation of the SAN system increased users' utilisation of IT systems.
(X37) Users' expectations of the SAN system increased after the implementation.
(X38) The implementation of the SAN system prompted users' participation in the SAN system implementation.
(X39) Users' attitudes to the SAN system implementation are positive.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X34 – X39.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.27.

Table 7.27 shows the results of the canonical correlation analysis for users' appreciation. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .761 and .705, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the six activity variables X34 – X39 are high.

The total cumulative redundancy index is .853, indicating that 85.3 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the six predictor variables (X34 – X39).

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, users' appreciation is positively related to SAN implementation success.

Table 7.27: The Canonical Correlation for Users' Appreciation

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.761	.000	.464
SUCCESS2	.705	.000	.389
			Total: .853
Predictor			**Canonical Loading** 1 2
X34 The implementation of the SAN system increased users' confidence.			.716 .757
X35 The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.			.673 .683
X36 The implementation of the SAN system increased users' utilisation of IT systems.			.596 .382
X37 Users' expectations of the SAN system increased after the implementation.			.797 .669
X38 The implementation of the SAN system prompted users' participation in the SAN system implementation.			.790 .494
X39 Users' attitudes to the SAN system implementation are positive.			.748 .511

7.8.8 Hypothesis Seven

The seventh hypothesis is the importance of technological competence for SAN implementation.

H_0: The organisation's technological competence for implementing the SAN system is not positively related to SAN implementation success.

H_7: The organisation's technological competence for implementing the SAN system is positively related to SAN implementation success.

The eight predictors for the canonical correlation are:

(X40) Our company has competent SAN technical staff.
(X41) There are reliable and qualified SAN services available.
(X42) SAN technical staff have facilitated an increase in the productivity of users.
(X43) SAN technical staff provide adequate control for SAN system implementation and maintenance.
(X44) There is adequate SAN infrastructure in place.
(X45) There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.
(X46) There are adequate SAN-related knowledge and skills throughout the organisation.
(X47) There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and seven predictor variables X40 – X47.

The result of the canonical correlation analysis for appropriateness of the SAN system is shown in Table 7.28.

Table 7.28 shows the results of the canonical correlation analysis for the organisation's technological competence. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .813 and .797, and the significance of the F-statistic is less than .000, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the eight activity variables X40 – X47 are high.

The total cumulative redundancy index is .800, indicating that 80.0 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the eight predictor variables X40 – X47.

The results indicate that the null hypothesis is rejected, and there is sufficient evidence for the research hypothesis to be supported. Thus, the organisation's technological competence for implementing the SAN system is positively related to SAN implementation success.

Table 7.28: The Canonical Correlation for Organisation's Technological Competence

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.813	.000	.709
SUCCESS2	.797	.000	.191
			Total: .800
Predictor			**Canonical Loading** 1 2
X40 Our company has competent SAN technical staff.			.822 .096
X41 There are reliable and qualified SAN services available.			.717 .170
X42 SAN technical staff have facilitated an increase in the productivity of users.			.618 .135
X43 SAN technical staff provide adequate control for SAN system implementation and maintenance.			.760 .248

X44 There is adequate SAN infrastructure in place.	.889	-.115
X45 There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.	.793	.382
X46 There are adequate SAN-related knowledge and skills throughout the organisation.	.613	.440
X47 There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).	.719	-.151

7.9 Hypotheses Testing by Factors

In addition, canonical correlation analysis was used for measuring the relationships between the predictor (independent) variable, the CSFs that have been extracted by factor analysis from the 47 implementation activities X1 – X47 and the two criterion (dependent) variables, SUCCESS1 and SUCCESS2, extracted by factor analysis from the 14 SAN implementation success variables Y1 – Y14.

Canonical correlation analysis was also used to test the hypotheses as well as the seven CSFs extracted from the survey instruments for SAN implementation success.

This following section will attempt to find the relationships between the expected CSFs and SAN implementation success.

7.9.1 Testing CSF1

The first success factor extracted from the 47 implementation activities is labelled "implementation effectiveness".

The hypothesis statements are:

H_0: Implementation's effectiveness is not positively related to SAN implementation success.

H_1: Implementation's effectiveness is positively related to SAN implementation success.

The ten activity variables for testing this hypothesis were:

(X2) The SAN system used in the company fully met users' expectations.
(X3) The chosen SAN system is right for the company.
(X4) The chosen SAN system is sufficient for users' needs.
(X5) The chosen SAN system provided ample storage for users.
(X6) The chosen SAN system is easy to operate.
(X7) The response time of the SAN system satisfies my expectations.
(X29) The implementation of the SAN system has improved the speed of the product/service cycle.
(X30) The SAN implementation has resulted in time savings in business operations and management.
(X32) The SAN implementation has resulted in improved productivity and efficiency of users.
(X33) The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and ten variables from the first factor extracted CSF1, X2, X3, X4, X5, X6, X7, X29, X30, X32 and X33.

The result of the canonical correlation analysis for implementation effectiveness is shown in Table 7.29. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .892 and .754, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the ten activity variables X2, X3, X4, X5, X6, X7, X29, X30, X32 and X33 are high.

The total cumulative redundancy index is .859, indicating that 85.9 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the ten predictor variables X2, X3, X4, X5, X6, X7, X29, X30, X32 and X33.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, implementation effectiveness is positively related to SAN implementation success.

Table 7.29: The Canonical Correlation for CSF1: Implementation Effectiveness for SAN Implementation

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.892	.000	.734
SUCCESS2	.754	.000	.125
			Total: .859

Predictor	**Factor Loading**	**Canonical Loading**	
		1	**2**
X2 The SAN system used in the company fully met users' expectations.	.848	.779	.632
X3 The chosen SAN system is right for the company.	.861	.873	.587
X4 The chosen SAN system is sufficient for users' needs.	.911	.741	.632
X5 The chosen SAN system provided ample storage for users.	.894	.815	.736
X6 The chosen SAN system is easy to operate.	.867	.803	.821
X7 The response time of the SAN system satisfies my expectations.	.893	.760	.533
X29 The implementation of the SAN system has improved the speed of the product/service cycle.	.848	.638	.874

X30 The SAN implementation has resulted in time savings in business operations and management.	.885	.789	-.421
X32 The SAN implementation has resulted in improved productivity and efficiency of users.	.876	.843	.692
X33 The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).	.858	.782	.657

7.9.2 Testing CSF2

The second success factor extracted from the 47 implementation activities is labelled "technological competence".

