IT Strategy for Electric Utilities
- A Framework towards Effectiveness

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ABSTRACT

Electric utilities are undergoing tremendous changes due to deregulation and rapid advancement in information technology (IT). While deregulation has brought about both threats and opportunities, along with many uncertainties to utilities, modern IT has often been regarded as an important tool in order to meet the challenges ahead. However, due to the increased complexity of IT and its potential business impacts, there is need for an effective IT strategy to fully exploit its benefits. Many utilities have recognized this and have formulated their IT strategies. However, the effectiveness of the IT strategies has largely remained unexplored.

The objective of this study is to provide some insights into this largely unexplored area and to enrich our knowledge. Apart from identifying the state-of-the-practice of existing utilities’ IT strategies and the important factors affecting the effectiveness of the strategies, one of the goals is also to provide a framework which utilities can use to enhance the effectiveness of their IT strategies.

This study has taken the form of a multi-disciplinary study. It started with a technical study on various information and control systems used in the electric utility industry. It was then supplemented with further research in other related disciplines including strategic management, organization theories, and information systems in order to provide a more holistic theoretical framework.

Through a combination of case study and questionnaire survey, this study has concluded that existing IT strategies within electric utilities, mostly formulated with the traditional mind-set of the industrial-age that focused primarily on technology, is inadequate and ineffective in dealing with today's IT which has a broader implication on an organization's business activities. In order to enhance the effectiveness of future IT strategy, a framework that adopts a system approach is proposed in this thesis. This framework emphasizes on the need to take into consideration the various interacting elements within an industrial organization as postulated by Leavitt, who is a renowned organization theorist. These elements are the tasks or processes, the people, the technology, and the structure of the organization.

**Keywords:** (partly adapted to INSPEC) Information Technology (IT), Information Systems, Electric Utilities, Deregulation, Distribution Management, Distribution Automation, Powerline Telecommunication, SCADA system (Supervisory Control And Data Acquisition System), Strategy, Strategic Management, Organization Theory, Organization Structure, Business Process Reengineering.
Preface

The thesis work has been carried out at the Department of Industrial Control Systems, Royal Institute of Technology (KTH), Stockholm. The profile of the department focuses upon the understanding and developing of theories and methods for the development of cost-effective industrial IT systems. Our discipline requires researchers to take a system as well as an industrial oriented approach in order to gain a deeper understanding of the broader ramifications IT systems have on organizations. An important objective is to achieve an overall view and insight into the requirements and technical solutions available when industrial activities are to be computerized. This thesis offers a theoretical addition to the field of IT strategy for modern electric utilities in a deregulated environment, aiming to achieve higher organization effectiveness through more effective utilization of modern IT systems. The thesis work was started in August 1995.

Acknowledgments

First of all, I would like to thank my supervisor, Professor Torsten Cegrell, for his encouragement and guidance during the course of my work. Many thanks also to Adj. Professor Johan Schubert, Dr. Patrik Forsgren, Dr. Göran Ericsson (now with the Swedish National Grid), Magnus Haglind, Jonas Andersson, and other colleagues of mine at the department for their valuable inputs and discussions. Mrs. Judith Westerlund is gratefully acknowledged for proofreading the English in this thesis.

My deep gratitude goes also to the sponsors of my research work, namely, TNB (a power utility in Malaysia) and ABB (Malaysia), without which this work would not have been possible. Many thanks also to a number of individuals from the utilities and the power industry in Sweden for their valuable inputs, time, and cooperation.

Finally, I want to express my gratitude to my beloved wife and son for their understanding, patience, and support during my study, and our parents for their love and encouragement.

Stockholm, September 1999.

Kam-Hoong Cheong
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List of Published Papers and Reports

In addition to an Introduction and Summary, this thesis also consists of published papers and technical reports in the following seven parts, A to G:


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## Abbreviations

The following abbreviations are used in this report:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADSL</td>
<td>Asymmetric Digital Subscriber Lines</td>
</tr>
<tr>
<td>API</td>
<td>Application Program Interface</td>
</tr>
<tr>
<td>BPR</td>
<td>Business Process Reengineering</td>
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<tr>
<td>COM</td>
<td>Component Object Model</td>
</tr>
<tr>
<td>CORBA</td>
<td>Common Object Request Broker Architecture</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial Off The Shelf</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>DA</td>
<td>Distribution Automation</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management Systems</td>
</tr>
<tr>
<td>DCOM</td>
<td>Distributed Component Object Model</td>
</tr>
<tr>
<td>DLMS UA</td>
<td>Device Language Message Specification User Association</td>
</tr>
<tr>
<td>DM</td>
<td>Distribution Management</td>
</tr>
<tr>
<td>DMS</td>
<td>Distribution Management System</td>
</tr>
<tr>
<td>DSM</td>
<td>Demand Side Management</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interchange</td>
</tr>
<tr>
<td>EDIFACT</td>
<td>Electronic Data Interchange For Administration, Commerce and Transport</td>
</tr>
<tr>
<td>EMS</td>
<td>Energy Management System</td>
</tr>
<tr>
<td>FTP</td>
<td>File Transfer Protocol</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HTML</td>
<td>HyperText Markup Language</td>
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<tr>
<td>HTTP</td>
<td>HyperText Transfer Protocol</td>
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<tr>
<td>IDL</td>
<td>Interface Definition Language</td>
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<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
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<tr>
<td>IS / IT</td>
<td>Information Systems / Information Technology</td>
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<tr>
<td>ISO</td>
<td>International Standards Organization</td>
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<td>Java VM</td>
<td>Java Virtual Machine</td>
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<tr>
<td>LCC</td>
<td>Life Cycle Cost</td>
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<tr>
<td>NOS</td>
<td>Network Operating System</td>
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<tr>
<td>OD</td>
<td>Organization Development</td>
</tr>
<tr>
<td>OLE</td>
<td>Object Linking &amp; Embedding</td>
</tr>
<tr>
<td>OMA</td>
<td>Object Management Architecture</td>
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<tr>
<td>OMG</td>
<td>Object Management Group</td>
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<tr>
<td>ORBs</td>
<td>Object Request Brokers</td>
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<tr>
<td>OSI</td>
<td>Open Systems Interconnection</td>
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<tr>
<td>PLC</td>
<td>Power Line Carrier</td>
</tr>
<tr>
<td>PLT</td>
<td>PowerLine Telecommunication</td>
</tr>
<tr>
<td>RPC</td>
<td>Remote Procedure Call</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>SMTP</td>
<td>Simple Mail Transfer Protocol</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunity, and Threats</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol / Internet Protocol</td>
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Introduction and Summary

This Introduction and Summary first presents an introduction to the field of study and introduces the research questions and the justification. The research design for this thesis work is then described and the main contribution of the thesis highlighted. This is followed by a comprehensive literature review and also a presentation of the research methodology used throughout this work. Thereafter, a summary of all the reports and published papers included in this thesis work (Part A to G) is presented to provide an overall perspective of the thesis work, bringing together the most interesting findings. Finally, some conclusions are drawn from the work and the implications discussed. A list of recommended references is also provided.

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1 INTRODUCTION

1.1 Background to the research

Worldwide, electric utilities are undergoing tremendous changes. Not only deregulation has changed the business environment of the industry from a relatively static and monopolistic market to a more dynamic and competitive market, the rapid advancement in information technology (IT) is also about to change the methods utilities use to operate and conduct their businesses.

Deregulation of the electricity industry not only has unbundled the traditional vertically integrated utilities business, separating transportation of electrical energy from its generation and sales, therefore causing structural changes to utilities organization, it also has brought about both threats and opportunities to the players in the industry. One of the major threats has been the removal of the “protective shield” that utilities have enjoyed ever since they were formed, exposing them to market forces. Another threat is the demand for higher efficiency and accountability both from the customers and the authority. On the other hand, deregulation also presents utilities with the possibility to increase their revenue and profits through better operational efficiency and/or diversification into new business areas.

In the technology arena, as revealed by the author’s first two years of research study in the DA/DSM (Distribution Automation / Demand Side Management) area, the development of technology especially Information Technology (IT), has presented utilities with a multitude of possibilities. The possibilities lie not only in automation of work processes to improve efficiency, but also in business process reengineering and business transformation. Today, we witness the introduction of computer-based work management systems, asset management systems, and advanced control systems to manage the operation of power systems down to and including the consumption level. The increasing availability of the so-called “open system technology” has also caused utilities to demand more integration between different computer and information systems, both horizontally as well as vertically, hoping to garner the benefits of information exchange between systems and to bring about better operational efficiency and decision support. The recent breakthrough in the Powerline Telecommunication (PLT) technology, providing high-speed permanent Internet connection over the power distribution networks has also provided electric utilities the possibility to venture into the huge and fast growing market of providing Internet access. Last but not least, the rapid growth of the Internet and its associated applications such as e-commerce, etc., is also a force to be reckoned with. Together, deregulation, new technology, and the Internet are rapidly transforming how companies (including utilities) define and manage their businesses.

The author’s Licentiate thesis also revealed that many utilities have become aware of the potentials of modern IT [Cheong, 1]. IT is increasingly being seen not only as an essential tool to assist electric utilities to achieve their business objectives, but also as an enabler that allows them to redefine their business processes and to broaden their business scope. However, despite the increase in awareness, very few utilities have actually managed to go beyond mere automation of tasks to harness the full potentials of modern IT. In order to exploit the full benefits of IT, there is a need for an effective IT strategy to manage the developments, acquisitions, and the utilization of IT systems within the organization. Essentially, an IT strategy should be able to ensure successful implementation of IT projects and bring about the desired benefits and competitive advantage to the organization.
Many published papers have recommended that utilities formulate a long term IT strategy to exploit the full potential of the technology in order to confront the challenges ahead, see for example [Cegrell, 2]. However, little has been said about the effectiveness of the strategy. For example, “Is IT strategy an effective tool?” “What is the state-of-the-practice of IT strategy today?” “What are the important considerations of an IT strategy?” “What else could be done to enhance the effectiveness of the strategy?”

Incidentally, a preliminary literature survey of IT-related literatures revealed that many IT projects have not succeeded or achieved the originally targeted goals. For example, according to a survey conducted by Standish group in 1995 [Standish group, 3], only about 16% of IT projects actually succeeded, which means that projects are completed on time and on budget, with all features and functions specified. About 53% of the projects were completed and operational but over-budget, over the time estimate and with fewer functionality than originally specified. Finally, about 31% of the projects were abandoned.

In yet another study conducted in the USA, it was shown that IT assets went up from 3.7% of all business assets in 1960s to 12.5% in 1980s. However, the rates of improvement in labor productivity and increase in added value actually fell over the same period [Moreton, 4]. More about these “runaway” IT projects can be found in [Eason, 5], [Glass, 6], and [Thorp, 7].

One conclusion that we can draw from all these studies is that we have yet to realize the potential of IT. A lot was written about these failed IT projects and the probable cause of failure. Concepts, theories, and methodologies were also put forward in much literature attempting to improve the chances of success. However, it was observed that most literature focused only on certain aspects of the cause of IT project failure. There was a lack of a holistic approach, i.e., an IT strategy that encompassed all major critical success factors that could guide the development and utilization of IT within an organization to achieve its business objectives.

For example, proponents, researchers and scientists from the School of Human Sciences and Information Systems like Eason argued that one of the primary causes of failure in IS/IT project was due to the technology-driven design process [Eason, 5]. There was very little consideration of the broader ramifications of the technology, especially on the social or human aspect of IS. He therefore proposed that the IS design process should be user-driven instead of technology-driven. In his proposed user-centered approach, he put forward a framework for the socio-technical design of IT systems which served to integrate both the social as well as the technical aspect of IS. Besides focusing on the stakeholder participation during the design process, the framework also covered other aspects vital to the success of IS implementation such as organization change.

Davenport, a well-known author and researcher in IT management and strategy, argued in his book [Davenport, 8] that so far most users of IT have not been able to exploit the full potential of the technology despite radical improvements in IT functionality. The improvement in productivity has only been marginal and has not commensurated with the amount of investment made in IT. According to him, in order to achieve more radical changes, IT should not be seen as merely a tool to replace the traditional manual process. Instead, it should be
seen as an enabler which an organization can use to reengineer its business processes and to restructure the organization to gain a competitive edge.

From the organization theory’s perspective, Harrington highlighted the important relationship between IT and organization structure by seeing an organization structure in two domains, namely the physical and perceptual domains [Harrington, 9]. According to him, IT, unlike other general technologies, has far greater impacts on the perceptual domain. By changing the perception of people who make up the organization, the perceived organization structure would be changed. He argued that the relationship between IT and organization structure is inseparable. This relationship must be considered when introducing IT in organizations.

Finally, lack of organization learning has often been quoted as one of the main reasons for organization failure. Leading management and system thinker Peter M. Senge argued in his well-known book [Senge, 10] that in order for organizations to excel in the future, the organizations must be able to tap people’s commitment and capacity to learn at all levels in an organization. He coined the notion of a “learning organization” and introduced the five “component technologies” necessary for the development of a “learning organization.” Among the five components, system thinking, which Senge named as the “Fifth Discipline,” is considered to be the integrating force for the components.

The goal of this project is therefore to further the author’s earlier works that led to his Licentiate thesis with the aim of providing a more comprehensive framework to enhance the effectiveness of utilities’ IT strategy, so that the benefits and potentials of IT can be better exploited to increase utilities efficiency and productivity. While there are many factors that can affect the effectiveness of IT strategies, the focus of this study is on factors related to the three dimensions of a strategy, namely: the strategy process, the strategy content, and the strategy context.

In the strategy process dimension, factors like people involvement, communication, consultant involvement, and the importance of SWOT (Strengths, Weaknesses, Opportunities and Threats) and business process analyses are investigated. In the strategy content dimension, factors concerning the relationships between IT and business processes, IT and people, as well as IT and organization structure are looked into. Finally, in the strategy context dimension, the extent of IT strategies have taken into consideration the internal and external environment is investigated.

1.2 Research questions and hypotheses

In order to achieve the goal set forth in this project, several research questions are formulated. These research questions are aimed at providing a better understanding of existing IT strategies. In particular, to gain better insight into factors related to the three dimensions of a strategy described briefly in the earlier subsection that can affect the effectiveness of IT strategies. The main questions formulated are as followed:

- What is the state-of-the-practice of IT strategy today?
- What impact has IT strategy on utilities’ business activities today?
- What are the strengths and weaknesses of today's IT strategy?
- What are the important considerations of an IT strategy?
- How could the effectiveness of the IT strategy be enhanced?
From these main questions, more specific questions are formulated. The “answers” to these questions not only can provide the insights necessary to formulate a framework for more effective IT strategy, but also help to “test” the following hypothesis:

*Existing IT strategy within electric utilities, formulated with the traditional mind-set of the industrial-age that focused primarily on technology, is inadequate and ineffective in dealing with today's IT that has a broader implication on an organization's business activities. In order to be more effective, IT strategy must be more comprehensive and must take into consideration other vital elements of an organization beside technology.*

1.3 Justification for the research

Together, deregulation, advancement in IT, and the rapid growth of the Internet and its related applications such as e-commerce, etc., mean that electric utilities' investments in IT will continue to grow and become more strategically important to businesses and indeed to entire industries. This is not just a matter of “technological literacy.” It involves the very survival of utilities in this emerging new economy. In order to avoid the pitfalls of failed investments and the inability to fully exploit the benefits of the investments, an effective IT strategy is needed.