The hypothesis statements are:

H_0: The organisation's technological competence for implementing the SAN system is not positively related to SAN implementation success.

H_2: The organisation's technological competence for implementing the SAN system is positively related to SAN implementation success.

The twelve activity variables for testing this hypothesis were:

(X36) The implementation of the SAN system increased users' utilisation of IT systems.

(X37) Users' expectations of the SAN system increased after the implementation.

(X38) The implementation of the SAN system prompted users' participation in the SAN system implementation.

(X39) Users' attitudes to the SAN system implementation are positive.

(X40) Our company has competent SAN technical staff.

(X41) There are reliable and qualified SAN services available.

(X42) SAN technical staff have facilitated an increase in the productivity of users.

(X43) SAN technical staff provide adequate control for SAN system implementation and maintenance.

(X44) There is adequate SAN infrastructure in place.

(X45) There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.

(X46) There are adequate SAN-related knowledge and skills throughout the organisation.

(X47) There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and twelve variables from second factor extracted CSF2, X36 - X47.

The result of the canonical correlation analysis for technological competence is shown in Table 7.30. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .912 and .721, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the twelve activity variables X36 – X47 are high.

The total cumulative redundancy index is .794, indicating that 79.4 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the ten predictor variables X36 – X47.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, the organisation's technological competence for implementing the SAN system is positively related to SAN implementation success.

Table 7.30: The Canonical Correlation for CSF2: Technological Competence for SAN Implementation

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.912	.000	.571
SUCCESS2	.721	.000	.223
			Total: .794

Predictor	Factor Loading	Canonical Loading 1	Canonical Loading 2
X36 The implementation of the SAN system increased users' utilisation of IT systems.	.614	.851	.786
X37 Users' expectations of the SAN system increased after the implementation.	.591	.749	.531
X38 The implementation of the SAN system prompted users' participation in the SAN system implementation.	.732	.756	.604
X39 Users' attitudes to the SAN system implementation are positive.	.756	.814	.692
X40 Our company has competent SAN technical staff.	.797	.721	.586
X41 There are reliable and qualified SAN services available.	.734	.812	-.346
X42 SAN technical staff have facilitated an increase in the productivity of users.	.763	.894	.604
X43 SAN technical staff provide adequate control for SAN system implementation and maintenance.	.705	.784	.722
X44 There is adequate SAN infrastructure in place.	.665	.657	.686
X45 There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.	.825	.643	.546

X46 There are adequate SAN-related knowledge and skills throughout the organisation.	.711	.756	.604
X47 There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).	.831	.684	.692

7.9.3 Testing CSF3

The third success factor extracted from the 47 implementation activities is labelled "users' appreciation".

The hypothesis statements are:

H_0: Users' appreciation is not positively related to SAN implementation success.

H_3: Users' appreciation is positively related to SAN implementation success.

The five activity variables for testing this hypothesis were:

(X16) The company streamlined the technical support for the implementation of the SAN system.

(X21) Top management promoted users' commitment and support for the SAN system implementation.

(X24) The implementation of the SAN system was communicated to all users and technical staff.

(X26) Users were provided with a good understanding of the implemented SAN system.

(X34) The implementation of the SAN system increased users' confidence.

The canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and five variables from third factor extracted CSF3, X16, X21, X24, X26 and X34.

The result of the canonical correlation analysis for users' appreciation is shown in Table 7.31. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .727 and .802, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the five activity variables X16, X21, X24, X26 and X34 are high.

The total cumulative redundancy index is .797, indicating that 79.7 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the five predictor variables X16, X21, X24, X26 and X34.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, users' appreciation is positively related to the SAN implementation success.

Table 7.31: The Canonical Correlation for CSF3: Users' Appreciation for SAN Implementation

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.727	.000	.365
SUCCESS2	.802	.000	.432
			Total: .797

Predictor	Factor Loading	Canonical Loading 1	Canonical Loading 2
X16 The company streamlined the technical support for the implementation of the SAN system.	.969	.831	.577
X21 Top management promoted users' commitment and support for the SAN system implementation.	.975	.755	.406
X24 The implementation of the SAN system was communicated to all users and technical staff.	.946	.718	.632
X26 Users were provided with a good understanding of the implemented SAN system.	.970	.710	.776
X34 The implementation of the SAN system increased users' confidence.	.985	.683	.624

7.9.4 Testing CSF4

The fourth success factor extracted from the 47 implementation activities is labelled "communication and training".

The hypothesis statements are:

H_0: Communication and training are not positively related to SAN implementation success.

H_4: Communication and training are positively related to SAN implementation success.

The six activity variables for testing this hypothesis were:

(X10) The company provided a satisfactory level of technical support for the implementation of the SAN system.

(X14) The response time for providing technical support for the implementation of the SAN system is good.

(X19) Top management made available for the implementation of SAN a wide range of resources.

(X25) The implementation of the SAN system was publicised to all organisational units.

(X27) Training resources for the SAN system were managed effectively and efficiently.

(X31) The SAN implementation has resulted in cost savings in business operations and management.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and six variables from fourth factor extracted CSF4, X10, X14, X19, X25, X27 and X31.

The result of the canonical correlation analysis for communication and training is shown in Table 7.32. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .771 and .773, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the six activity variables X10, X14, X19, X25, X27 and X31 are high.

The total cumulative redundancy index is .846, indicating that 84.6 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the six predictor variables X10, X14, X19, X25, X27 and X31.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, communication and training are positively related to SAN implementation success.

Table 7.32: The Canonical Correlation for CSF4: Communication and Training for SAN Implementation

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.771	.000	.227
SUCCESS2	.773	.000	.619
			Total: .846

Predictor	**Factor Loading**	**Canonical Loading** 1	2
X10 The company provided a satisfactory level of technical support for the implementation of the SAN system.	.903	.639	.734
X14 The response time for providing technical support for the implementation of the SAN system is good.	.896	.724	.689
X19 Top management made available for the implementation of SAN a wide range of resources.	.868	.798	.613
X25 The implementation of the SAN system was publicised to all organisational units.	.878	.761	.633
X27 Training resources for the SAN system were managed effectively and efficiently.	.899	.807	.233

X31 The SAN implementation has resulted in cost savings in business operations and management.	.507	.752	.658

7.9.5 Testing CSF5

The fifth success factor extracted from the 47 implementation activities is labelled "management commitment and support".