An effective IT strategy that aligns with the business strategy is imperative in steering the organization in the right direction, and in enabling organization to fully exploit the benefits and potentials of the technology.

1.4 Research Design

The research design basically consists of two main parts (see Figure 1). The first part that led to the author’s Licentiate degree focused on the study of various Distribution Management Systems and their associated technologies for electric utilities and the understanding of the functioning of the Swedish utilities industry. Special focus was on communication systems and their requirements to satisfy the needs of electric utilities in a deregulated environment.

One of the findings from this part of the study was that despite the drastic increase in IT functionality and new potentials, many electric utilities were still lacking an effective IT strategy that could help them to tap into the new potentials.

While the first part of the study primarily focused on technical or technological issues, the second part that led to this Ph.D. thesis continued from where the first part left off and brought in a new dimension to the study that is vital for the success of electric utilities in the new millennium, i.e., the management of information technology (IT). This new dimension was necessary to complement the continuing technological study as the author’s earlier findings in his Licentiate thesis have indicated that one of the reasons for utilities’ inability to harness the potentials of modern IT was not due to technical reasons but mainly due to issues related to how IT was managed.

The aim of this part of the study was to increase the knowledge on how electric utilities could better utilize information technology to confront the threats posed by a deregulated market and also to exploit the opportunity in the new market environment. A goal envisioned from this study was a framework of knowledge that could be used to achieve a more effective IT strategy. Apart from continuing with the technological study, this study also involved several
related disciplines including organization theory, information systems theory, and strategic management theory in order to achieve the goal.

In the first part of the study, case study methodology was used. In the second part of the study, a combination of qualitative and quantitative methods was used. The purpose was to provide triangulation of data by using multiple sources of evidence. With triangulation, the potential problem of construct validity can be addressed [Yin, 11]. Good discussions of triangulation can be found in [Ragin, 12], [Gable, 13], [Kaplan, 14] and [Lee, 15].

![Figure 1. Research Overview](image)

While the qualitative method (a combination of the case study methodology prescribed by [Yin, 11], and by [Walsham, 16]) provides an opportunity to gain deeper insights into the relationship between people, the organization, and information technology, as well as helps to identify parameters that can influence the effectiveness of the IT strategy, the quantitative method (questionnaire survey combined with statistical analysis) complements it with the ability to examine the parameters in a larger population and to generalize the findings.

### 1.5 Definitions

In today’s information age, a lot of terms have been used by many people to mean many different things, especially in the field of Information Technology. The purpose of this subsection is to clarify some of the terms used in the context of this thesis.

**Framework.** In the context of this thesis, a framework is a collection of concepts, theories, principles and ideas. It provides the guiding principle, direction, and guidelines for actions and decision making. It is not a methodology in the sense that it is loosely structured.
Efficiency and effectiveness. These two terms are often used interchangeably in many articles. However, it is important to distinguish the difference between them. Achieving effectiveness is not the same as achieving efficiency. For instance, an organization may be efficient in producing more outputs within a given amount of resources. It may still be ineffective in the sense that its outputs (products) are not what the customers want, thus jeopardizing its long-term survivability.

According to [Harrington, 9], who views an organization as essentially consisting of two strongly inter-related and inseparable parts, namely the physical organization and the virtual organization, efficiency is to a great extent achievable in the physical domain. Effectiveness on the other hand, is more within the virtual or perceptual domain of organization.

In the context of this thesis, the term effective means the ability to produce the intended results given certain resources, including but not limited to IT. Effectiveness has a larger impact on the functioning of an organization and often has a longer time perspective than efficiency, for instance, in achieving the intended results.

An effective IT strategy means an IT strategy that can help organizations to better achieve their intended results through better resource planning, deployment, monitoring and assessment. The measurement for effectiveness of IT strategies is further discussed in subsection 1.8 later.

Information Technology (IT) and Information Systems (IS). IT is perhaps the most common buzzed word today. It is a general term used to refer to all aspects of computing and communications technology, including hardware and software (both system and application software) that encompasses the creation, storage, processing, distribution and display of information. OECD defined IT more explicitly to include also embedded products. According to [OECD, 17], IT covers technologies used in the collection, processing and transmission of information. It includes micro-electronic and opto-electronic based technologies incorporated in many products and production processes. It covers among others, computers, data communication and communication systems, computer-controlled machines, electronic components, software products, etc.

The term IT is often used interchangeably with the term IS (Information Systems). While a lot of literature considered IT and IS being essentially the same and did not make any distinction between the two, [Earl, 18] did distinguish the two. According to Earl, IT deals with how information can be delivered and IS deals with what to do with information, systems and technology, and how to manage the application from a business point of view. IS and IT are distinct but complementary. The relationship between IS and IT is shown in Figure 2.

Despite the distinction, IS and IT are essentially complementary and inseparable, especially in this information era. Without IT, IS would not have been possible; without IS, IT would have been rendered meaningless because no technology implements itself. Information System is just an instantiation of Information Technology.

It is for this reason that I chose not to differentiate between IS and IT in the context of this thesis because it is my opinion that IT should be viewed in a larger context and not narrowly on technology itself. This is especially important when we are dealing with strategies that
apply to a business organization. Thus the term IT used in this thesis can be interpreted as IT/IS.

<table>
<thead>
<tr>
<th>What is required</th>
<th>Information Systems strategy</th>
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<tr>
<td>Business based</td>
<td>• Business based</td>
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<td>Demand oriented</td>
<td>• Demand oriented</td>
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<tr>
<td>Application focused</td>
<td>• Application focused</td>
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<th>Needs and priorities</th>
<th>Infrastructure and services</th>
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<tr>
<th>Information Technology strategy</th>
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<tr>
<td>Activity based</td>
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<tr>
<td>Supply oriented</td>
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<tr>
<td>Technology focused</td>
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</table>

**Figure 2. Relationship between IT & IS**

**Strategy.** In the strategic management literature, there are many definitions given to the term “strategy.” A discussion of this will be given in the “Literature review” section later in this thesis. For the time being, it is suffice to say that concept of strategy used in this thesis is that presented in [Hax, 19], which states that:

“For this unifying point of view, strategy becomes a fundamental framework through which an organization can assert its vital continuity, while at the same time purposefully managing its adaptation to the changing environment to gain competitive advantages. Strategy includes the formal recognition that the recipients of the results of a firm’s actions are the wide constituency of its stakeholders. Therefore, the ultimate objective of strategy is to address stakeholders’ benefits -- to provide a base for establishing the host of transactions and social contracts that link a firm to its stakeholders.”

There are several keywords in this definition that are of interest, namely, “fundamental framework,” “changing environment,” “competitive advantage,” and “stakeholders’ benefits.” These keywords are used to establish the definition of an IT/IS strategy used in the context of this thesis.

**IT strategy.** Within the context of the thesis, IT strategy refers to a fundamental framework, whether explicitly expressed or otherwise, that provides guidelines and directions for an organization to manage the developments, acquisitions, and the utilization of IT within the organization. The ultimate objective of the IT strategy is to assist the organization in achieving its business objectives and to bring about stakeholders’ benefits by creating competitive advantage through the use of IT in a continuously changing environment.

**Electric utilities.** Before deregulation, electric utilities used to have a vertically integrated structure consisting of production (generation), transmission, and distribution functions. With deregulation, this traditional structure was decoupled (see Figure 3).
The network business was separated from the production and the sales or trading of electric energy. In Sweden, we witnessed the formation of the National Swedish Grid (Svenska Kraftnät), a multitude of distribution network companies and energy trading companies. It should be noted, however, that in Sweden, it is sufficient for the traditional distribution utilities to maintain separate accounts for their network business and energy trading business to avoid cross-subsidies in order to affect the separation as required by the regulation. It is not necessary to have “physical” separation. This has resulted in several organization models for the new distribution utilities. An example of a distribution utility organization after deregulation is shown in Figure 4.

The term electric utility used in this thesis refers to a distribution utility that has at least a function or business unit for the network. It may or may not have other functions or business units under its umbrella organization. This definition is based on the profile of the companies that took part in the study.

1.6 Related works

Related works can be seen from two perspectives: first from the perspective of literature written on the subject, and second from the perspective of research work carried out on the subject.

From the literature survey, it appeared that not much has been written with a special focus on IT strategy, especially when the target group was electric utilities. The literatures that were found closest to the work of this thesis were [Boar, 20] and [Frenzel, 21], which covered many aspects of IT strategy. Most other literatures briefly mentioned the importance of IT strategy, but the focus was on a specific IT issue such as the contribution of IT toward business process reengineering, e.g. [Davenport, 8] and [Hammer, 22], management of IT
projects, e.g. [Thorp, 7], etc. More of these related literatures will be presented in the literature review section.

On the other hand, it was found that most IT consultants have developed some kind of methodology in-house that they use to help their clients to develop an IT strategy. See for example [MST, 23], [DMR, 24], [Nolan, 25], [C international, 26], [Amtec, 27] and [DSG, 28]. Most of the methodology reviewed has its roots in the discipline of strategic management and focuses primarily on the process of formulating the strategy.

From the research perspective, there was even lesser work done that covered the scope and research questions of this thesis. A research study that was found to be somewhat related to this thesis work was a study jointly conducted by the Norwegian Computer Association (Den Norske Dataforening) and the Polytechnic University of Norway (Den Polytekniske Høgskolen) in 1997. The purpose of the study was to identify the important characteristics of the IT strategy content has on its implementation [DND, 29].

To conclude, this thesis work can be considered as a piece of pioneer work concerning IT strategy with special focus on the electric utility industry.

1.7 Main contribution of this thesis

There is no doubt that IT is going to change many aspects of how utilities conduct their businesses in the very near future. Today, we already witnessed how IT has transformed the airlines, the entertainment, and the retail industry. The electric utility industry is not likely to be an exception. Also, due to deregulation, electric utilities will need to make more investment into IT in order to cope with the increasing need for communication and the challenges ahead.

As IT becomes more ubiquitous, what differentiates a more successful firm from the others is not merely the stock of technology that a firm has, but how a firm manages its technology to achieve its business objectives and competitive edge. An effective IT strategy that aligns with the business strategy, is a pre-requisite in steering the organization in the right direction, enabling it to exploit the benefits and potentials of the technology fully.

In view of the importance of IT strategies, the main contribution of this thesis is that through a cross-disciplinary study, this thesis manages to increase the knowledge on how electric utilities could improve their management of information technology by:

- Identifying and bringing to the surface the crucial parameters affecting the effectiveness of utilities’ IT strategy. The importance of these parameters, together with the relationships between them, are elaborated and explained with the help of theories and concepts from other related disciplines. A better understanding of these parameters is vital in changing the mind-set or paradigm of utilities towards better management of IT strategies.

- Identifying the current state-of-the practice of how IT strategy is managed and its related strengths and weaknesses. It is often said that one cannot improve upon something that one cannot measure. It is therefore imperative that one must establish or determine the present state of the thing that one wishes to improve. The current practice of how IT
strategy is managed, together with its strengths and weaknesses highlighted, serves as a “reflecting mirror” bringing utilities face to face with some of the vital issues that affect the effectiveness of IT strategies. These issues are very often overlooked or its impact underestimated.

- Proposing a framework towards more effective management of IT strategy, drawing not only from experiences gained from the study, but also from well-established concepts and theories from information systems, strategic management, as well as organization study. In dealing with a complex issue such as IT strategy that transcends several disciplines, it is very likely that utilities may overlook certain aspects. These overlooked aspects may very well be the “failing point” of the strategy. In order to minimize this risk, a framework is provided in this thesis. This framework highlights the critical aspects where adequate consideration should be given and triggers more in-depth thinking into issues surrounding these aspects to avoid the pitfalls identified in this study.

With the increase knowledge contributed in this thesis, it is the author’s hope that electric utilities could better position themselves in this turbulent time through more effective planning and utilization of IT.

1.8 Delimitation of scope and key assumptions

The focus and units of analysis of this study were electric utilities. All the data on which results and conclusions were drawn came from electric utilities. Therefore, it is appropriate to say that the results and conclusions of this thesis are applicable only to the electric utilities. However, the framework proposed in this thesis is somewhat general in nature and therefore it is possible to use it in other organizations where business processes are heavily dependent on IT.

One key assumption in this study is the measurement of effectiveness. Although the meaning of “effectiveness” has been defined within the context of this thesis as described in the earlier subsection, what constitute the appropriate measures for effectiveness is very much debatable. In this thesis work, the results obtained from questions on the following factors are used to determine if a utility’s IT strategy is considered effective.

- The degree of satisfaction with the IT strategy process.
- The degree existing IT strategy has addressed the needs of utility business functions.
- The degree existing IT strategy has identified the strengths and weaknesses of existing IT systems in the organization.
- The degree existing IT strategy has identified the strengths and weaknesses of existing IT function in the organization (e.g. competence level, support/service level, relative position of IT functions in the organization, etc.).
- The degree existing IT strategy has taken into consideration the prevailing culture of the organization? (E.g. the decision process, reward system, formal channel of communication, etc.).
- The degree existing IT strategy has taken into consideration the changing business environment caused by deregulation.
- The degree existing IT strategy has identified the critical areas where IT could contribute to the success of the company in the new business environment.
• The degree existing IT strategy has defined the roles of IT to the identified critical areas.
• The degree existing IT strategy has provided direction in achieving the new business objectives.

These factors are based on the insights gained from the initial case study and also from concepts and theories drawn from an extensive literature study, which will be presented in section three later. These factors cover the three important dimensions of a strategy, namely, the strategy process, the strategy content, and the strategy context dimension.

1.9 Outline of the thesis

This thesis is divided into eight main sections (chapters). Section one provides an overall perspective of the research work, providing the background to the research and defining the research questions, as well as briefly introduces the research design and sets the research context. The main contributions of the thesis are also presented.

In section two, readers are introduced to the IT environment commonly found in electric utilities. In particular, the complexity of the IT systems that distinguish them from IT systems used in other industry is highlighted and also the need for a seamless information exchange between different IT systems and some of the obstacles in achieving that are described. Finally, some technologies that are of strategic values to utilities are presented and described.

Section three provides a comprehensive review of literatures related to this thesis work. These literatures are from various disciplines including organization theory, strategic management, and information systems study. Major concepts and theories that are found to be important to the effectiveness of IT strategies are highlighted and discussed in this section. These concepts and theories provide the foundation and the theoretical framework for this research study.

In section four, a brief introduction to researching in the field of IT/IS is given. It discusses two major underlying philosophies or paradigms in conducting research in this multi-disciplinary field, namely, the positivist and the hermeneutics approaches. It then describes the research methodology used in this thesis work and the justification for it. Some of the ethical consideration taken in the conduct of this research is also described.

Section five provides a summary of all the reports and published papers included in this thesis, bringing together the most important findings and conclusions of this research study, including the proposed framework. The reports and papers are organized in a coherent manner so that readers can easily follow the development of the study, as each report or paper provides a foundation for the next.

In section six, some conclusions drawn from this study are presented and the implications of the proposed framework are discussed. Possible future works that could be spurred off as a result of this study are discussed in section seven. Finally, a list of selected references is given in section eight to enable interested readers to probe further in the subject covered in this thesis.

1.10 Conclusions

In this section, the readers are provided with an overview of the research work, its background and the research questions. Justifications are also given to the intended research work.
Definitions of terminology used in the context of this thesis are clarified and the research design, the research methodology, and the main contributions of the thesis are presented. Some limitations of this thesis are stated and the organization of this report is outlined. On these foundations, the report can now proceed with a detailed description of the research.