The hypothesis statements are:

H_0: Commitment and support from management are not related to SAN implementation success.

H_5: Commitment and support from management are related to SAN implementation success.

The five activity variables for testing this hypothesis were:

(X18) Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.

(X20) Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.

(X22) Top management were continuously involved in the SAN implementation efforts and processes.

(X23) The success of the SAN implementation was due to the effort of the top management leadership.

(X35) The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and five variables from fifth factor extracted CSF5, X18, X20, X22, X23 and X35.

The result of the canonical correlation analysis for top management commitment and support is shown in Table 7.33. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .876 and .821, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the five activity variables X18, X20, X22, X23 and X35 are high.

The total cumulative redundancy index is .780, indicating that 78.0 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the five predictor variables X18, X20, X22, X23 and X35.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, commitment and support from management are related to SAN implementation success.

Table 7.33: The Canonical Correlation for CSF5: Management commitment and support for the SAN Implementation

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.876	.000	.348
SUCCESS2	.821	.000	.432
			Total: .780

Predictor	**Factor Loading**	**Canonical Loading** 1	2
X18 Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.	.948	.681	.438

X20 Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.	.978	.707	.504
X22 Top management were continuously involved in the SAN implementation efforts and processes.	.972	.850	.601
X23 The success of the SAN implementation was due to the effort of the top management leadership.	.988	.798	.658
X35 The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.	.988	.838	.595

7.9.6 Testing CSF6

The sixth success factor extracted from the 47 implementation activities is labelled "selection of the SAN system (hardware, software and network)".

The hypothesis statements are:

H_0: The selection of the SAN system for implementation is not positively related to SAN success.

H_6: The selection of the SAN system for implementation is positively related to SAN success.

The five activity variables for testing this hypothesis were:

(X1) The SAN system used in the company is suitable for the company's intended use.

(X8) The selected SAN system is useful for my intended use.

(X9) The use of the SAN system has streamlined my work.

(X15) The technical support was useful for the implementation of the SAN system.

(X17) Top management thoroughly understood the goals and objectives of SAN implementation.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and five variables from sixth factor extracted CSF6, X1, X8, X9, X15 and X17.

The result of the canonical correlation analysis for selection of SAN system is shown in Table 7.34. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .793 and .816, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the five activity variables X1, X8, X9, X15 and X17 are high.

The total cumulative redundancy index is .871, indicating that 87.1 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the five predictor variables X1, X8, X9, X15 and X17.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, the selection of the SAN system for implementation is positively related to SAN success.

Table 7.34: The Canonical Correlation for CSF6: The Selection of a SAN System for SAN Implementation

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.793	.000	.683
SUCCESS2	.816	.000	.188
			Total: .871

Predictor	Factor Loading	Canonical Loading 1	Canonical Loading 2
X1 The SAN system used in the company is suitable for the company's intended use.	.796	.794	.647
X8 The selected SAN system is useful for my intended use.	.825	.845	.644
X9 The use of the SAN system has streamlined my work.	.863	.653	.577
X15 The technical support was useful for the implementation of the SAN system.	.751	.706	.755
X17 Top management thoroughly understood the goals and objectives of SAN implementation.	.625	.813	.651

7.9.7 Testing CSF7

The seventh success factor extracted from the 47 implementation activities is labelled "organisation's technical support".

The hypothesis statements are:

Ho: An organisation's technical support for the implementation of the SAN system is not positively related to SAN success.

H7: An organisation's technical support for the implementation of the SAN system is positively related to SAN success.

The four activity variables for testing this hypothesis were:

(X11) The technical support for the implementation of the SAN system fulfilled users' requirements.
(X12) The technical support for the implementation of the SAN system is sufficient.
(X13) The technical support made the implementation of the SAN system easier.
(X28) The implementation of the SAN system has improved system availability.

Canonical correlation analysis was performed on the two criterion variables, SUCCESS1 and SUCCESS2, and four variables from seventh factor extracted CSF7, X11, X12, X13 and X28.

The result of the canonical correlation analysis for an organisation's technical support is shown in Table 7.35. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, .853 and .717, thus indicating that the bivariate correlation between the two linear composites SAN implementation success and the four activity variables X11, X12, X13 and X28 are high.

The total cumulative redundancy index is .792, indicating that 79.2 percent of the variance in SUCCESS1 and SUCCESS2 has been explained by the canonical variate for the four predictor variables X11, X12, X13 and X28.

The results indicate that the null hypothesis is rejected, at the significance of F-statistic .000, and there is sufficient evidence for the research hypothesis to be supported. Thus, an organisation's technical support for the implementation of the SAN system is positively related to SAN success.

Table 7.35: The Canonical Correlation for CSF7: An Organisation's Technical Support for SAN Implementation

Criterion	Canonical Correlation	Significance of F-Statistic	Redundancy Index
SUCCESS1	.853	.000	.578
SUCCESS2	.717	.000	.214
			Total: .792

Predictor	Factor Loading	Canonical Loading 1	Canonical Loading 2
X11 The technical support for the implementation of the SAN system fulfilled users' requirements.	.618	.789	.642
X12 The technical support for the implementation of the SAN system is sufficient.	.827	.818	.754
X13 The technical support made the implementation of the SAN system easier.	.816	.694	.554
X28 The implementation of the SAN system has improved system availability.	.722	.707	-.330

7.10 Prediction Model

In order to determine the prediction model for SAN implementation success, a stepwise approach within the regression analysis was used. The stepwise approach method uses the *partial correlation coefficient* to identify predictor variables that explain both a significant portion, and the largest portion of the error remaining from the previous regression equation. One of the main ways in which the multivariate analysis of relationship is conducted in the social sciences is through the partial correlation coefficient. The partial correlation coefficient allows examining the relationship between two variables while holding one other or more variables constant.

The first regression model (stepwise approach) was tested using the first SAN implementation success factor SUCCESS1 as the dependent variable and the 47 SAN implementation activities as the independent variables. SUCCESS1 is the weighted mean of the seven SAN implementation success variables Y5, Y6, Y7, Y8, Y9, Y13 and Y14.

The results from stepwise approach indicate the variables X40, X36, X13 and X20 are in the regression model.

Table 7.36 presents the regression model for user-oriented improvements. In this regression model, multiple R is .474 This indicates that the correlation between SUCCESS1 and independent variables X40, X36, X13 and X20 is 47.4 percent. R-square (coefficient of determination) is .225 and indicates that 22.5 percent of the variance in SUCCESS1 is explained by the independent variables X40, X36, X13 and X20. The F-statistic for the regression model is .000, indicating that there is sufficient evidence to support this regression equation. The t-test for each coefficient is less than .022, indicating that each coefficient is significantly different from zero at the significance level of .022 or less.

Therefore, from this equation model, "Our company has competent SAN technical staff (X40)", "The implementation of the SAN system increased users' utilisation of IT system (X36)", "The technical support made the implementation of the SAN system easier (X13)", and "Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm (X20)" may be used to explain and predict one part of the SAN implementation success – user-oriented improvements (SUCCESS1).

Table 7.36: Stepwise Regression for SUCCESS1: User-Oriented Improvements

Stepwise Regression for SUCCESS1 (User-Oriented Improvements)			
Multiple R = .474	**R Square** = .225	**Significance of F** = .000	
Independent variables		**Regression Coefficient**	**Sigma T**
X40	Our company has competent SAN technical staff.	.437	.022
X36	The implementation of the SAN system increased users' utilisation of IT systems.	.285	.007
X13	The technical support made the implementation of the SAN system easier.	.169	.002
X20	Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.	.135	.001
Constant		5.933	.000

The second regression model (stepwise approach) was tested using the second SAN implementation success factor SUCCESS2 as the dependent variable and the 47 SAN implementation activities as the independent variable. SUCCESS2 is the weighted mean of the seven SAN implementation success variables Y1, Y2, Y3, Y4, Y10, Y11 and Y12.

The results from stepwise approach indicate the variables X28 and X5 are in the regression model.

Table 7.37 presents the regression model for SAN system effectiveness. In this regression model, multiple R is .439. This indicates that the correlation between SUCCESS2 and independent variables X28 and X5 is 43.9 percent. R-square (the coefficient of determination) is .193 and indicates that 19.3 percent of the variance in SUCCESS2 is explained by the independent variables X28 and X5. The F-statistic for the regression model is .000, indicating that there is sufficient evidence to support this regression equation. The t-test for each coefficient is less than .016, indicating

that each coefficient is significantly different from zero at the significance level of .016 or less.

Therefore, from this equation model, "The implementation of the SAN system has improved system availability (X28)" and "The chosen SAN system provided ample storage for users (X5)" may be used to explain and predict second part of the SAN implementation success – SAN system effectiveness (SUCCESS2).

Table 7.37: Stepwise Regression for SUCCESS2: SAN System Effectiveness

Stepwise Regression for SUCCESS2 (SAN System Effectiveness)			
Multiple R = .439	**R Square =** .193	**Significance of F =** .000	
Independent variables		**Regression Coefficient**	**Sigma T**
X28	*The implementation of the SAN system has improved system availability.*	.296	.000
X5	*The chosen SAN system provided ample storage for users.*	.288	.016
Constant		3.436	.000

7.10.1 Prediction by Extracted Factors

Stepwise regression analysis was also performed on the seven factors extracted from the factor analysis. The dependent variables SUCCESS1 and SUCCESS2 in the regression were used. The independent variables in the regression are the seven CSFs CSF1, CSF2, CSF3, CSF4, CSF5, CSF6 and CSF7 extracted from the 47 SAN implementation variables.

The result of the canonical correlation analysis for the seven CSFs is shown in Table 7.38. The canonical correlations for both the factors SUCCESS1 and SUCCESS2 are high, 0.844 and 0.721.

The total cumulative redundancy index is .536, indicating that 53.6 percent of the variance in SUCCESS1 and SUCCESS2 can be explained by the canonical variate for the seven CSFs. The results shows that redundancy index of 30.1 percent of the variance of user-oriented improvements can be explained by the seven CSFs; and 23.5 percent of the variance of SAN system effectiveness can be explained by the seven CSFs.

The canonical loadings indicate that CSF5, CSF6, and CSF7 each contributes more than 51 percent for SUCCESS1, and CSF2 contributes more than 60 percent for SUCCESS2. The following regression analysis ascertains this relationship.

Table 7.38: The Canonical Correlation for the seven CSFs

Criterion	**Canonical Correlation**	**Significance of F-Statistic**	**Redundancy Index**
SUCCESS1	.844	.000	.301
SUCCESS2	.721	.000	.235
			Total: .536

Predictor CSF	**Alpha**	**Canonical Loading** 1	2
CSF1: Implementation effectiveness (X2, X3, X4, X5, X6, X7,X29, X30, X32, X33)	.986	.103	.357
CSF2: Technological competence (X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)	.958	.172	.605
CSF3: Users' appreciation (X16, X21, X24, X26, X34)	.991	.312	.282
CSF4: Communication and training (X10, X14, X19, X25, X27, X31)	.952	.296	.328
CSF5: Management commitment and support (X18, X20, X22, X23, X35)	.991	.511	-.312
CSF6: Selection of SAN system (hardware, software and network) (X1, X8, X9, X15, X17)	.845	.648	-.261
CSF7: Organisation's technical support (X11, X12, X13, X28)	.833	.731	-.147

Table 7.39 shows the regression model for SUCCESS1 and the variables of the predictor factors. According to the results obtained, multiple R value is .513, which indicates that the correlation between SUCCESS1 and the three independent variables CSF5, CSF6 and CSF7 is 51.3 percent. R-square is .263 and indicates that 26.3 percent of the variance in SUCCESS1 is explained by the three independent variables CSF5, CSF6 and CSF7.

The F-statistic for the regression model is .000, indicating that there is sufficient evidence to support this regression equation. The t-test for each coefficient is less than .012, indicating that each coefficient is significantly different from zero at the significance level of .012 or less. This result indicates that the null hypothesis cannot be rejected, and the three critical factors CSF5, CSF6 and CSF7 can be used to predict SAN implementation success - SUCCESS1 (user-oriented improvements).