2 IT AND ELECTRIC UTILITIES

2.1 Introduction

In this section, IT systems commonly used in electric utilities are first described. The purpose is to introduce to the readers the complexity of the IT systems in utilities that distinguish them from IT systems used in other industry. Then, the need for a seamless information exchange between different IT systems is highlighted and some of the obstacles in achieving this are described. Two scenarios are presented to illustrate the impact of modern IT has on the functioning of utilities’ organization. Finally, some technologies that are of strategic value to utilities are presented and described. It must be stressed here that the main purpose of describing these technologies in this section is merely to highlight some of the new potentials and enhanced capabilities of modern IT. It is not intended to imply that these are the technologies of “choice” that must be adopted by utilities, as the “choice” of technology must be seen in the total context in which it is to be deployed.

2.2 IT within utilities

Information Technology (IT) is revolutionizing almost every aspect of our life. In the time span of a mere 30 years software systems have gone from being the arcane tools of scientists to being a necessity in every-day life in modern society. The expected long-term impact of IT is immense and it is routinely compared to such technologies as electricity, the internal combustion engine, the printing press, and even the wheel [Thor, 7]. IT is considered to be the next big wave that will transform the world into a new era -- the era of information-age, and enable a new economic structure for industry in a global economy, revolutionizing methods of supply, production, management, distribution, marketing and service.

Electric utilities have a long tradition of using computer-based information systems. One classic example of these systems that has been used in most utilities for more than 30 years is the SCADA/EMS (Supervisory Control and Data Acquisition / Energy Management System) that is used to monitor and control the electrical power process, an industrial process which is considered to be the most advanced in a modern society [Cegrell, 30].

A major difference between electric utilities and many other industrial organizations is their broad mixture of systems [Andersson, 31]. These systems were introduced in order to supervise the geographically distributed process and to automate administrative tasks within the utility. Traditionally, such systems have been acquired as stand-alone applications intended to meet isolated needs. Due to the nature of the activities and to support the various requirements, the computer systems have evolved into three categories in most utilities, namely Technical Operation Support Systems, Administrative Systems, and a Network of PCs (see Figure 5).

Technical Operation Support Systems are an important group of systems used primarily in support of the operation of the power process. This group of systems may be further
differentiated into two categories based on their performance requirements such as response
time, deterministic system behavior, etc. These two categories are “hard real-time” and “soft
real-time” systems.

![Diagram of various IT systems in electric utilities]

Figure 5. Various IT systems in electric utilities

According to a publication from Microsoft Corp. dated June 29, 1995, called Real-Time
Systems and Microsoft Windows NT, which is quoted in [Babb, 32], hard real-time
requirements imply that the system must without fail provide a response to an event in the
process within a specified time window. The response must be predictable and independent of
other activities undertaken by the system. On the other hand, systems with soft real-time
requirements imply that the systems can manage events rather quickly, but not within a
guaranteed response time.

Traditionally, technical operation support systems with hard real-time requirements, e.g.
SCADA-systems that are used for the supervision and control of the power process, have
been using their own hardware and software architecture to realize the real-time requirements
required by the power process. The computers used have typically been of the mainframe or
workstation type. In order to achieve sufficient system performance, proprietary operating
systems and software solutions for distributed access have most often been employed.
Another system that falls under this category is the substation control system that often
includes microprocessor-based protection-relays.

For systems or applications that require only soft real-time requirements, general purpose high
performance IT systems have been used. Some examples of applications running on Technical
Operation Support Systems that have soft real-time requirements are:

- Advanced Simulation Studies,
- Network Calculation,
- Geographical Information Systems (GIS),
- Remote Metering systems,
- Trouble-call systems, etc.

These applications or systems are part of the Distribution Management Systems commonly
known in the distribution utilities. Concerning computer platforms (especially in the Human-
Machine-Interface), there is a trend towards using standardized personal computers in
Technical Operation Support Systems. This trend can be largely attributed to the desire to
streamline the computer base within electric utilities.
Administrative systems within utilities usually comprise systems for customer care, billing, accounting, business control, office-related work tasks such as word-processing, etc. Most of a utility’s administrative applications have their heritage from the mainframe era. Typically, these applications run on minicomputers. New requirements on inter-application communication in combination with increased capability of personal computers and workstations providing many improvements in ease of use, have implied a move towards standardized distributed client-server environments.

Network of PCs. Today, due to the decreasing cost of PCs coupled with increased processing performance, we also witness networks of PCs in utilities’ offices. These networks of PCs, which are typically Windows-based, include network servers and all personal computers connected to the office local area network and serve as a personal productivity tool for common office applications such as word processing, spreadsheet applications, etc. Apart from this, the PC networks also support group applications such as file and print sharing, e-mail, calendar and scheduling applications, etc.

2.3 A need for information exchange

Traditionally, a utility organization is characterized by a strict functional structure with rather limited cross-functional information exchange. Therefore, utilities could be viewed as a group of loosely coupled functional departments, each running fairly autonomously from its siblings. Although this often has simplified the management structure, it has been found to incur various inefficiencies.

Due to the deregulation of the electricity market, the concept of business process is a keyword in today’s utilities. The increasing demand on flexible energy, characterized by value-added services, and enhanced efficiency in operation have forced the utilities to focus on their business processes and integrate them more tightly as customer interaction usually cuts through traditional functional organizations. This integration must however also be reflected in the information systems supporting the business. A major integration obstacle is that most of the present systems lack built-in software connectivity capabilities [Andersson, 31]. As these systems were intended to be used as stand-alone applications, they lack software connectivity capabilities normally included in modern distributed computing environments, e.g. middleware concepts like Object Request Brokers (ORB). Thus, the inflexibility of existing systems is still a major obstacle to achieve system integration.

Furthermore, with a heritage characterized by limited need for integration, most utilities have implemented their information systems without having a long-term architectural planning. The more or less “ad hoc” basis of implementation coupled with the state of technology then, has resulted in “islands of automation” that still exist today [Cheong, 1]. Consequently, many utilities are faced with the challenge of providing integrated information systems in support of the business taking-off from a heterogeneous system environment lacking in architectural planning.

2.4 From Distribution Automation to Distribution Management Systems

The first integrated Distribution Automation (DA) test project reported, to the author’s knowledge, is the one implemented in Athens (Tennessee) Utilities Board (AUB) in the

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1 Windows is a trademark of Microsoft Corporation.
1980s. The project, which was prompted by the energy crisis in the 1970s, covered the principal areas of voltage control, reactive power control, system reconfiguration and load control. The project was jointly sponsored by the AUB, the U.S. Department of Energy’s (DOE’s) Office of Energy Storage and Distribution and was conducted in cooperation with the Tennessee Valley Authority (TVA), the Electric Power Research Institute (EPRI), the Tennessee Valley Public Power Association (TVPPA), and the Baltimore Gas and Electric Company. The purpose of the project was to develop and test various load control options, voltage and reactive power control options, and distribution system reconfiguration capabilities on an electric distribution system from the transmission substation transformer to individual residential appliances. Testing of the automated system began in the fall of 1985 and its results are published in [Gnadt, 33].

Since then, DA has gained a lot of attention from electric utilities, vendors and research institutions especially in the early 1990s. This was due to the drastic improvement in the price/performance ratio of computer systems and also the trend towards deregulation that would change the business environment in the energy market. However, early DA applications or systems were mostly proprietary, stand-alone systems. It was extremely difficult to make them communicate and exchange information with each other, especially if they were from different vendors. For a good overview of the various DA applications and systems, please refer to [Cheong, 1].

The increasing need for information exchange in a deregulated market environment has prompted the need for a more integrated computer systems environment where different computer systems could communicate and exchange information with one another to achieve higher efficiency and effectiveness. The integration is needed both vertically, i.e., from a high hierarchical level deep into the power process itself, and horizontally, i.e., on the same hierarchical level (e.g. voltage level), for example within a substation. A third dimension of integration is the “time-scale”, i.e., from design to maintenance. This is illustrated in Figure 6 [Cegrell, 2].

Figure 6. Horizontal and vertical integration of power system control
In distribution utilities for example, we witness today the integration of SCADA function with applications for network planning and maintenance, trouble-call system, as well as GIS, the integration of remote metering system with billing and invoicing systems, as well as customer information system, etc. The integration of the traditional DA applications that are close to the process with other administrative applications in the office environment forms the concept of Distribution Management Systems (DMS) as shown in Figure 7. This integration is made possible due to the advancement in information technology (IT) in the recent years. Some of these technologies that are considered to have strategic value to electric utilities are discussed in subsection 2.6 later.

![Distribution management](image)

- computerized mapping systems
- network documentation
- spare parts
- maintenance
- planning
- other administrative tasks, etc.

**DISTRIBUTION AUTOMATION**
- SCADA
- volt/var control, coordinated protection and control
- feeder control: feeder switches and reconfiguration
- fault detection, location, isolation and supply restoration
- automatic meter reading
- load management
- equipments: automation of network devices, fault detectors, RTUs, communication
- etc.

![Figure 7. Distribution Automation & Distribution Management Systems](image)

2.5 **On systems integration: issues and impacts**

Although the advancement of IT today has made it possible to integrate heterogeneous systems together, considerable efforts are still required to integrate them to form a coherent system that is “transparent” to the users [Rahkonen, 34]. This is especially so when the systems are from different vendors or in utilities that have “legacy” systems that lack the software connectivity capability as mentioned in subsection 2.3.

Thus, a well thought-out IT strategy is still needed to guide the development, the procurement, the utilization, and the maintenance of IT systems in utilities. The IT strategy should provide, among others, an architectural platform that takes into consideration available open-system technology including standard communication protocols, middlewares, etc. A good discussion on the communication architecture and protocols relevant to the electric utilities industry can be found in the author’s earlier works leading to his Licentiate degree [Cheong, 1]. These works contribute to the “technical” aspect of the IT strategy and more discussion on other related strategic technology will be given in subsection 2.6 later.
course of the author’s earlier works, it has also become clear to the author that to achieve a comprehensive framework for utilities’ IT strategy, the works have to be complemented with other organizational considerations. These considerations are being addressed in this thesis.

One of the main objectives of systems integration is to enhance efficiency and productivity through free exchange of information. In order to achieve this objective, the free exchange of information must be accompanied by other organizational changes. These changes may involve the people, the processes, the tasks, and even the organization structure. In the following, two scenarios are given to illustrate the impacts of IT on utility organizations.

2.5.1 Processing new service application

Figure 8 shows a typical process of how utilities process a new service application from customers. Basically, the customer submits the application to an energy supplier who then forwards the application to a Network Company. In the Network Company which is functional-based, the Network Services Department (NSD) that receives the application from the supplier has to refer the application to the Network Planning Department (NPD) that checks for the network capacity and makes the network design where necessary. The application and the design (where appropriate) is then returned to the NSD for implementation. The NSD has to inform the supplier when the customer will get his/her supply.

![Figure 8. Existing process for new service application](image)

Note that in this process, no one involves in the process has full information concerning the application. This makes it difficult for the supplier to answer inquiries from the customer and therefore unable to provide a good customer service. Furthermore, no one is ultimately responsible for the quality of the output, i.e. the time taken from application received to connection of supply.

Figure 9 shows a possible new process for new services application. Notice that the Network Company is now reconfigured based on process. If the energy supplier’s computer system can exchange information with that in the New Service Process Unit, then the energy supplier is able to answer customer inquiries more accurately, thereby raising the quality of its customer services. Furthermore, with the new process-based organization in the Network Company, the New Service Process Unit is now totally responsible for the quality of the output.
2.5.2 Customer Inquiry Process

Another process that is critical to the quality of customer services in a Network Company is the customer inquiry process. Customer inquiries may range from issues such as billing to interruption of supply. Figure 10 shows a typical customer inquiry process. During daytime, customers call to the office receptionist who then redirects the inquiry to the Customer Management Unit. If the inquiry concerns technical issue that this unit is unable to answer, for instance, an inquiry on supply interruption, the inquiry is redirected to other department. Thus, customers are being “passed” around as a result of the inability of the Customer Management Unit to answer all types of inquiries until they finally get to the right person. At night, customers call to the Operation Center that normally only handles technical issue concerning power supply.

Figure 10. A typical customer inquiry process

Figure 11 shows a possible “one-stop” customer care unit made possible by modern IT. In this configuration, the customer care unit is constantly fed with information from various information systems. With the integration of computer and telephony, it is possible for the people manning this unit to even browse through the calling customer’s information before he/she answers the call. The customer information available can also be used to offer new services to customers according to their profiles. With this configuration, the customer care unit becomes the most important function in the company -- managing customer relationship and offering new services.
In the two scenarios presented above, it is noteworthy that apart from the necessary computer systems, other organization changes are also necessary in order to operationalize the new configurations. For instance, people must be educated and retrained to handle the new tasks and processes. Empowerment is also necessary for people to make decision based on available information. In view of the increase in responsibility, the reward or appraisal system of the organization may also need to be changed.

In the following, some of the technologies that are of strategic value to the utilities industry are further discussed.

2.6 Some strategic technologies

2.6.1 Client-server architecture

Client/server is a computational architecture that involves client processes requesting service from server processes. Client/server computing is the logical extension of modular programming. Modular programming has as its fundamental assumption that separation of a large piece of software into its constituent parts (“modules”) creates the possibility for easier development and better maintainability. Client/server computing takes this one step farther by recognizing that those modules need not all be executed within the same memory space. With this architecture, the calling module becomes the “client” (that which requests a service), and the called module becomes the “server” (that which provides the service). The logical extension of this is to have clients and servers running on the appropriate hardware and software platforms for their functions, for example, database management system servers running on platforms specially designed and configured to perform queries, or file servers running on platforms with special elements for managing files.

The client is a process (program) that sends a message to a server process (program), requesting that the server perform a task (service). Client programs usually manage the user-interface portion of the application, validate data entered by the user, dispatch requests to server programs, and sometimes execute business logic. The client-based process is the frontend of the application that the user sees and interacts with. The client process contains solution-specific logic and provides the interface between the user and the rest of the application system. The client process also manages the local resources that the user interacts with such as the monitor, keyboard, workstation CPU and peripherals. One of the key elements of a client workstation is the graphical user interface (GUI). Normally a part of
operating system i.e. the window manager detects user actions, manages the windows on the display and displays the data in the windows.

A server process (program) fulfills the client request by performing the task requested. Server programs generally receive requests from client programs, execute database retrieval and updates, manage data integrity and dispatch responses to client requests. Sometimes server programs execute common or complex business logic. The server-based process “may” run on another machine on the network. This server could be the host operating system or network file server; the server is then provided both file system services and application services. Or in some cases, another desktop machine provides the application services. The server process acts as a software engine that manages shared resources such as databases, printers, communication links, or high powered-processors. The server process performs the back-end tasks that are common to similar applications.

The basic characteristics of client/server architectures are as follows: 1) There is a combination of a client or front-end portion that interacts with the user, and a server or back-end portion that interacts with the shared resource. The client process contains solution-specific logic and provides the interface between the user and the rest of the application system. The server process acts as a software engine that manages shared resources such as databases, printers, modems, or high powered processors. 2) The front-end task and back-end task have fundamentally different requirements for computing resources such as processor speeds, memory, disk speeds and capacities, and input/output devices. 3) The environment is typically heterogeneous and multivendor. The hardware platform and operating system of client and server are not usually the same. Client and server processes communicate through a well-defined set of standard application program interfaces (APIs) and RPC's. 4) An important characteristic of client-server systems is scalability. They can be scaled horizontally or vertically. Horizontal scaling means adding or removing client workstations with only a slight performance impact. Vertical scaling means migrating to a larger and faster server machine or multiservers.

Client/server computing has arisen because of a change in business needs. Businesses today need integrated, flexible, responsive and comprehensive applications to support the complete range of business processes. Client/server computing helps to resolve several problems with existing systems that include: applications were built in isolation, applications were implemented as monolithic systems, applications were complex, and the supporting technology was based on a centralized control model.

2.6.2 Middleware – CORBA

“Middleware” is a term used to refer to a piece of software that provides the connectivity needed for applications to transparently communicate with other programs or processes, regardless of their location. The key element of connectivity is the network operating system (NOS). NOS provides services such as routing, distribution, messaging, file and print, and network management services. NOS relies on communication protocols to provide specific services. The protocols are divided into three groups: media, transport and client-server protocols. Media protocols determine the type of physical connections used on a network (some examples of media protocols are Ethernet, Token Ring, Fiber Distributed Data Interface (FDDI), coaxial and twisted-pair). A transport protocol provides the mechanism to move packets of data from client to server. Some examples of transport protocols are Novell’s IPX/SPX, Apple’s AppleTalk, Transmission Control Protocol/Internet Protocol (TCP/IP),
Open Systems Interconnection (OSI) and Government Open Systems Interconnection Profile (GOSIP). Once the physical connection has been established and transport protocols chosen, a client-server protocol is required before the user can access the network services. A client-server protocol dictates the manner in which clients request information and services from a server and also how the server replies to that request. Some examples of client-server protocols are NetBIOS, RPC, Advanced Program-to-Program Communication (APPC), Named Pipes, Sockets, Transport Level Interface (TLI) and Sequenced Packet Exchange (SPX).

**CORBA.** The Common Object Request Broker Architecture (CORBA), is a specification by the Object Management Group (OMG) for object-based inter-process communication in distributed, heterogeneous environments. The OMG now has over 700 members including HP, IBM, IONA, Microsoft and Netscape. CORBA addresses the need for interoperability among the rapidly proliferating number of hardware and software products available today. Simply stated, CORBA defines the industry “software bus” that allows applications to communicate with one another no matter where they are located or who has designed them in a transparent way [OMG, 35]. CORBA also reduces software development costs and time-to-market by enabling embedded systems designers to move away from proprietary software towards commercial off the shelf (COTS) components. This “component mentality” is analogous to hardware system design with systems being built from a “parts-bin” of hardware components and sub-systems. Most importantly, CORBA allows legacy applications to be rapidly integrated into the distributed application with little or no modification. This is achieved by encapsulating the existing application in a CORBA “wrapper” [IONA, 36].

Current version of CORBA, version 2.0 was specified in 1995. It defines interoperability by specifying how ORBs (Object Request Brokers) from different vendors can interoperate. While CORBA is a specification, ORBs are implementations of CORBA. In other words, the ORB is the middleware that establishes the client-server relationships between objects. Using an ORB, a client can transparently invoke a method on a server object, which can be on the same machine or across a network (see Figure 12) [OMG, 35]. The ORB intercepts the call and is responsible for finding an object that can implement the request, pass it the parameters, invoke its method, and return the results. The client does not have to be aware of where the object is located, its programming language, its operating system, or any other system aspects that are not part of an object's interface. In so doing, the ORB provides interoperability between applications on different machines in heterogeneous distributed environments and seamlessly interconnects multiple object systems.

![Figure 12. A Request Being Sent Through the Object Request Broker](image)
The trick to ORB’s capability lies in the CORBA Interface Definition Language (IDL), which is a declarative language that describes the interfaces to server object implementations, including the signatures of all server object methods that are callable by clients. The surface syntax of IDL is similar to that of C++, but IDL is language-independent. Mappings from IDL to C, C++, Ada, and Smalltalk have been specified whereas mappings to COBOL, Java, and Objective C are in the works [Orfali, 37].

It must be noted that CORBA was not specified in light of real-time requirements. Neither CORBA nor the Object Management Architecture (OMA) currently addresses questions of real-time quality of service. The OMA consists of CORBA plus a collection of object services hosted on CORBA. However, there is an ongoing effort within the OMG concerning real-time CORBA (RT-CORBA). An RT-CORBA special interest group (RTSIG) is investigating possible future extensions to the OMG Object Management Architecture (OMA) to support a wide spectrum of distributed, real-time, fault-tolerant systems [Polze, 38]. A few vendors are already offering RT-CORBA products today. An example is Orbix-RT by IONA Technologies PLC. Orbix-RT is available on Windows, UNIX and real-time systems such as VxWorks, QNX and pSOS [IONA, 36].

While CORBA has many advantages such as broad platform support, strong programming language support, local/remote transparency whereby objects can invoke services without needing location details, reliable cross-ORB behavior, etc., it is not totally without disadvantages. Among some of its disadvantages are: proprietary extensions to CORBA whereby vendors may add non-standard features that may sacrifice interoperability and portability, and the lack of development tools -- many ORB vendors don't provide productivity tools for building components [IDG, 39].

DCOM (Distributed Component Object Model) by Microsoft is currently the major competitor to CORBA. It is the distributed extension to COM (Component Object Model) that builds an object remote procedure call (ORPC) layer on top of DCE RPC (Distributed Computing Environment Remote Procedure Call) to support remote objects. DCOM will not be discussed here further except to note that DCOM is not CORBA-compliant. Readers who are interested in more details about DCOM should refer to Microsoft web-site. COM is further discussed in the following subsection.

2.6.3 Object technology

Object technology (OT) was introduced to the computing mainstream in the late 1970s by Adele Goldberg and Alan Kay with a language called Smalltalk [Goldberg, 40]. In the object-oriented model, systems are viewed as cooperating objects that encapsulate structure and behavior and belong to hierarchically constructed classes. Object technology became more popular through the 1980s. One reason for its increased popularity is the rapid development of workstation technology. The modern workstation has the ability to support a sophisticated personal programming environment and also to provide a graphic-based human computer interface. The other reason is the continuing software crisis, the increasing demands placed on computing in terms of complex applications, and a general move from quantitative to qualitative aspects of computing [Hutchison, 41].

The object-oriented approach is now being used in such diverse fields as programming languages, design methodologies, formal specification, operating systems, distributed
computing, artificial intelligence (AI), real time systems, databases, human computer interfaces and even hardware design.

In [Hutchison, 41], it is proposed that an object-oriented model be consisted of four dimensions:

- **Encapsulation**: defined as the grouping together of various properties associated with an identifiable entity in the system in a lexical and logical unit, i.e. the object. Furthermore, access to the object should be restricted to a well-defined interface.
- **Classification**: the ability to group associated objects according to common properties.
- **Polymorphism**: implies that an object can belong to more than one classification.
- **Interpretation**: is defined as the resolution of polymorphism. In polymorphic environments, it is possible for a particular item of behavior to have several different meanings depending on the context. It is the task of interpretation to resolve this ambiguity and to determine the precise interpretation of an item of behavior.

An object is a self-contained software module that consists of a set of data and its associated processing information (Figure 13). A significant benefit of object technology is that an object encapsulates all of the data and processing details, hiding its inner complexity from programmers and users. This makes it easy to use objects once they are defined.

![Figure 13. Anatomy of an Object. An object is a self-contained software module that encapsulates both data and processing details.](image)

Objects are also more easily protected from misuse, because they can only be accessed through well-defined interfaces, called *methods*. In addition, because all implementation detail is hidden from other objects (other software modules), it is easy to modify an object’s internal details without affecting any other objects in the system. As a result, object-based systems are much more flexible and easier to maintain than their procedural-based counterparts.

The two areas of object technology that will have a growing impact on business systems are the following:

- Object-enabling system software, and
- Object-oriented programming languages.
Object-oriented programming languages and development tools are useful for building self-contained, custom applications by creating object definitions in the form of source code. These language-based object definitions can be shared and reused in different applications. Object-oriented programming languages, however, do not provide a means for separate applications to be integrated with other custom applications or packaged software. They do not fulfill the need for diverse objects, supplied by any company, written in any programming language, to freely interact. To fulfill this critical need, object-enabling technology must also be incorporated into system software, and applications must be designed to use these system software capabilities.

Object-enabling system software, as opposed to object-oriented programming, enables the creation of component software, addressing the following critical needs:

- The need to smoothly integrate components written by different companies using different programming languages.
- The need for an overall object model to facilitate component communication across application and machine boundaries (that is, across a network).
- The need to enhance and upgrade software components autonomously, without disrupting the operation of a distributed system.

The advantages of such object-enabling system software are:

- Users can manipulate objects that represent any information, including text, graphics, reports, and even multimedia clips, across application boundaries, no matter who designed the component applications or what language or development tool was used to program the software components.
- Through a standard programmatic interface based on the system object standard, off-the-shelf, packaged components can communicate with each other and be integrated into complete line-of-business solutions. Component software offers a more efficient and productive model for the software industry, and will dramatically reduce the programming effort and time required to deliver new business solutions.

In the following, two important object-enabling system softwares by Microsoft will be reviewed. They are based on “The Microsoft Object Technology Strategy: Component Software” [Microsoft, 42].

**COM (Component Object Model).** COM is an underlying system software object model or software architecture developed by Microsoft that allows complete interoperability between components that are written by different companies even when programmed in different languages. The primary responsibility of COM is to ensure that software components behave in a well-known and consistent manner without constricting how programmers implement different components. COM accomplishes this by defining a binary interface for objects that is independent of any programming language. Objects conforming to COM can communicate with each other without being programmed with specific information about each other's implementations. Objects that are written to support the Component Object Model are collectively called COM components.
The distinction between components as opposed to objects is that an object is a piece of software source code or a specification that can be used to build part of an application. A component, on the other hand, is not merely a specification; it is an actual working software module.

COM is the underlying architecture that forms the foundation for higher-level software services, like those provided by OLE (Object Linking & Embedding) as shown in Figure 14 [Microsoft, 43]. OLE services span various aspects of commonly needed system functionality, including compound documents, custom controls, inter-application scripting, data transfer, and other software interactions. The OLE services are further discussed below.

**Figure 14. OLE technologies build on one another, with COM as the foundation.**

**OLE (Object Linking & Embedding).** OLE is a set of object services built on top of COM and it depends on COM to provide basic inter-object communication. In other words, COM provides the “plumbing and wiring” of OLE. Although many of the OLE services are related to compound documents, OLE is much more than a compound document architecture. OLE provides a robust platform for building custom business applications that can be easily integrated with other business applications as well as with packaged software, whether the applications execute on a single machine or are distributed across a network. Some of the major features of OLE are listed below.

- **OLE Component Object Model (COM).** COM provides all of the interface standards and handles all inter-component communication that allows software components to be integrated. Because it is a binary standard, OLE software components can be written in any language, and supplied by any software vendor, yet are still seamlessly integrated into a single application. COM also allows software components to be autonomously upgraded without affecting the operation of the component-based solution. Besides providing the underlying foundation for all OLE features, COM can be used by corporate developers and system integrators to build
custom business components. These custom business components can be easily integrated with off-the-shelf, OLE-enabled applications.

- **OLE Automation.** OLE Automation allows applications to expose command sets that operate within and across applications. For example, a user can invoke a command from a word processing program that sorts a range of cells in a spreadsheet created by a different application.

- **OLE Controls.** OLE Controls (now called ActiveX™ Controls) are OLE-enabled software components that can be purchased to extend and enhance an application's functionality. OLE Controls can be used in custom or off-the-shelf OLE-enabled applications. Most popular development environments, including the Microsoft Visual Basic® programming system and the Visual C++® development system, support OLE Controls as an efficient means to build business applications using high-quality, prefabricated software components.

- **OLE Version Management.** OLE's underlying Component Object Model allows software components to evolve over time without disrupting the operation of existing applications.

- **OLE Drag-and-Drop.** Users can drag (move) objects from one application window to another, and drop (paste) objects inside other objects.

- **OLE Documents.** OLE Documents (or OLE Compound Documents) are a form of compound documents that can incorporate data created in any OLE-enabled application. For instance, an OLE-enabled word processor can accept tables and charts from an OLE-enabled spreadsheet. OLE Documents allow users to convey their ideas more effectively by incorporating diverse information into any business document. In addition to incorporating static information such as charts and tables, OLE Documents can also incorporate live data such as sound, video and animation. OLE Documents also make users more productive by improving the process of creating compound documents. The following are features specific to OLE Documents:

  - **OLE object linking and embedding.** Through object linking, applications can be linked to data objects within other applications. For example, a spreadsheet table can be linked into multiple custom business reports, and as changes are made to this table within the spreadsheet application, all report documents are automatically updated. Object embedding is the ability to embed an object within another document without maintaining a link to the object's data source. In both object linking and object embedding, applications supplying objects are called **OLE servers**, while applications containing objects are called **OLE containers**. An application can be both an OLE container and an OLE server.

  - **OLE Visual Editing.** Visual Editing allows users to create rich compound documents easily, incorporating text, graphics, sound, video, and other diverse object types. Instead of switching between applications to create parts of the compound document, users can work within the context of their document. As the user begins to edit an object that originated in another application, such as a spreadsheet or graphic, the menus and tools of the OLE container application automatically change to the menu and tools of that object's native (OLE server) application. The user can then edit the object in the context of the document, without worrying about activating and switching to another application.

OLE is available today for the Microsoft® Windows® family of operating systems, and for the Apple® Macintosh® platform.
2.6.4 Internet and Intranet

First started as a research and development project in 1969 sponsored by the U.S. Defense Department agency, the Internet (it was known as ARPANET then) has changed the way we carry out our daily routines, be it at home, at work, or even at our leisure time. In fact, the impact of Internet on the world is often being quoted as being analogous to the impact of such technologies as electricity, the internal combustion engine, the printing press, and even the wheel [Thorp, 7]. The Internet technology has and will continue to become an integral part of our society and will become a fundamental need just as electricity. The Internet provides significant business value to users by providing a ready-made infrastructure for network connectivity and tool-enabled capabilities.

Primarily due to the rapid development in the Internet, we witness today a dramatically accelerated rate at which different forms of information (data, voice, video, audio, control, etc.) are merging, thus allowing uninhibited mixing of information types for solving everyday problems. This convergence is allowing the end-user to communicate and share information more efficiently with the rest of the world. It also transforms the way business is transacted and enables new applications and services to be developed and delivered. Services like electronic-business and new organization form such as “virtual” or “network” organization would not be possible without the Internet.

The underlying strengths of the Internet are its robustness made possible by the packet switching technology, and most importantly, its open and accepted standards for protocols. Internet network and application protocol standards allow for rapid sharing of information, dynamic application deployment, and leveraged network operations. Among some of the vital standard protocols are:

- **TCP/IP** (Transmission Control Protocol/Internet Protocol), a standard protocol for the transport and network layer respectively. Together, they provide the robustness of the system by enabling packets of data to be routed around the interconnected networks to reach its final destination.
- **FTP** (File Transfer Protocol), a standard application layer protocol for file transfer between two communication nodes connected to the Internet.
- **SMTP** (Simple Mail Transfer Protocol), a standard application layer protocol for exchanging of e-mail.
- **HTTP** (HyperText Transfer Protocol), the standard Web transfer protocol. Each interaction consists of one ASCII request, followed by one RFC 822 MIME-like response.
- **HTML** (HyperText Markup Language), the standard language for writing Web pages. It allows users to produce Web pages that include text, graphics, and pointers to other Web pages.
- **XML** (Extensible Markup Language). Unlike the HTML that defines a fixed way to describe information in one specific class of documents, XML lets you define your own customized markup languages for different classes of document. XML is primarily intended to meet the requirements of large-scale Web content providers for industry-specific markup, vendor-neutral data exchange, media-independent publishing, one-on-one marketing, workflow management in collaborative authoring environments, and the processing of Web documents by intelligent clients. The specification for XML is still evolving.
Today, many corporations have discovered that the same Internet technologies can be used for internal client/server applications with the same ease they are used on the Internet. Thus the concept of the “Intranet” was born with the implementation of Internet tools and standards across organizations’ internal network. Intranets frequently provide access to the public Internet through firewalls, which provide security and controlled access between the networks.