Table 7.39: Regression for SUCCESS1 and the three CSFs (CSF5, CSF6 and CSF7)

Regression for SUCCESS1 and (CSF5, CSF6 and CSF7)			
Multiple R = .513	**R Square** = .263	**Significance of F** = .000	
Dependent variables			**Factor Loading**
Y6	SAN implementation has improved overall productivity.		.951
Y8	SAN implementation has led to higher user/customer satisfaction.		.948
Y9	SAN implementation has increased revenue and market share.		.910
Y14	The security of the SAN system has enabled me to perform my tasks better.		.907
Y13	The SAN system is effective because of its high quality, efficiency, adequacy and security.		.895
Y5	SAN implementation has reduced the overall systems' administration.		.887
Y7	SAN implementation has improved the overall efficiency of users.		.877
Independent variables		**Regression Coefficient**	**Sigma T**
CSF5	Management commitment and support (X18, X20, X22, X23, X35)	.154	.012
CSF6	Selection of SAN system (hardware, software and network) (X1, X8, X9, X15, X17)	. 473	.009
CSF7	Organisation's technical support (X11, X12, X13, X28)	.365	.008
Constant		.034	.927

Table 7.40 shows the regression model for SUCCESS2 and the variables of the predictor factors. According to the results obtained, multiple R value is .448, which indicates that the correlation between SUCCESS2 and the three independent variables of CSF2 is 44.8 percent. R-square is .201 and indicates that 20.1 percent of the variance in SUCCESS2 is explained by the independent variable CSF2.

The F-statistic for the regression model is .000, indicating that there is sufficient evidence to support this regression equation. The t-test for each coefficient is less than .000, except for the constant .946, indicating that the coefficient is significantly

different from zero at the significance level of .000 or less. This result indicates that the null hypothesis cannot be rejected, and the critical factor CSF2 can be used to predict SAN implementation success - SUCCESS2 (SAN system effectiveness).

Table 7.40: Regression for SUCCESS2 and the one CSF (CSF2)

Regression for SUCCESS2 and (CSF2)			
Multiple R = .448	**R Square =** .201	**Significance of F =** .000	
Dependent variables			**Factor Loading**
Y1	SAN implementation has improved systems' availability.		.957
Y12	The SAN system has improved organisational effectiveness.		.952
Y2	SAN implementation has improved systems' response time.		.948
Y3	SAN implementation has improved systems' scalability (ability to upgrade the hardware in future).		.944
Y10	SAN implementation has led to overall time saving in business operations.		.930
Y11	Communication with other staff has improved because of the SAN implementation.		.719
Y4	There have been overall cost savings as the result of SAN implementation.		.690
Independent variables		**Regression Coefficient**	**Sigma T**
CSF2	Technological competence (X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)	.432	.000
Constant		-.011	.946

CHAPTER 8

DISCUSSION AND CONCLUSION

8.1 Discussion

The results in chapter 7 indicated that the distribution between the respondents that have implemented SAN and the entire number of organisations to which the questionnaire was sent could be similar. In this regard, the survey results may not be affected by response bias, and the findings are reliable and reflect the whole population.

Accordingly, this study calculated Cronbach's coefficient alpha (α) to test the reliability of the questions making up each of the hypotheses. According to Nunnally (1978), reliability of 0.50 and 0.60 should suffice. In this study a cut-off point of 0.60 was considered. The results indicated that the selected hypotheses were reliable, and each had a Cronbach's alpha over 0.679 (table 8.1). The results from table 8.1 also show that all the extracted factors had a Cronbachs' alpha over 0.833, which indicates that the extracted factors are reliable. As all the Cronbach's alphas were above 0.6, the cut-off point for this study, none of the items was dropped from further analysis. The significant results from canonical correlation analysis support both the hypotheses of the original research model and the hypotheses of the seven composite CSFs (CSF1 – CSF7).

Table 8.1: Cronbach's Alpha (α) for the hypotheses and the extracted factors

Hypotheses	Cronbach's coefficient alpha (α)
H1: Selection of SAN system (hardware, software and network)	.817
H1a: Appropriateness of SAN system	.679
H2: Organisations technical support	.751
H3: Management commitment and support	.821
H4: Communication and training	.747
H5: Implementation's effectiveness	.717
H6: Users' appreciation	.768
H7: Technological competence	.837
Extracted Factors	
CSF1: Implementation's effectiveness (X2, X3, X4, X5, X6, X7,X29, X30, X32, X33)	.986
CSF2: Technological competence (X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)	.958
CSF3: Users' appreciation (X16, X21, X24, X26, X34)	.991
CSF4: Communication and training (X10, X14, X19, X25, X27, X31)	.952
CSF5: Top Management commitment and support (X18, X20, X22, X23, X35)	.991
CSF6: Selection of SAN system (hardware, software and network) (X1, X8, X9, X15, X17)	.845
CSF7: Organisation's technical support (X11, X12, X13, X28)	.833

The canonical correlation result, based on the seven extracted factors from factor analysis and their related implementation activities, is presented in table 8.5.

Table 8.2: Components of the seven CSFs for SAN implementation system

CSF1: Implementation's effectiveness	
X4	The chosen SAN system is sufficient for users' needs.
X5	The chosen SAN system provided ample storage for users.
X7	The response time of the SAN system fits my expectations.
X30	Time savings in business operations and management (eg. reduced order process cycle and transaction times).
X32	Improved productivity and efficiency of the users (through reduced operations and process cycle/shortened cycle time).
X6	The chosen SAN system is easy to operate.
X3	The chosen SAN system is right for the company.
X33	Higher user/customer satisfaction (through better information/service quality and timely response).
X2	The SAN system used in the company fully fitted the user's expectations.
X29	Improved speed of product/service cycle.
CSF2: Technological competence	
X47	There is a high level of technological readiness and access to technical competence (eg. hardware, software, and human resources components, etc).
X45	There is a high level of organisation's technological competence of SAN system knowledge, experience and expertise in the company.
X40	There are competent SAN Technical staffs.
X42	Facilitate an increase in the productivity of users and their business processes.
X39	Users' attitude is positively related to SAN system implementation.
X41	Provide reliable and qualified SAN services, enabling tools and education (training).
X38	The implementation of the SAN system prompted users' participation in the SAN system implementation.
X46	There is an adequacy of SAN related knowledge and skills of users and managers throughout the organization
X43	Provide adequate control for SAN system implementation and plan for maintenance and its costs.
X44	There is an adequate SAN infrastructure (eg. reliable system)
X36	The implementation of the SAN system increased users' utilization of IT systems.
X37	User's expectations of the SAN system increased after the implementation.
CSF3: Users' appreciation	
X34	The implementation of the SAN system increased users' confidence.
X21	Top management promoted users' commitment and support for the SAN system implementation.
X26	Users' were provided a good understanding of the implemented SAN system.

Table 8.2: Continued...