One key advantage of Web-based intranets is that the problem of managing code on the client is greatly reduced. Assuming a standard browser on the desktop, all changes to user interface and functionality can be done by changing code on the HTTP server. A second advantage is that if the corporation is already using the Internet, no additional code needs to be licensed or installed on client desktops. To the user, the internal and external information servers appear integrated. A rapidly disappearing disadvantage is that there is limited ability to provide custom coding on the client. In the early days of the Web, there were limited ways of interacting with the client. The Web was essentially “read-only”. With the release of code tools such as Java and JavaScript, this limitation is no longer a major issue.

2.6.5 Java

Java is an interpretive, high-level object-oriented programming language, developed by Sun Microsystems in 1991 to address the programming of embedded systems and hand-held computers. Sun's goals for Java were to create a small, fast, efficient, and portable programming language. According to Sun Microsystems, Java is both a programming language and a platform [Sun, 44]. As a programming language, Java is architecture-neutral, portable, distributed, multithreaded, and dynamic.

Java achieves most of its features by translating a Java program into an intermediate language called Java bytecodes with a compiler. The bytecodes, which are platform-independent, are then interpreted by the Java interpreter. With an interpreter, each Java bytecode instruction is parsed and run on the computer. Compilation happens each time the program is executed.

Java bytecodes can be thought of as the machine code instructions for the Java Virtual Machine (Java VM). Every Java interpreter, whether it is a Java development tool or a Web browser that can run Java applets, is an implementation of the Java VM.

Java program can be compiled into bytecodes on any platform that has a Java compiler. The bytecodes can then be run on any implementation of the Java VM. For example, the same Java program can run on Windows NT, Solaris, and Macintosh (see Figure 15).

Java as a platform differs from most other platforms in that it is a software-only platform that runs on top of other, hardware-based platforms. Most other platforms are described as a combination of hardware and operating system. The Java platform has two components:

- The Java Virtual Machine (Java VM).
- The Java Application Programming Interface (Java API).

Java VM, which has been described above, is the base for the Java platform and is ported onto various hardware-based platforms. The Java API on the other hand, is a large collection of ready-made software components that provide many useful capabilities, such as graphical
user interface (GUI) widgets. The Java API is grouped into libraries (packages) of related components.

**Figure 15. Bytecodes can run on any implementation of the Java VM.**

Source [Sun, 44]

Figure 16 depicts a Java program, such as an application or applet, that’s running on the Java platform. As the figure shows, the Java API and Virtual Machine insulates the Java program from hardware dependencies.

**Figure 16. Java as a Platform.**

Source [Sun, 44]

As a platform-independent environment, Java can be a bit slower than native code. However, efforts are being undertaken to bring Java’s performance close to that of native code without threatening portability. Smart compilers, well-tuned interpreters, and just-in-time bytecode compilers are a few examples of the effort.

Probably the most well known Java programs are *Java applets*. An applet is an executable Java program that adheres to certain conventions that allow it to run within a Java-enabled browser. Unlike ordinary applications, which reside on the local hard drive, a Java applet resides on a Web server. When a Web page containing a Java applet is viewed with a Java-compatible browser, the applet’s code is downloaded to the local computer and executed within the browser window. Java applets transform the used-to-be “static” web pages with more “dynamic” features, bringing to users more interactivity and richer multimedia contents.

Another type of Java program is Java application. Unlike applets that run within a Java-enabled browser, a Java application is a stand-alone program that runs directly on the Java platform. A special kind of application known as a *server* serves and supports clients on a network. Examples of servers include Web servers, proxy servers, mail servers, print servers, and boot servers. Another specialized program is a *servlet*. Servlets are similar to applets in
that they are runtime extensions of applications. Instead of working in browsers, servlets run within Java servers, configuring or tailoring the server [Sun, 44].

Besides becoming an integral part of the Internet technology, the real strategic value of Java technology, from the perspective of electric utilities, rests on its platform-independent and portability. These salient features are imperative for the development of net-PC, thin-clients, etc. Another recent important development that is based on the Java technology is Jini.

Sun Microsystems’ vision for the Jini technology is to provide simple mechanisms which enable devices to plug together to form an impromptu community [Sun, 45]. Jini builds upon Java technology (see Figure 17) to allow smart devices such as TVs, VCRs, DVDs, cameras, phones, personal digital assistants (PDAs), radios, printers, etc., to be put together quickly to form impromptu systems unified by a network without any planning, installation, or human intervention. Each device provides services that other devices in the community may use. These devices provide their own interfaces, which ensures reliability and compatibility. Devices in a network employing Jini technology are tied together using Java Remote Method Invocation (RMI).

Jini technology not only defines a set of protocols for discovery, join, and lookup, but also a leasing and transaction mechanism to provide resilience in a dynamic networked environment. And the Jini connection infrastructure is small enough that a community of devices enabled by Jini connection software can be built out of the simplest devices. For example, it is entirely feasible to build such a device community out of home entertainment devices or a few cellular telephones with no “computer” in sight.

![Figure 17. Jini builds upon Java technology to allow interaction between smart devices.](source: [Sun, 45])

### 2.6.6 Electronic Data Interchange (EDI)

EDI is a strategic business solution that facilitates the transfer of business data (purchase orders, invoices, etc.) in a computer-processable form from the computer-supported business applications in one company to those in another. EDI provides many benefits: the elimination of data re-keying is important when confronted with the fact that 70% of data keyed into a computer is taken from a computer-produced document. Besides the reduction of clerical errors and improved data accuracy, EDI also provides improved customer service, reduced costs and delivery times, faster trading cycle, lower administration costs and improved cash flow.
If EDI is being utilized in the corporation, the messaging technology must provide enterprise-wide automated EDI translation supporting the most commonly used EDI standards including UN/EDIFACT (United Nations Electronic Data Interchange For Administration, Commerce and Transport).

The UN/EDIFACT comprises a set of internationally agreed standards, directories and guidelines for the electronic interchange of structured data, and in particular those related to trade in goods and services between independent, computerized information systems. Recommended within the framework of the United Nations, the rules are approved and published by UN/ECE in the United Nations Trade Data Interchange Directory (UNTDID), and are maintained under agreed procedures.

Deregulation has increased the trade with electrical power and increased the need for metering. The settlement is based on hourly metering. This has increased the focus on EDI (Electronic Data Interchange) as a tool for handling the increased needs for information and transport of data between the participants, the System Operator, and the Power Exchange.

To deal with the increased need for information, data and the interchange between different parties in the power industry, EDIEL Nordic-Forum was established in the autumn 1995. The scope of the EDIEL Nordic-Forum is to standardize the use of EDI based on the UN/EDIFACT standard in the Nordic power industry. EDIEL Nordic-Forum maintains and develops the standard and also handles topics in related areas, such as standards for communication, security and communication network [EDIEL, 46].

The standard EDIEL is supposed to cover all needs for the interchanging of data between participants, System Operators, and trade organizations in the power industry except real-time process data. Both domestic and interchange between the countries is to be handled by EDIEL. The philosophy of EDIEL is shown in Figure 18.

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**Figure 18. The EDIEL philosophy. Source [EDIEL, 46]**
It is noteworthy that standardized EDI based on UN/EDIFACT has been used in the power industry in Norway since 1994, and in October 1997, EDIEL was used as a standard in Norway.

2.6.7 Windows NT

Windows NT operating system is becoming more and more popular among business organizations. It has the advantage of having a user interface that most PC users are familiar with. According to a survey conducted by PlugIn Datamation and the investment banking firm SG Cowen in 1998, NT will be considered the strategic operating system by more organizations compared with UNIX in 1999, see Figure 19 [Robinson, 47]. Apart from this, NT is also being used increasingly as Web server, application server (e.g. exchange server) and database server other than file and print server. According to a Gartner Group report [McNee, 48], Microsoft Windows NT server will continue as the “platform of choice” through 2002.

![Figure 19. Trend of NT as strategic operating system](image)

Although Wintel (Windows and Intel) systems will have adequate performance, availability and manageability to compete with traditional mainframe through the year 2000, a number of issues still require attention, particularly on NT scalability [McNee, 48]. Scalability is a key differentiator in server selection. Much focus is put on the scalability limits of Microsoft’s Windows NT. Although NT is not as scalable as Unix in most cases, Gartner Group expects NT to improve in scalability at a substantial rate during the next few years.

The Windows NT operating system is, by design, highly scalable. It is designed to support symmetric multiprocessing (SMP) and does not have any fundamental architectural limits that will keep it from supporting up to 32 processors. However, Microsoft has implemented NT only on four, six, and eight-processor systems, and has only begun to tune it for six and eight-processor systems. Furthermore, although NT has scalable characteristics, it is limited by the composite of the NT operating system and the DBMS or other software subsystems running on top of it. SQL Server, Oracle, Informix Software and Sybase each has its own scalability characteristics in the NT environment. These DBMSs all scale fairly well in a four-processor environment. Four Intel Pentium Pro processors with any of these DBMSs can support several hundred concurrent users with fairly large databases. Scalability from four to six processors...
drops off markedly and does not provide the performance boost of going from two to four processors. Running with eight processors is only slightly faster than with six.

Another issue concerning NT is its ability to handle mission-critical applications. Windows NT by itself is not designed as a real-time operating system. It does not provide the needed real-time performance and determinism required by real-time tasks. Today, a number of vendors have extended the usage of Windows NT to applications that require real-time performance and determinism. An example is the INtime from RadiSys. The architecture of INtime is shown in Figure 20 [RadiSys, 49].

![INtime Product Architecture](image)

The components of INtime consists of:

1. **Real-time kernel**: The real-time kernel that provides deterministic scheduling and execution of real-time threads. Real-time interrupts and active Intime threads immediately preempt the execution of any NT threads and disable all non-real-time interrupts.
2. **RT API**: Real-time threads access the capabilities of the real-time kernel via a Win32-like real-time application programming interface (RT API).
3. **NTX Driver**: The NTX driver is a Windows NT device driver that provides centralized support for the OSEM. The NTX driver facilitates communications between real-time kernel threads and NT threads.
4. **NTX API**: The NTX API extends the Win32 API to enable non-real-time threads to communicate and synchronize with real-time threads. Mechanisms such as semaphores, mailboxes, and shared memory are provided.
5. **Patented OS encapsulations mechanism (OSEM)**: The OSEM manages the simultaneous operation and integrity of the NT kernel and the real-time kernel, and provides memory protection and address isolation between processes for added reliability and robustness.
6. **Modified Windows NT Hardware Abstraction Layer (HAL)**: INtime includes a special version of the Windows NT HAL that improves the overall reliability and robustness of the system.
2.6.8 PowerLine Telecommunication (PLT)

Using power lines to communicate is not new to electric utilities; they have been using them for many years, although mainly for low bandwidth applications. PLC (Power Line Carrier), for example, has been used since the 1900s in protective relaying, SCADA (Supervisory Control and Data Acquisition), voice communication between control centers and primary substations, and telemetering [Newbury, 50]. Another classic system using power lines as the communication medium is the ripple control system, which is a one-way communication system used since the 1950s for street light control, load control, and tariff switching.

However, the technology used to communicate over power lines has undergone dramatic changes over time. In the period from the late 1980s to the early 1990s, systems capable of providing two-way communication over low voltage lines at a speed of up to 2400 bps were developed. Huge interest was shown for this by utilities. Since then, the data rate has kept increasing. Bounded by the CENELEC standard (EN50065-1) on frequency allocation for power lines (Figure 21), these narrowband systems that utilized a frequency range of 3 - 95 kHz finally reached their limit with a data rate of 9600 bps.

![Figure 21. CENELEC frequency allocation on power line (EN50065-1 standard)](image)

Fuelled by the trend of deregulation, many utilities saw this as an opportunity for them not only to improve their operational efficiency, but also to introduce value-added services to retain their existing customers and to attract new ones. Even at this limited data rate, many “narrowband” DA/DSM (Distribution Automation / Demand Side Management) services and applications such as supervision and control of distribution networks, automatic meter reading (AMR), theft detection, load management including real-time-pricing and tariff switching, home automation, etc., can already be introduced [Cheong, 51]. In Europe, ENEL of Italy and EDF of France can be considered the utilities with the most wide spread implementation of DA/DSM services and applications by using this “narrowband” PLT technology.

During this same period, many similar but incompatible systems have been developed by vendors trying to get a share of the potential market [Cheong, 1]. Trying to provide some standards in this development, IEC (International Electrotechnical Commission) finally released in 1996 a set of standards governing communication over low voltage lines (IEC 1334 series). However, the standards, which specify up to the application layer on the OSI (Open System Interconnection) model are still not sufficient. To ensure interoperability, a further standard above the application level, e.g., companion standard for the mapping of metering object is required [Cheong, 1]. The DLMS UA (Device Language Message...
Specification User Association) is currently working in conjunction with other standardization bodies to develop the companion standard.

Currently, the most widely used system on the market is the LonWorks system by Echelon. This system has more or less become a de facto standard by virtue of its wide acceptance in various control market segments, including electric utilities’ DA/DSM (Distribution Automation/Demand Side Management) low bandwidth applications and services as well as home automation [Echelon, 52].

Towards the end of 1997, a system capable of delivering 1 Mbps was announced by Norweb. This high speed full duplex, symmetric system represented a breakthrough in PLT technology. The vendor claimed that the system could support up to 250 homes per substation. To achieve such high speed, the system utilizes a frequency band in the MHz range (between 2.5 - 6 MHz) [Norweb, 53], thus it is outside the frequency band allocated under the CENELEC EN50065-1 standard. Due to the high frequency used, this system can only be used on shielded or screened cables to prevent it from interfering with other radio equipment, for example, in underground cables. It is not suitable for use in overhead cables that are not shielded.

It is important to note that at present this system can only provide Internet access. It has the advantage of providing a permanent Internet connection without the need to dial-up. The available bandwidth, however, is shared among users connected by the same feeder from the substation. Thus, the effective data rate is lower than 1 Mbps if more than one user is connected. Another point worth noting is that the connection to Internet is via a coaxial cable from a conditioning unit installed near the fuse box of the premise (Figure 22) and not from any socket outlet as many people had hoped for. The signal is not designed to be carried over in-house wiring.

![Figure 22. The NORWEB’s PLT system.](Source: NORWEB)
Since this breakthrough, reactions from electric utilities have been very strong. Many utilities see this as an opportunity for them to “break into” the already deregulated telecommunication industry and tap the enormous market of the Internet. Within a few months, ten utilities worldwide signed up for trial runs, including three of the largest utilities in Sweden. Fuelled by the intense interests of utilities and the huge potential of the Internet market, other vendors also jumped on the bandwagon announcing similar but incompatible systems. It should be noted that until today, there has been little or no effort targeted to achieve any kind of standard in this “broadband” PLT technology.

Thus, today, basically two different categories of PLT technology and system exist: the “narrowband” systems that comply with the CENELEC standards and the “broadband” systems that utilize a frequency outside the spectrum provided by CENELEC. These two technologies, serving different application areas, are undergoing different stages of technological development and are at different maturity levels as shown in Figure 23.

![Figure 23. Stages of technological development (adapted from Gartner Group)](image)

2.7 Conclusion

In this section, readers are introduced to the IT environment commonly found in electric utilities. The changing role of IT and the increasing need for a seamless information exchange between different IT systems within electric utilities are highlighted. Some of the limitations in systems integration are described. The impacts of IT on the functioning of utilities’ organization are illustrated by two example scenarios. Finally, some of the modern Information Technologies that have strategic values to electric utilities are presented and described. These technologies are considered strategic as they can contribute not only to enhance the efficiency and effectiveness of utilities business processes, but also to enable new business activities beyond the traditional core business. Utilities should monitor the development of these technologies and deploy them where necessary to create strategic values for their organization.

Client-server architecture addresses one of the needs of modern business for an integrated, flexible, responsive and comprehensive applications to support the complete range of business processes. It helps to distribute computing resources to where it is required. An important characteristic of client-server systems is scalability. They can be scaled horizontally or
vertically. Horizontal scaling means adding or removing client workstations with only a slight performance impact. Vertical scaling means migrating to a larger and faster server machine or multiservers.

Object technology enables the development of standard, reusable component software that offers a more efficient and productive model for the software industry, and will dramatically reduce the programming effort and time required to delivering new business solutions.

Middleware provides the connectivity needed for applications to transparently communicate with other programs or processes, regardless of their location. Middleware standard such as CORBA addresses the need for interoperability among the rapidly proliferating number of hardware and software products available today. Most importantly, CORBA allows legacy applications to be rapidly integrated into the distributed application with little or no modification by encapsulating the existing application in a CORBA “wrapper.”

The Internet provides significant business value to users by providing a ready-made infrastructure for network connectivity and tool-enabled capabilities. It not only enables end-user to communicate and share information more efficiently with the rest of the world, but also transforms the way business is transacted and enables new applications and services to be developed and delivered. Services like e-business and new organization forms such as “virtual” or “network” organization would not be possible without the Internet.

Java enhances the Internet by transforming the used-to-be “static” web pages with more “dynamic” features, bringing to users more interactivity and richer multimedia contents. Most importantly, the real strategic value of Java technology, from the perspective of electric utilities, rests on its platform-independent and portability.

EDI facilitates the transfer of business data in a computer-processable form from the computer-supported business applications in one company to those in another. EDI provides many benefits such as the elimination of data re-keying, the reduction of clerical errors and improved data accuracy, reduced costs and delivery times, faster trading cycle, lower administration costs and improved cash flow. Currently, a version of EDI based on UN/EDIFACT is being used in the Nordic power industry. This version, known as EDIEL, is being developed and maintained by the EDIEL Nordic-Forum formed in 1995 with the task to standardize its use in the Nordic power industry.

Windows NT operating system is becoming more and more popular among business organizations. It has the advantage of having a user interface that most PC users are familiar with. Although according to a Gartner Group report that Windows NT server will continue as the “platform of choice” through 2002, there are a number of issues that utilities must be aware of. First, Windows NT by itself is not designed as a real-time operating system. It does not provide the needed real-time performance and determinism required by real-time tasks, and therefore it is unable to handle mission-critical applications. Second is on NT’s scalability. Scalability is a key differentiator in server selection. In most cases, NT is not as scalable as Unix.

Powerline technology is of great strategic value to electric utilities as it transforms utilities’ existing infrastructure (the electric distribution networks) into a communication networks. Powerline technology not only could enable utilities to deliver more energy related value-
added services to their customers, but also enable them to move into the already deregulated telecommunication industry. While the “narrowband” version of the technology, sufficient to deliver most energy related services, is entering its mature phase, the “broadband” version that delivers Internet access is still evolving and suffers from a total lack of standard.

3 LITERATURE REVIEW

3.1 Introduction

Section one provided the background to the research and outlined the research questions. Section two described the complex IT environment of electric utilities and the potentials of some modern information technologies that could be of strategic values to utilities. This section is aimed at building a theoretical foundation upon which the research is based by reviewing the relevant literature.

As mentioned in section one, the research questions of this thesis are centered around how to bring about a more effective IT strategy so that electric utilities can better exploit the benefits and potentials offered by the advancement in IT to face their future challenges.

An initial search on IT strategy related literature showed that the issue of IT strategy seemed to fall under the realm of IT consultants rather than the academia. While many literatures have been written about strategy in general, especially about business or competitive strategy, for instance, [Porter, 54], [Andrews, 55] and [Mintzberg, 56, 57], very little literature has been written with a special focus on IT strategy. Exceptions were found in [Boar, 20] and [Frenzel, 21]. On the other hand, most IT consultants have developed some kind of methodology in-house that they use to help their clients develop an IT strategy. See for example [MST, 23], [DMR, 24], [Nolan, 25], [C international, 26], [Amtec, 27] and [DSG, 28]. Most of the methodology has its roots in the discipline of strategic management and focuses primarily on the process of formulating the strategy.

Furthermore, a preliminary literature survey of IT-related literatures also revealed that most IT projects have not succeeded or achieved the originally targeted goals not because of the technical issue or the technology itself, but due to other so-called “soft” factors that are not technical in nature but strongly linked to the effective functioning of an organization. See for instance [Standish Group, 3], [Moreton, 4], [Eason, 5], [Glass, 6], and [Thorp, 7]. This led to the need to look into the discipline of organization theory as well, in order to achieve an effective IT strategy.

To summarize, the initial literature search and review has provided the direction in which the research study should go. It indicated that in order to achieve an effective IT strategy, one must look beyond just technical or technological issues, an aspect that the author has been focusing on in his earlier part of his research study. The IT strategy must incorporate concepts and theories from other fields such as strategic management and organization theory. In other words, the study of IT strategy must involve a multi-disciplinary study. This provided a framework for the research study as shown in Figure 24.
Based on this framework, more in-depth literature review was pursued in order to build a theoretical foundation upon which the research is based. More detailed description of the literature reviewed is given in the subsection below. Attempts have been made to categorize the literature into three groups as depicted in Figure 24, although the scope of some literature might span across more than one group.

3.2 **IT strategy and organization theory**

3.2.1 **Introduction**

According to [Cartwright, 58], an “organization” is an arrangement of interdependent parts, each having a special function with respect to the whole. Members of an organization vary greatly in ability, training, knowledge, cultural background, and needs. Simply put, organization means a social unit with some particular purposes. Implicit in the concept of an organization is the need to maximize coordination and cooperation that ultimately contribute to the efficient functioning of the organization to achieve its purposes.

The study of organization is in itself a very broad discipline encompassing for example organization processes, organization structure, organization change, organization culture, and human relation, etc. Contributions to organization theories can be dated back to as far as 1491 B.C. During the exodus from Egypt, Jethro, the father-in-law of Moses, urged Moses to delegate authority over the tribes of Israel along hierarchical lines [Shafritz, 59].

Over the years, organization theory has evolved, expanded, and matured. Although the basic elements of organizations have remained relatively constant through history, their purposes, structures, ways of doing things, and methods for coordinating activities have always varied widely. To a large extent the variations are a reflection of an organization’s adaptation to its environment.

Today, there is a rich collection of organization theories. These theories are often grouped into different “schools” depending on their perspectives on organizations. For instance, the grouping may be based on the basic assumptions about humans and organizations and by those aspects of organizations that are seen as most important for understanding
organizational behavior. The grouping may also be based on the period of time during which the most important contributions were written. Readers who are interested in the chronological development and the various “schools” of organization theory are recommended to refer to [Shafritz, 59].

In the following, some of the important organization theories that are related to or will have an impact on the effectiveness of IT strategies will be presented. These theories provided the framework within which this research study was carried out.

### 3.2.2 Leavitt’s model

In his attempt to interrelate several distinct sets of approaches to organizational change, Leavitt, in his paper [Leavitt, 60], viewed industrial organizations as complex systems with at least four interacting variables, namely, the task variables, the structural variables, the technological variables, and the human variables (see Figure 25).

![Figure 25. The Leavitt’s Diamond](image)

Leavitt contends that the interactions of these forces are mutually dependent: as one changes, so do the others in response. The result is that it is difficult to achieve any significant degree of change without tackling each of the factors in parallel.

For example, structural change in the electric utility industry due to deregulation has resulted in changes in the task of the new organization. It may also change the technology used for certain procedures, for example, in accounting procedures, billing and invoicing procedure, etc. Finally, it may also bring about changes in the number, motivation and attitudes of people in the organization.

Similarly, the introduction of new technology, especially information technology, may cause changes in structure (e.g., in the communication system or decision map of the organization), changes in people (their number, skills, attitudes, and activities), and changes in performance or even definition of task. Thus, it is argued that any effort to effect change, whether it begins with people, technology, structure, or task, soon must deal with the others. However, people approaches, according to Leavitt, are in wide and increasing use in industry.
Leavitt’s model provides a powerful system view of the interacting forces within an organization. Since its introduction, this model has been used, referenced to, or enhanced by more contemporary publications in the field of information systems research and management, for example, [Rockart & Scott Morton, 61], [Rockart, Earl, & Ross, 62], and [Moreton & Chester 4]. In [Rockart & Scott Morton, 61], another important element, the management process that was seen as part of the “glue that holds organizations together” was added to the model. Management processes include, for example, strategic planning, budgeting, statutory reporting, conducting staff appraisals and doing corporate public relations [McHugh, 63].

This model spurred further literature research and review in order to gain a deeper understanding on the relationships between technology and the other three vital elements of an organization, namely, the tasks, the structure, and the people.

3.2.3 IT and tasks/processes

As mentioned above, task refers to industrial organizations’ purpose: the production of goods and services, including the large numbers of different but operationally meaningful subtasks that may exist in complex organizations. The task-based view of an organization, which is largely based on the traditional Adam Smith's task-based business model focusing on division of labor as presented in [Smith, 64], has resulted in many organizations being structured or compartmentalized into various functional units, each responsible for performing a pre-specified task. Many contemporary organization theorists have called for a change from the traditional task or functional-based view to a more process-oriented view in order for organizations to enhance their overall effectiveness in contrast to just task efficiency. For instance, [Senge, 10] called for thinking in terms of processes of change rather than “snapshots,” and learning to see the underlying “structures” rather than “events.”

Today, many organizations are still being organized in this manner. However, there is an increasing tendency for organizations to adopt a process-based view instead of the traditional task-based view as evident from the number of organizations being restructured into a more process-based organization.

A process is simply a structured, measured set of activities or tasks designed to produce a specified output for a particular customer or market. It implies a strong emphasis on how work is done within an organization, in contrast to a product focus’s emphasis on what. According to [Davenport, 8], a process is a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action.

A process structure can provide a dynamic view of how the organization delivers value. Furthermore, cost can be attached to a process and when we reduce cost or increase customer satisfaction, we have bettered the process itself. In this context, a process structure is more measurable than the traditional hierarchical structure, which is often difficult to measure.

The relationship between IT and tasks or processes is perhaps one of the most written one. The theme of most literature on this subject mostly centered on business process reengineering (BPR). This is primarily due to the increased ability and potential of the modern IT applications to cut across the functional or departmental barrier to bring about
increased efficiency. Some of the more well known literature in this area include [Hammer, 22], [Johansson, 65], [Davenport, 8], and [McHugh 63].

The term BPR was first coined by [Hammer, 22] in 1993 to call for a radical shift from the traditional Adam Smith’s task-based business model to a process-based business model to achieve higher efficiency and effectiveness. Hammer defined BPR as “the fundamental rethinking and radical redesign of business process to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed.” He highlighted IT as an essential enabler for the reengineering effort. [Johansson, 65] further classified BPR into three categories:

1. **Single function**, which concentrated on single functions of a business and was predominantly a cost reduction effort.
2. **Cross functions**, which began to exploit the synergy of cross-functional processes and were aimed at achieving competitive parity.
3. **Breakpoint**, in which the aim was to identify customer or market values such as speed, flexibility, etc. which when realized, would result in redefining the market rules to the advantage of the practitioner.

[Davenport, 8] provided evidence showing that so far most users of IT have not been able to exploit the full potential of the technology despite radical improvements in IT functionality. The improvement in productivity has been only marginal and does not commensurate with the amount of investment made in IT. While he agreed with the view put forward by Hammer that IT should not be seen as merely a tool to replace the traditional manual process but as an enabler, he coined the term “business process innovation” to differentiate it from other commonly used terms such as business process redesign and business reengineering. Basically, all these terms implied radical process change initiatives against the traditional process improvement initiatives that seek continuous and incremental improvement. Business process innovation, according to Davenport, “encompasses the envisioning of new work strategies, the actual process design activity, and the implementation of the change in all its complex technological, human, and organizational dimensions.” In this context, he combined business reengineering, which referred specifically to the design of the new process, with other important organization factors such as organization change and people.

Business process innovation implies the need to adopt a process view of the organization (as against the traditional functional-based view) to facilitate the implementation of cross-functional solutions. While process time and cost reduction used to be some of the primary objectives of process innovation, process innovation, according to Davenport, can also support low-cost producer strategies by eliminating, for example, costly product delivery processes. Today, competitive pressure is not the only driver of process innovation; increasingly, customers are the impetus for radical process change.

The key aspects that differentiate business process innovation from the traditional process improvement are summarized in the Table 1 [Davenport, 8]. In practice, most firms need to combine process improvement and process innovation in an ongoing quality program.
Table 1. Differences between traditional process improvement and process innovation

<table>
<thead>
<tr>
<th>Area of difference</th>
<th>Improvement</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of change</td>
<td>Incremental</td>
<td>Radical</td>
</tr>
<tr>
<td>Starting point</td>
<td>Existing process</td>
<td>Clean slate</td>
</tr>
<tr>
<td>Frequency of change</td>
<td>One time/continuous</td>
<td>One-time</td>
</tr>
<tr>
<td>Time required</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Participation</td>
<td>Bottom-up</td>
<td>Top-down</td>
</tr>
<tr>
<td>Typical scope</td>
<td>Narrow, within functions</td>
<td>Broad. Cross functional</td>
</tr>
<tr>
<td>Risk</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Primary enabler</td>
<td>Statistical control</td>
<td>Information Technology</td>
</tr>
<tr>
<td>Type of change</td>
<td>Cultural</td>
<td>Cultural/structural</td>
</tr>
</tbody>
</table>

While many literatures argue for the need for business process reengineering or business process innovation, [McHugh, 63] further argued that with today’s development in IT, it would be possible for an organization to go beyond BPR within the organization. He put forward the concept of a “holonic” network, which is a set of companies that acts integratedly and organically; it is constantly reconfigured to manage each business opportunity a customer presents. Each company in the network provides a different process capability that represents the core competence of the company. Figure 26 presents a model adopted from [Scott Morton, 66] summarizing the different levels of IT deployment and its potential business impact.

![Figure 26. Maturity levels of IT deployment and its potential business impact](image)

3.2.4 IT and structure

All social units including organizations have a structure and control their members [Etzioni, 67]. Organizations, however, differ from other social units such as family, ethnic group, or community in that they serve specific purposes. They are planned, deliberately structured, constantly and self-consciously reviewing their performances, and restructuring themselves accordingly.