X16	The company streamlined the technical support for the implementation of the SAN system.
X24	The implementation f the SAN system was communicated to all users and technical staff.
CSF4: Communication and training	
X10	The company provided a suitable level of technical support for the implementation of the SAN system.
X27	The training resources for the SAN system were managed effectively and efficiently.
X14	The response time for providing the technical support for the implementation of the SAN system is good.
X25	The implementation of the SAN system was publicized to all the organisational units.
X19	Top management made available to the implementation of SAN a wide range of resources.
X31	Cost savings in business operations and management (eg. from reduced inventories, communication, order process, access to real-time data).
CSF5: Management commitment and support	
X35	The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.
X23	The success of the SAN implementation was due to the effort of the top management leadership.
X20	Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.
X22	Top management were continuously involved in the SAN implementation efforts and processes.
X18	Top management assisted the SAN implementation team in setting the strategic direction in SAN implementation.
CSF6: Selection of the SAN system (hardware, software and network)	
X9	The use of SAN system has streamlined my work.
X8	The selected SAN system is useful for my intended use.
X1	The SAN system used in the company is suitable for the company's intended use.
X15	The technical support was useful for the implementation of the SAN system.
X17	Top management thoroughly understood the goals and objectives of SAN implementation.
CSF7: Organisation's technical support	
X12	The technical support for the implementation of the SAN system is sufficient.
X13	The technical support made the implementation of the SAN system easier.
X28	Improved system availability.
X11	The technical support for the implementation of the SAN system fulfilled the user's requirements.

Next, the mapping of the seven original research hypotheses and the extracted composite factors (CSFs) from factor analysis are shown in table 8.3.

Table 8.3: The hypotheses and the extracted CSFs

Research Hypotheses	**Seven CSFs extracted from factor analysis**
H1: Selection of SAN system (hardware, software and network) **H1a:** Appropriateness of SAN System	**CSF6:** Selection of SAN system
H2: Organisations technical support	**CSF7:** Organisation's technical support
H3: Management commitment and support	**CSF5:** Management commitment and support
H4: Communication and training	**CSF4:** Communication and training
H5: Implementation's effectiveness	**CSF1:** Implementation's effectiveness
H6: Users' appreciation	**CSF3:** Users' appreciation
H7: Technological competence	**CSF2:** Technological competence

Based on the canonical correlation analysis the cumulative redundancy index for all the hypotheses was higher than 69.3 percent. The results indicate that at least 69.3 percent of the variance of SAN implementation success can be explained by the particular SAN implementation activities.

Table 8.4 shows that the seven original research hypotheses proposed by the research model are all significantly supported based on the results from canonical correlation analysis.

Table 8.4: The Original Research Hypotheses and the Results from Canonical Correlation Analysis

Research Hypotheses	Canonical Correlation 1	Canonical Correlation 2	Total Cumulative Redundancy Index	Results from Canonical Correlation Analysis
H1: Selection of SAN system (hardware, software and network)	.874	.726	.807	Significantly supported
H1a: Appropriateness of SAN System	.931	.741	.818	Significantly supported
H2: Organisations technical support	.735	.816	.792	Significantly supported
H3: Management commitment and support	.910	.732	.845	Significantly supported
H4: Communication and training	.743	.786	.731	Significantly supported
H5: Implementation's effectiveness	.832	.798	.693	Significantly supported
H6: Users' appreciation	.761	.705	.853	Significantly supported
H7: Technological competence	.813	.797	.800	Significantly supported

The lowest cumulative redundancy index for the seven extracted factors (CFSs) was 79.4 percent, which indicates that the set of seven extracted factors (CSFs) were also significantly supported.

Table 8.5: The Seven SAN Composite CSFs and Results from Canonical Correlation Analysis

Research CSFs	Results from Canonical Correlation Analysis
CSF1: Implementation's effectiveness	Significantly supported
CSF2: Technological competence	Significantly supported
CSF3: Users' appreciation	Significantly supported
CSF4: Communication and training	Significantly supported
CSF5: Management commitment and support	Significantly supported
CSF6: Selection of SAN system	Significantly supported
CSF7: Organisation's technical support	Significantly supported

From the data analysis in chapter 6, the prediction model (table 8.6) for SAN implementation reveals the following four composite CSFs as the most important CSFs for SAN implementation systems:

CSF2 : Technological competence for SAN implementation

(X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)

CSF5 : Management commitment and support for SAN implementation

(X18, X20, X22, X23, X35)

CSF6 : Selection of SAN system (hardware, software and network)

(X1, X8, X9, X15, X17)

CSF7 : Organisation's technical support for SAN implementation

(X11, X12, X13, X28)

Table 8.6: Prediction Model for SAN Implementation Success

Prediction Model	
CSF2	Technological competence (X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47)
CSF5	Management commitment and support (X18, X20, X22, X23, X35)
CSF6	Selection of SAN system (hardware, software and network) (X1, X8, X9, X15, X17)
CSF7	Organisation's technical support (X11, X12, X13, X28)

Table 8.7 shows the prediction model, mapping the original research hypotheses and the most important composite factors extracted based on the regression analysis.

Table 8.7: Prediction Model of Hypotheses and CSFs in the Order of Importance

Prediction Model (Original Hypotheses and CSFs)	
H2: Organisations technical support	**CSF7:** Organisation's technical support
H1: Selection of SAN system (hardware, software and network) **H1a:** Appropriateness of SAN system	**CSF6:** Selection of SAN system
H7: Technological competence	**CSF2:** Technological competence
H3: Management commitment and support	**CSF5:** Management commitment and support

Although four of the CSFs were identified as the most important CFSs, one should not disregard the other CSFs, as they have also been significantly supported by this study.

The other prediction model is based on the individual SAN implementation activities as the predictors. The prediction model identifies the following six most important SAN implementation activities and their corresponding original hypotheses:

1. "Our company has competent SAN technical staff" (X40) is one of the variables for the hypothesis "technological competence (H7)".
2. "The implementation of the SAN system increased users' utilisation of IT systems" (X36) is one of the variables for the hypothesis "users' appreciation (H6)".
3. "The technical support made the implementation of the SAN system easier" (X13) is one of the variables for the hypothesis "organisation's technical support (H2)".
4. "Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm" (X20) is one of the variables for the hypothesis "management commitment and support (H3)".

5. "The implementation of the SAN system has improved system availability" (X28) is one of the variables for the hypothesis "implementation effectiveness (H5)".
6. "The chosen SAN system provided ample storage for users" (X5) is one of the variables for the hypothesis "selection of the SAN system (H1)".