As mentioned in the introduction to this section, an organization is an arrangement of interdependent parts (also known as subsystems or entities), each having a special function with respect to the whole. Members of an organization vary greatly in ability, training, knowledge, cultural background, and needs. In order to achieve the task or the purpose of an organization, these different parts or entities must be able to “fit” together in a cohesive
manner. Organization structure provides a framework for this purpose. Discussions of organization structure often include the concepts of levels of management and span of control.

Organization structure has been studied for many years [Frenzel, 21], and theorists generally agree that some sort of structure is necessary for the effective operation of human enterprise.

There are many literatures concerning organization structure. Most of the contemporary literatures build upon previous research study conducted as far back as 1950s such as the study conducted by Woodward and documented in [Woodward, 68]. The aim is to increase organization effectiveness by having a better understanding of the factors affecting the design of organization structure. Some of the well known literature in this area are, [Mintzberg, 69, 70], [Harrington, 9], and [Hall, 71].

In [Hall, 71], the emphasis is on the relationship between organizational structure and processes within organization. Organizational processes are the organizational actions. They are the dynamics of organizations including, among others, the process in which power is exercised, the handling of conflicts, leadership, decision making, communications, and change. Organization structure, on the other hand, serves three functions. First, it is intended to produce organizational outputs and to achieve organizational goals. Second, it is designed to minimize or at least regulate the influence of individual variations on the organization. Third, structure is the setting in which power is exercised, decisions are made, and in which organization's activities are carried out.

[Hall, 71] identifies four crucial factors that affect the organization structure, namely, size, technology, environmental, and choice. The size factor has four components. They are the physical capacity of the organization, the personnel available to the organization, the size of organizational inputs and outputs, and the size of the discretionary resources available to an organization. Technology has the notion of the technical systems used by the organization to transform inputs into outputs. Environmental factors include not only the social environment of organizations, but also the physical environment such as climate or geography. Finally, choice means the strategic choice for the business organization.

In [Mintzberg, 70], the emphasis is on the design parameters of organizations and how these parameters are chosen and combined in different ways in structuring organizations. He identifies nine design parameters and these parameters are classified into four groups according to the purpose of these parameters. These parameters together with their respective grouping are shown in the Table 2.

Mintzberg also identifies several crucial factors that he labels as contingency factors that can affect the choice of the design parameters. Besides size, technology or technical system, and environment (which Hall also identifies), he also identifies the age of the organization as well as the power factors that include the presence of outside control of the organization and the power of the social norms within the organization itself.
### Table 2. Design parameters of organization structure.

*Source: [Mintzberg, 70]*

<table>
<thead>
<tr>
<th>Group</th>
<th>Design Parameter</th>
<th>Related Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design of positions</td>
<td>Job specialization</td>
<td>Basic division of labor.</td>
</tr>
<tr>
<td></td>
<td>Behavior formalization</td>
<td>Standardization of work content. System of regulated flows.</td>
</tr>
<tr>
<td></td>
<td>Training and indoctrination</td>
<td>Standardization of skills.</td>
</tr>
<tr>
<td>Design of superstructure</td>
<td>Unit grouping</td>
<td>Direct supervision. Administrative division of labor. Systems of formal authority, regulated flows, informal communication, and work constellations.</td>
</tr>
<tr>
<td></td>
<td>Unit size</td>
<td>System of informal communication. Direct supervision. Span of control.</td>
</tr>
<tr>
<td>Design of lateral linkage</td>
<td>Planning and control systems</td>
<td>Standardization of outputs. System of regulated flows.</td>
</tr>
<tr>
<td></td>
<td>Liaison devices</td>
<td>Mutual adjustment. Systems of informal communication, work constellations, and ad hoc decision process.</td>
</tr>
<tr>
<td>Design of decision making system</td>
<td>Vertical decentralization</td>
<td>Administrative division of labor. Systems of formal authority, regulated flows, work constellations, and ad hoc decision process.</td>
</tr>
<tr>
<td></td>
<td>Horizontal decentralization</td>
<td>Administrative division of labor. Systems of informal communication, work constellations, and ad hoc decision process.</td>
</tr>
</tbody>
</table>

In terms of the influence of technology or technical system on organizations, Mintzberg distinguishes the influence into three dimensions:

- The flexibility of the technical system, that is, the degree of member choice the instruments permit.
- The complexity of the technical system, that is the composition of the technical system.
- The complexity of the technology itself, including the skills required in the organization.
The distinction made on the complexity of the technical system and that of the technology is important, noting for example that a complex technical system may, in fact, be easy to operate; while a simple technical system may require very complex technology that in turn requires complex knowledge and skills to work on.

Mintzberg uses two terms, *regulation* and *sophistication*, to describe the dimensions described above. The regulation dimension describes the influence of the technical system on the work of the operators, that is, the extent to which the operators’ work is controlled, or regulated, by the technical system. The sophistication dimension describes the complexity or intricateness of the technical system, namely how difficult it is to understand from the perspective of its design and subsequent maintenance, and not from the perspective of the work of the operator on the technical system. This dimension influences the need for an elaborate support staff.

Based on these two dimensions, Mintzberg formulated three hypothesis about the influence of the technical system on organizations. He used results from previous research to support his hypothesis. These three hypothesis are:

1. The more regulating the technical system, the more formalized the operating work and the more bureaucratic the structure of the operating core.
2. The more sophisticated the technical system, the more elaborate the administrative structure, specifically the larger and more professional the support staff, the greater the selective decentralization (to that staff), and the greater the use of liaison devices (to coordinate the work of the staff).
3. The automation of the operating core transforms a bureaucratic administrative structure into an organic one.

It is noteworthy that the term “technology” or “technical system” used in [Hall, 71] and [Mintzberg, 70] refers to the “collective instruments” used by the operators to do their work. Thus, it has the notion of “operation technology” that focuses on the operating core of the organizations. It does not go beyond the operating core of the organizations as information systems do today. This is quite understandable since both [Hall, 71] and [Mintzberg, 70] were written in the early 1980s and built upon prior research studies before the “big boom” of information technology (IT). A more contemporary literature on the relationship between IT and organization structure can be found in, for example, [Harrington, 9].

While Mintzberg analyzes organization structure from a management policy’s perspective and Hall analyzes the relationship between organization structure and processes, Harrington looks at the impact technology, in particular Information Technology, has on organizations, and attempts to develop a new organization model to better understand the relationship between IT and organization.

According to [Harrington, 9], the structure of an organization is seen as providing the framework which turns a collection of people and resources into identifiable form. He argues that the definition proposed by Mintzberg in his book [Mintzberg, 69] that “structure as the summation of the ways in which a firm’s labor is directed and coordinated into tasks” is too simplistic. Such a definition, according to Harrington, merely lists a functional relationship, which although important, reveals only part of the organization structure.
Organization structure, according to him, is as much perceptual as physical. That is, it exists because its members perceive it to do so. For example, it is common for small business organizations to share resources such as office space, equipment and even staff, therefore possessing the same physical structure. There is no suggestion, however, that they are the same organization. Their differentiation is thus established by the perception of the actors (employees, suppliers, customers, etc.) and not the physical aspects. Thus, organization structure has to be more than a static framework of functional and coordinative hierarchy. Whatever their apparent characteristics, they are manifest not because of the way we organize our physical resources but rather as a consequence of the way we relate to those resources. Structure, he argues, is indeed in our minds.

Harrington highlighted the impacts of IT on organization structure by seeing an organization structure in two domains, namely the physical domain (the division into departments and functions) and perceptual domains (what the employees perceive). IT, according to him, unlike other general technologies, has far greater impact on the perceptual domain. By changing the perception of people who make up the organization, the perceived organization structure is changed. He argued that the relationship between IT and organization structure is inseparable. This relationship must be considered when introducing IT in organizations.

Incidentally, [Zuboff, 72] also coined the term “informating” to distinguish the huge potential impact of IT on organization from the mere “automating” capability of other general technologies. According to her, “informating” is concerned with “radical changes as it alters the intrinsic character of work. It also poses fundamentally new choices for our organizational futures, and the ways in which labor and management respond to these new choices will finally determine whether our era becomes a time for radical change or a return to the familiar patterns and pitfalls of the traditional workplace.” She further argued that “informating” requires the adoption of new concepts of authority for management as well as a redistribution of authority.

To summarize this subsection on IT and organization structure, it is clear from the discussion that technology certainly has an impact on the organization structure. The relationship between organization structure and technology has been identified as far back as the 1950s as revealed in the work of [Woodward, 68]. With the evolution of technology from a mere “general” or “operation” technology to “information” technology, and with the increasing pervasiveness of the use of information technology in organizations, the impact it has on organization will be even stronger. This is one of the points made in, for example, [Porter, 73].

3.2.5 IT and people

It was mentioned in section one that many IT projects have not succeeded or achieved the originally targeted goals. Today, it is well known that many of these IT projects failed for reasons unrelated to technical feasibility and reliability [Markus, 74]. Instead, these projects failed due to the lack of consideration given to other “soft” factors that are related to, among others, people. Failure to incorporate change management into massive IT projects or IT-enabled transformation projects is often quoted as one of the main causes [Markus, 74][Thorp, 7]. A large number of people must be motivated and prepared to change.

Organization theory literature on the relationship between IT and people often centers on the concept of change that involves both people and organization. As pointed out in [Leavitt, 60],
there are several approaches to effect change in organizations, for example, the structural approach, the technological approach, and the people approach. However, Leavitt highlighted that most efforts to affect change, whether they begin with people, technology, or structure, soon must deal with others.

In structural approach, one changes the structure to change people to improve task performance, for instance, by decentralization. The structural approach has been the major mechanism of the “classical” organization theorist. Some of the underlying assumptions of this approach are that people, having contracted to work, would willingly carry out all terms of their contract; that people assigned responsibility would necessarily accept it; that people when informed of the organization’s goal would strive wholeheartedly to achieve them. The emphasis of this approach is on internal consistency, orderliness, and hierarchical coordination.

The technological approach seeks to affect change in the organization by introducing new techniques or a technology that can subsequently cause changes to the structure as well as people, for instance, by introducing automation. This approach, said to have its root in Taylor’s Scientific Management, has been widely argued by many observers to be demeaning mankind.

In people approach, one seeks to change the organization by first changing the behavior of the organization’s members, for instance, by setting up a training program. By changing human behavior, it is argued that one can cause the creative invention of new tools, or one can cause modifications in structure (especially power structure). By either or both of these means, changing human behavior will cause changes in task solution and task performance and also cause changes toward human growth and fulfillment.

Leavitt observed that people approaches are becoming increasingly popular as reflected by the fact that recent literature dealing with organizational change is heavily people-oriented [Leavitt, 60]. Proponents of people approach are mostly people belonging to the human behavior school, strongly influenced by the Elton Mayo’s Hawthorne studies that highlight the important of human relations and motivation in increasing organization effectiveness.

[Spitzer, 75] summarizes the differences between a mechanistic organization and a “people-wise” organization (see Table 3), and argues strongly for the “people-wise” approach to organizational change. At base, the people-wise organization is looking to its people first, as though they were the first agents of change, rather than the last or the second to last. The mechanistic approach to organization change, according to Spitzer, that purposefully put employees last, is not only outdated, but is often disastrous.

Among other literatures that emphasize on the importance of people in affecting organization change are [Markus, 74] and [Senge, 10].

Markus put forward a theory known as “the magic bullet theory” to explain why many IT-enabled change projects fail, despite all that is known about ensuring success. He argued that failure to employ the best practices in IT-enabled changes stems from mistaken beliefs about the cause of change -- belief in IT as a magic bullet. Deeply held beliefs that IT can cause change lead to both line managers and IT specialists restricting their own efforts as change
agents. A more detailed discussion on the magic bullet theory will be given in subsection 3.4.4 later.

Table 3. Mechanistic organization versus people-wise organization

<table>
<thead>
<tr>
<th>Issue</th>
<th>Mechanistic Organization</th>
<th>People-wise Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining Principle</td>
<td>A set of structures and systems</td>
<td>A community of people</td>
</tr>
<tr>
<td>Main Thrust</td>
<td>Efficiency</td>
<td>Creation and deployment of knowledge</td>
</tr>
<tr>
<td>Approach to Change</td>
<td>Reengineer and the people will follow</td>
<td>Prepare people for change</td>
</tr>
<tr>
<td>Time Frame</td>
<td>Do it now</td>
<td>Do it forever</td>
</tr>
<tr>
<td>Competitive Advantage</td>
<td>Business systems, processes and structures</td>
<td>People -- their knowledge and skills</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Under utilizes human potential</td>
<td>Diffuses responsibility</td>
</tr>
<tr>
<td>Key Job Requirements</td>
<td>Technical skills and dependability</td>
<td>Critical thinking, intuition, experience, technical skills and commitment</td>
</tr>
</tbody>
</table>

At this point, it is suffice to say that, in order to avoid being trapped in the magic bullet mindset, Markus suggests two distinctly different prescriptions: the IT change facilitator role that originated from organization development literature, and the IT change advocate role that originated from literature on management innovation, IT implementation, reengineering, and organizational transformation.

From the perspective of the organization development (OD) practitioners, the major objective of facilitators is to see that their clients take responsibility for making informed decisions based on valid information. Facilitator, as the name implies, facilitates and enables rather than creates change. OD practitioners believe that people, not technologies, create change. In order to make real, lasting improvements, people need more than good IT; they also need to use it in line with clear organizational goals. As agents of IT-enabled organizational change, IT change facilitators bring together all the necessary conditions for successful change: good technologies, supportive organizational conditions, and knowledgeable, mindful users.

Because people have to create change, they must be empowered to do so. IT can deliver only one necessary condition for human empowerment -- valid information. Therefore, whenever possible, IT change facilitators also empower all kinds of people (technologists, users, executives) about IT. They expand their opportunities to learn more about IT and organizational change and to participate effectively in IT decision-making. Most of all, they foster a state of mind in which people accept responsibility for their IT-oriented behavior, however great or small their potential impact on organizational results.

While OD practitioners firmly believe that only neutral “third parties” – non-members of the groups they facilitate and non-experts in the issue -- can formally perform the facilitator role, Markus is of the opinion that even in-house executives and IT specialists should learn how to play this role.
The other role for IT-enabled change agents prescribed by Markus is the IT change advocate role. From the perspective of IT change advocates, IT can enable organizational change, but change is created by people who know the objective and how to use their tools to achieve it. Agents of IT-enabled organizational change can see clearly how the people in an organization can achieve better performance by adopting different work practices and using certain kinds of IT in certain ways.

The IT change advocate focuses less on empowerment and more on inspiring people to adopt and tackle a specific new organizational challenge or undertake a specific change in work methods. Unlike OD facilitators who try to unleash their clients’ ideas and energies for change, change advocates have their own visions and attempt to direct people toward them. IT change advocates focus on results. To realize their visions, change advocates follow the strategy of “whatever works.” They do not limit themselves to OD facilitators’ precise ethical guidelines and use whatever tactics seem likely to work to change people’s minds about the goals, the means, and the outcomes of their everyday actions. When the agents’ tactics pay off eventually, they let others take the credit for the success (a tactic that pays off in credibility when it’s time for the next big idea.)

Although the approach to the two prescriptions described above differs, one thing that is clear about the prescriptions is that they both recognize the importance of people’s roles in ensuring the success of IT-enabled projects. Both prescriptions seem to share a common theme that IT only delivers capability, it is people who deliver the benefits.