Although the second prediction model identifies six most important SAN implementation activities, one should not disregard the other implementation activities.

8.2 Expected Contribution of the Research

The purpose of this study is to develop and test a comprehensive model which identifies CSFs in implementation of SANs in organisations, thereby providing much needed guidance to corporate management to help them evaluate the effectiveness of SAN implementation.

Therefore, the results of this study may provide a contribution to both academic research and management as well as to large corporates that have plans to implement SAN. Assessment of SAN could help focus future research on questions that significantly impact decisions regarding SAN implementation. It is also believed that the expected findings may help extend the existing knowledge on SAN and e-business implementation research.

The other expected contribution from this study is to identify and provide knowledge on key factors or CSFs for companies which have already implemented or plan to implement SAN in their business operations. This study will also provide a basic knowledge for further research on SAN implementation. Companies may also benefit from the results and be able to utilise the assessment for planning purposes. As a result they may be better equipped to deal with SAN implementation concerns.

8.3 Possible Limitations of the Research

As this research is the first of its kind, the first possible limitation is due to the lack of information in the following areas:

a) research field;
b) empirical data; and
c) theoretical framework.

The second possible limitation is related to the response bias. In the course of the survey, respondents can be biased for many reasons such as pressure from top management to provide positive feedback, anger towards top management that may lead to negative feedback and limited time to appropriately complete the questionnaire. As the main ethical issue related to this research was to maintain the confidentiality and anonymity to respondents and to protect the respondents' privacy so that the respondents would remain anonymous, the research could not identify which companies responded to the questionnaire. However, even if response bias does exist, it is possible that the respondents are adequate representatives of the entire organisations, because of their experience in SAN implementation. Nevertheless, the tests for non-response bias have provided satisfactory results.

The third possible limitation is the statistical approach. The stepwise regression procedure allows only one variable to enter the regression equation in each step. In the event that some combination of variables would explain a significant portion of the variance, but no single one is significant by itself, none of them would be included in the regression model. However, if regression of all possible subsets were used, there would be a large number of models to be tested, and as a result the prediction model might not provide suitable model.

The fourth possible limitation is the possibility of collinearity (a relationship between two independent variables) or multi-collinearity (a relationship between an

independent variable and a set of other independent variables) may cause the regression coefficient to be unreliable.

The fifth possible limitation is that the survey was aimed at exploring the perception of the respondents with respect to the importance of the CSFs. It would be interesting to expand this study in the future by investigating the practice of these factors. Hence the emphasis would shift from "perceived importance" to what organisations do in practice in order to make their SAN implementation successful.

Finally, the results of this research should be interpreted with caution, since the survey data have number of limitations discussed above.

8.4 Areas for Future Research

There are number of areas for future research.

It is believed that behaviour and attitude of users could impact on the usage of SAN systems. Accordingly, further research may be warranted in the following two areas:

The first area is influence of regional differences. Because regional factors may affect users' behaviour and attitude towards SAN systems, it may be of interest to study the influence of such factors on the implementation of SAN systems.

The second area is influence of demographics. Demographic refers to "a population's size, age, structure, geographic distribution, ethnic mix and income distribution" (Hanson et al. 2005, p. 51). Within the global environment that SAN systems may operate, there could be a diverse mix of all the features that make up the demographic segment. Accordingly, it is imperative that companies, embarking on the implementation of global SAN systems, study the relevance of demographic factors in adding value and creating strategic advantages and innovations to those companies.

The third area is to consider the affect of globalisation-glocalisation on the criticalness of the success factors for SAN implementation.

The fourth area is to determine if senior management perceives the importance of the critical success factors differently from other, lower levels of management.

The fifth area is to study the perception of software-hardware developers regarding the SAN implementation.

The sixth area is to study the impact of successful implementation of SAN on the growth of e-commerce and/or e-businesses.

The seventh area is to examine the impact of efficacy knowledge management programs on the success of SAN implementation.

The eighth area is to study the impact of the success of SAN implementation on organisational corporate governance.

The ninth area is to use the success factors of SAN implementation in a carefully simulated research environment to test if they really work in real company settings.

The tenth area is to conduct a limited number of case studies for the purpose of comparing the results in order to clarify and evaluate the possible response bias in this study.

8.5 Conclusions

This research project was intended to provide both theoretical and practical new insights into the implementation of a SAN system as a strategic knowledge management tool. A SAN implementation is complex and involves a vast number of different hardware, hardware vendors, software and infrastructure setups. This research found number of factors that can all contribute to the success of a SAN implementation as a strategic knowledge management tool in organisations. It is hoped that the framework presented in this research and the findings presented could form a base for a fundamental theory that can aid the further development of the SAN and the IS research field.

As this was one of the first kind of research conducted in this field, there is a probability that the data offered reliability but not necessarily consistency. The prediction models presented are to be perceived as guidelines only. The parameters set in these models are snapshots of the conditions of the industry at that particular time and place. Since the prediction model meets the minimum requirements of the overall goodness of fit measures, it can estimate the observed variance-covariance matrix in the dataset but no more than that (Hair et al. 1998).

The current study delivers valuable insights into the CSFs of SAN as a strategic knowledge management tool in medium to large organisations. Organisations that are considering the implementation of a SAN strategy can utilise these results to become better acquainted with SAN implementations. Results indicate that SAN implementation is successful when adequate *management commitment and support*, supported by a suitable *selection of the SAN system (hardware, software and network)* IT infrastructure measured by *organisations technical support* and *technological competence* in implementing SAN, are in place.

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APPENDICES

APPENDIX-A

A SAMPLE OF FINAL QUESTIONNAIRE

SAMPLE QUESTIONNAIRE

SECTION 1: Implementation of the SAN

Please choose (tick or circle) the answer that best describes the characteristics of your company.

1. How long has your company been using SAN?

   ☐ < 1 year ☐ 1-2 years ☐ 2-3 years
   ☐ 3-4 years ☐ > 4 years

2. How would you rate your company's overall satisfaction with SAN implementation in your business?

   ☐ Very dissatisfied ☐ Dissatisfied ☐ Neutral (uncertain)
   ☐ Satisfied ☐ Very satisfied

3. How many employees (including part-time) work in your company?

   ☐ <20 ☐ 21-50 ☐ 51-100
   ☐ 101-500 ☐ >500

(SD) Strongly disagree 1	(MD) Moderately disagree 2	(D) Disagree 3	(U) Uncertain 4	(A) Agree 5	(MA) Moderately agree 6	(SA) Strongly agree 7

SECTION 2: Success of the SAN's implementation

Please circle the appropriate scale 1 (Strongly disagree) to 7 (Strongly agree) for the following items.

1. SAN implementation has improved systems' availability.

1	2	3	4	5	6	7

2. SAN implementation has improved systems' response time.

1	2	3	4	5	6	7

3. SAN implementation has improved systems' scalability (ability to upgrade the hardware in future).

1	2	3	4	5	6	7

4. There have been overall cost savings as the result of SAN implementation.

1	2	3	4	5	6	7

5. SAN implementation has reduced the overall systems' administration.

1	2	3	4	5	6	7

6. SAN implementation has improved overall productivity.

1	2	3	4	5	6	7

7. SAN implementation has improved the overall efficiency of users.

1	2	3	4	5	6	7

8. SAN implementation has led to higher user/customer satisfaction.

1	2	3	4	5	6	7

9. SAN implementation has increased revenue and market share.

1	2	3	4	5	6	7

10. SAN implementation has led to overall time saving in business operations.

1	2	3	4	5	6	7

11. Communication with other staff has improved because of the SAN implementation.

1	2	3	4	5	6	7

12. The SAN system has improved organisational effectiveness.

1	2	3	4	5	6	7

13. The SAN system is effective because of its high quality, efficiency, adequacy and security.

1	2	3	4	5	6	7

14. The security of the SAN system has enabled me to perform my tasks better.

1	2	3	4	5	6	7

SECTION 3: Impact of SAN's implementation

Please circle the appropriate scale 1 (Strongly disagree) to 7 (Strongly agree) for the following items.

1. The SAN system used in the company is suitable for the company's intended use.

1	2	3	4	5	6	7

2. The SAN system used in the company fully met users' expectations.

1	2	3	4	5	6	7

3. The chosen SAN system is right for the company.

1	2	3	4	5	6	7

4. The chosen SAN system is sufficient for users' needs.

1	2	3	4	5	6	7

5. The chosen SAN system provided ample storage for users.

1	2	3	4	5	6	7

6. The chosen SAN system is easy to operate.

1	2	3	4	5	6	7

7. The response time of the SAN system satisfies my expectations.

1	2	3	4	5	6	7

8. The selected SAN system is useful for my intended use.

1	2	3	4	5	6	7

9. The use of the SAN system has streamlined my work.

1	2	3	4	5	6	7

10. The company provided a satisfactory level of technical support for the implementation of the SAN system.

1	2	3	4	5	6	7

11. The technical support for the implementation of the SAN system fulfilled users' requirements.

1	2	3	4	5	6	7

12. The technical support for the implementation of the SAN system is sufficient.

1	2	3	4	5	6	7

13. The technical support made the implementation of the SAN system easier.

1	2	3	4	5	6	7

14. The response time for providing technical support for the implementation of the SAN system is good.

1	2	3	4	5	6	7

15. The technical support was useful for the implementation of the SAN system.

1	2	3	4	5	6	7

16. The company streamlined the technical support for the implementation of the SAN system.

1	2	3	4	5	6	7

17. Top management thoroughly understood the goals and objectives of SAN implementation.

1	2	3	4	5	6	7

18. Top management assisted the SAN implementation team in setting strategic directions in the SAN implementation.

1	2	3	4	5	6	7

19. Top management made available for the implementation of SAN a wide range of resources.

1	2	3	4	5	6	7

20. Top management promoted acceptance of the SAN implementation concept and efforts within the whole firm.

1	2	3	4	5	6	7

21. Top management promoted users' commitment and support for the SAN system implementation.

1	2	3	4	5	6	7

22. Top management were continuously involved in the SAN implementation efforts and processes.

1	2	3	4	5	6	7

23. The success of the SAN implementation was due to the effort of the top management leadership.

1	2	3	4	5	6	7

24. The implementation of the SAN system was communicated to all users and technical staff.

1	2	3	4	5	6	7

25. The implementation of the SAN system was publicised to all organisational units.

1	2	3	4	5	6	7

26. Users were provided with a good understanding of the implemented SAN system.

1	2	3	4	5	6	7

27. Training resources for the SAN system were managed effectively and efficiently.

1	2	3	4	5	6	7

28. The implementation of the SAN system has improved system availability.

1	2	3	4	5	6	7

29. The implementation of the SAN system has improved the speed of the product/service cycle.

1	2	3	4	5	6	7

30. The SAN implementation has resulted in time savings in business operations and management.

1	2	3	4	5	6	7

31. The SAN implementation has resulted in cost savings in business operations and management.

1	2	3	4	5	6	7

32. The SAN implementation has resulted in improved productivity and efficiency of users.

1	2	3	4	5	6	7

33. The SAN implementation has resulted in higher user/customer satisfaction (through better information/service quality and timely response).

1	2	3	4	5	6	7

34. The implementation of the SAN system increased users' confidence.

1	2	3	4	5	6	7

35. The implementation of the SAN system improved users' access (easier and quicker) to the organisation's resources.

1	2	3	4	5	6	7

36. The implementation of the SAN system increased users' utilisation of IT systems.

1	2	3	4	5	6	7

37. Users' expectations of the SAN system increased after the implementation.

1	2	3	4	5	6	7

38. The implementation of the SAN system prompted users' participation in the SAN system implementation.

1	2	3	4	5	6	7

39. Users' attitudes to the SAN system implementation are positive.

1	2	3	4	5	6	7

40. Our company has competent SAN technical staff.

1	2	3	4	5	6	7

41. There are reliable and qualified SAN services available.

1	2	3	4	5	6	7

42. SAN technical staff have facilitated an increase in the productivity of users.

1	2	3	4	5	6	7

43. SAN technical staff provide adequate control for SAN system implementation and maintenance.

1	2	3	4	5	6	7

44. There is adequate SAN infrastructure in place.

1	2	3	4	5	6	7

45. There is a high level of technological competence of SAN system knowledge, experience and expertise in the company.

1	2	3	4	5	6	7

46. There are adequate SAN-related knowledge and skills throughout the organisation.

1	2	3	4	5	6	7

47. There is a high level of technological readiness and access to technical competence (e.g. hardware, software and human resources components).

1	2	3	4	5	6	7

This completes the survey. Thank you very much for your participation.

Please return in the reply-paid envelope.