Another well-known literature emphasizing the importance of people in ensuring organization effectiveness and success is [Senge, 10]. Although not explicitly linked to IT, the concept and theories presented by Senge are applicable to any organization that undergoes organization changes, be it IT-enabled changes or otherwise.

Lack of organization learning, according to Senge, has often been quoted as one of the main reasons for organization failure. He argued that in order for organizations to excel in the future, the organizations must be able to tap people’s commitment and capacity to learn at all levels in an organization. It is no longer possible just to “figure it out” from the top, and have everyone else following the orders of the “grand strategist.”

He coined the notion of a “learning organization,” which he defined as:

“an organization where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together.”

In order to assist organization to achieve this learning organization, he introduced the five “component technologies” (personal mastery, mental models, building shared vision, team learning, and systems thinking) necessary for the development of a “learning organization.”

**Personal mastery** means the attainment of a special level of proficiency. People with a high level of personal mastery are able to consistently realize the results that matter most deeply to them. They do this by becoming committed to their own lifelong learning and approach their life as an artist approaches a work of art. Personal mastery is therefore the discipline of
continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and seeing reality objectively.

“Mental models” are deeply engrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action. It is important to inculcate a right mental model in a learning organization, as a wrong one can be a major source of “learning disabilities.” According to Senge, the discipline of working with mental models starts with turning the mirror inward, learning to unearth our internal pictures of the world, to bring them to the surface and hold them vigorously to scrutiny.

Building shared vision is the capacity to hold a shared picture of the future we seek to create. When there is a genuine vision (as opposed to the all-too-familiar “vision statement”), people excel and learn, not because they are told to, but because they want to. The practice of shared vision involves the skills of unearthing shared “pictures of the future” that foster genuine commitment and enrollment rather than compliance.

Team learning is vital because, according to Senge, teams, not individuals, are the fundamental learning unit in modern organizations. Unless teams can learn, the organization cannot learn. When teams are truly learning, not only are they producing extraordinary results, but also the individual members are growing more rapidly than could have occurred otherwise. The discipline of team learning starts with “dialogue” that facilitates a free flowing of meaning through the group, allowing the group to discover insights not attainable individually.

System thinking is a discipline for seeing the wholes. It is a conceptual framework for seeing the interrelationships rather than things, for seeing patterns of change rather than static “snapshots.” Seeing the major interrelations underlying a problem lead to new insight into what might be done. The essence of the discipline of systems thinking, according to Senge, lies in the shift of mind. The art of systems thinking lies in seeing through complexity to the underlying structures generating change. Systems thinking does not mean ignoring complexity. Rather, it means organizing complexity into a coherent story that illuminates the cause of problems and how they can be remedied in enduring ways. To facilitate this, Senge developed several “systems archetypes” that help people to better structure their problems in order to establish the underlying cause. Interested readers are strongly recommended to refer to [Senge, 10].

Among the five “component technologies,” system thinking, which Senge named as the “Fifth Discipline,” is considered to be the integrating force for the components.

3.2.6 Conclusion

Based on an industrial organization model first put forward by organization theorist Leavitt, this subsection presented a review of literature that explores and expands the relationships between technology, in particular Information Technology (IT), with other crucial organizational elements such as tasks or processes, structure, and people.

A few things can be concluded from this subsection. First, although the relationship between technology and other organizational elements has been studied for decades as revealed from the literature review, the relationship has become stronger more than ever. This is primarily due to the evolution of technology, from a simple “automating” technology to a “informating”
technology, from a simple tool helping organization to improve task efficiency to a business enabler, making it possible for organizations to perform business activities and processes that were not possible before.

Second, despite the “enormous” potential of modern information technology, many literatures have argued that the potential has not been fully exploited. The literatures presented many cases of failed IT projects, evidence that the increase in productivity has not commensurated with the increase in IT spending. Many argued that one of the main reasons for this is that organizations have not changed their mind-set about how technology should be managed. Many organizations are still managing information technology in the way they managed other general technology before, without realizing the broader impact IT has on organizations.

Finally, as evident from the many literatures covering the topic, we see a trend towards a more process-oriented organization model as opposed to the traditional tasks or functional oriented model. There is also an increased focus on the people approach towards organization change as opposed to the more mechanistic approach such as structural and technological approach.

3.3 IT strategy and strategic management

3.3.1 Introduction

The discipline of strategic management can be considered as one of the sub-disciplines of organization theory. Many literatures on organization theory also include issues related to strategic management. However, over the years, the discipline of strategic management has grown to such an extent that it deserves to be considered as a separate discipline by itself and therefore there is a separate subsection in this thesis that deals with strategic management.

There is an enormous amount of literatures related to strategic management. Most of these originated from the school of business management or business policy studies and are targeted at business organizations. Such literature touches on a wide range of issues from concept of strategy and management, planning processes, strategy formulation, and the process of transforming strategy into plans and actions.

In the following, some of the major concepts and theories from this school of study uncovered from the literature review will be presented and discussed. These concepts and theories are, in the author’s opinion, relevant and applicable to the study of IT strategy as well.

3.3.2 Concept of strategic management

Strategic management is a process that assures future success of organizations through planned renewal of their technologies, products, markets, and socio-political relationships with their environments. It focuses on managerial issues that affect the organization as a whole -- issues that have long-term implications and deal with organization-environment relationships. Strategic management aims to maximize the effectiveness of the entire organization. It secondarily also strives to improve efficiency [Drucker, 76]. This orientation toward effectiveness, in addition to efficiency, is strategic management’s hallmark.
**Efficiency** refers to the ratio of inputs over outputs. An efficiency orientation attempts to maximize outputs for any given set of inputs. It involves producing goods and services in the most technologically and economically competent manner with minimum waste of resources.

**Effectiveness**, on the other hand, is the ratio of achieved outputs over needed outputs (goals). The output needs are determined by environmental demands. An effectiveness orientation involves understanding these demands. It requires developing organizational objectives that are consistent with the environment, as well as managing the organization’s resources to be responsive to environmental changes while meeting specific objectives.

The emphasis on effectiveness does not imply that efficiency is unimportant. Efficiency is highly desirable and even necessary for success. However, it is not sufficient by itself to ensure long-term success.

According to [Frenzel, 21], strategic management means “reorganizing and redeploying resources to attain competitive advantage. It also means implementing creative and flexible long- and short- range planning systems supporting resource deployment actions.” The purpose of strategic management is to make organizations effective in meeting environmental demands and organizational objectives.

There are two major concepts that underlie the study of strategic management. They are the concepts of planning and the concept of strategy. These two concepts are strongly inter-related to each other and a good discussion of them can be found in [Mintzberg, 57]. Due to these two underlying concepts, the term strategic planning is sometimes used in certain literature as a synonym to strategic management. However, the term strategic planning should not be confused with the term long-range planning, which is also often used in certain literature. The difference between the two is a subtle one.

Strategic planning and long-range planning differ in their emphasis on the “assumed” environment. Long-range planning is generally considered to mean the development of a plan for accomplishing a goal or set of goals over a period of several years, with the assumption that current knowledge about future conditions is sufficiently reliable to ensure the plan's reliability over the duration of its implementation.

On the other hand, strategic planning assumes that the environment is not as stable as the one assumed in the long-range planning. Instead, the environment is continuously changing and therefore an organization must be responsive to a dynamic, changing environment. Strategic planning, then, stresses the importance of making decisions that will ensure the organization's ability to successfully respond to changes in the environment.

There are many strategic management approaches as revealed from the literature review. For example, [Mintzberg, 57] classifies the various approaches into ten schools of thought based on a process view, that is, the process in which the strategy is formed, see Table 4. The first three are prescriptive in nature, seeking to explain the “proper” ways of going about making of strategy. The others are more descriptive than prescriptive in nature.

The “design school” considers strategy making as an informal process of conception, typically in the leader's conscious mind. The design school model, sometimes called the SWOT (for internal strengths and weaknesses to be compared with external opportunities and threats),
also underlies the “planning model,” which accepts the premises of the former, except for the informal process and the chief executive as the key actor. The “positioning school” focuses on the content of strategies (differentiation, diversification, etc.) more than on the processes by which they are prescribed to be made (which are generally assumed, often implicitly, to be those of the planning school). In other words, the positioning school simply extrapolates the messages of the planning school into the domain of actual strategy content.

Table 4. Schools of thought on strategy formation.

<table>
<thead>
<tr>
<th>School</th>
<th>View of Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design</td>
<td>Conceptual</td>
</tr>
<tr>
<td>2 Planning</td>
<td>Formal</td>
</tr>
<tr>
<td>3 Positioning</td>
<td>Analytical</td>
</tr>
<tr>
<td>4 Cognitive</td>
<td>Mental</td>
</tr>
<tr>
<td>5 Entrepreneurial</td>
<td>Visionary</td>
</tr>
<tr>
<td>6 Learning</td>
<td>Emergent</td>
</tr>
<tr>
<td>7 Political</td>
<td>Power</td>
</tr>
<tr>
<td>8 Cultural</td>
<td>Ideology</td>
</tr>
<tr>
<td>9 Environmental</td>
<td>Passive</td>
</tr>
<tr>
<td>10 Configurational</td>
<td>Episodic</td>
</tr>
</tbody>
</table>

For the other descriptive models, “cognitive school” considers what happens in a human head that is trying to cope with strategy; the “entrepreneurial school” depicts strategy making as the visionary process of a strong leader. The “learning school” finds strategy to emerge in a process of collective learning; the “political school” focuses on conflict and the exploitation of power in the process. The “cultural school” considers the collective, cooperative dimension of the process; the “environmental school” sees strategy as a passive response to external forces; and the “configurational school” seeks to put all the other schools into the contexts of specific episodes in the process.

On the different schools of thought, [Wit, 77] argues that if the category boundaries are drawn broadly, the various schools of thought can be grouped into two fundamentally different approaches to strategy process, namely the planning approach and the incrementalist approach.

The planning approach views strategy as a plan – to be fully formulated, explicitly and rationally, and only then implemented. In Mintzberg’s term, the planning approach focuses on deliberate strategies. The incrementalist approach views strategy as a pattern in the stream of organizational activities – strategy is formulated, implemented, tested, and adapted, sometimes rationally, sometimes influenced by non-rational behavior, but always in small steps and on a continuous basis, blurring the distinction between formulation and implementation. In Mintzberg’s term, the incrementalist approach focuses on emergent strategies. The concept of deliberate and emergent strategies will be further discussed in the subsection “concept of strategy” that follows.

In the following, two models based on the planning approach will be reviewed because it is the author's opinion that much concept can be learned and applied in the formation of IT strategy from these models.
Figure 27 shows a model presented in [Wheelen, 78] that describes strategic management as a process that involves four basic elements, namely: environment scanning, strategy formulation, strategy implementation, and evaluation and control. These four elements are further described below.

**Environment scanning** -- Prior to the formulation of strategy, it is important that the organization performs an environment scanning. In environment scanning, the top management scans both the external environment for opportunities and threats, and the internal environment for strength and weaknesses. This is normally carried out by a SWOT (Strength, Weaknesses, Opportunities, Threats) analysis. The external environment has two parts: task (industry) environment that includes those elements that directly affect the organization’s major operation, and societal environment that includes the more general forces such as economic, socio-cultural, technological, and political-legal forces. On the other hand, the internal environment includes the structure, culture, and resources of the organization.

**Strategy formulation** -- This is the development of long-range plans for the effective management of environmental opportunities and threats, in light of corporate strengths and weaknesses. It includes defining the corporate mission, specifying achievable objectives, developing strategies, and setting policy guidelines.

**Strategy implementation** -- This is the process by which strategies and policies are put into action through the development of programs, budgets, and procedures. This process might involve changes within the overall culture, structure, and/or management system of the organization.

**Evaluation and control** -- This is the process in which activities and performance results are monitored so that actual performance can be compared with desired performance. This is the basis for corrective actions to be taken and provides useful inputs in reviewing existing strategy and plans.
Another model of strategic management is presented in [Schendel, 79] as shown in Figure 28. [Schendel, 79] describes seven tasks that constitute strategic management in organizations. These tasks are *environmental analysis, goal formulation, internal resource analysis, strategy formulation, strategy implementation, strategy evaluation, and strategy monitoring and control*. According to Schendel, together these tasks allow firms to analyze their environment and strategically align their resources for long-term success.

![Strategy Formulation Diagram](image)

**Figure 28. Strategic management model by Schendel.**

When comparing these two models, we can see that despite some minor dissimilarity in the order of the first two tasks, they are very similar in other aspects. Both models are *iterative* in nature, emphasizing the importance of *environmental scanning* and *goal formulation* in the process of strategy formulation. In the strategy implementation stage, the models emphasize the need for strategy *monitoring and control*. Because both the models adopt the planning approach, they emphasize the role of planning throughout the process. In particular, the models call for careful planning in transforming the strategy into a set of programs for implementation.

On the role of planning in the process of strategy formulation, [Mintzberg, 57] cautions that excessive formalization of the planning process can lead to a number of “pitfalls.” Some of the pitfalls include destroying commitment, narrowing a company’s vision, discouraging change, and breeding an atmosphere of politics. Despite all his criticism towards overly “formalized” planning approach, he does recognize that planning does have a role to play in the process. To circumvent the so-called “planning pitfalls,” he urges organizations to couple analysis and intuition. By combining the analytical mind of the planners and the intuitive mind of the managers, and by giving consideration also to the “soft” data instead of only considering the “hard” data, he argues that the planning dilemma can be overcome.

### 3.3.3 Concept of strategy

Strategy has its genesis in the military. Some literatures even trace the origin of the concept of strategy as far back as to Sun Tzu’s *The Art of War* [Sun Tzu, 80], originally written about 2,400 years ago. The word strategy comes from the Greek strategos meaning “the art of the
general.” Hence, strategy is concerned with general management or the overall direction and performance of the firm. As a general, the strategist surveys the competitive landscape determining grand maneuvers and tactics. Strategists need to have conceptual skills, or a high level of abstraction, to see the entire business system and understand its complexities and ambiguities.

Many interpretations have been given to the term “strategy.” Some say that strategy is a plan, or something equivalent – a direction, a guide or course of action into the future, a path to get from here to there, etc. Some say that strategy is a pattern, that is, consistency in behavior over time. Yet to some people, notably Porter and his followers, say that strategy is position, namely the determination of particular products in particular markets. To others, however, strategy is perspective, namely an organization’s way of doing things, its concept of the business [Mintzberg, 57].

The many interpretations given to the concept of strategy reflect that it embraces the overall purpose of an organization. Defining it properly means examining the many facets that make up the whole. Although there are certain elements within the strategy that have universal validity and can be applied to any organization, there are other elements within the strategy that are heavily dependent on the nature of the organization, its constituencies, its structure, and its culture. It is therefore not easy to provide a simple definition. Despite the difficulty, an attempt to provide an unified concept of strategy is presented in [Hax, 19], which states that:

“From this unifying point of view, strategy becomes a fundamental framework through which an organization can assert its vital continuity, while at the same time purposefully managing its adaptation to the changing environment to gain competitive advantages. Strategy includes the formal recognition that the recipients of the results of a firm’s actions are the wide constituency of its stakeholders. Therefore, the ultimate objective of strategy is to address stakeholders’ benefits -- to provide a base for establishing the host of transactions and social contracts that link a firm to its stakeholders.”

The term stakeholder refers to everyone who directly or indirectly receives the benefits or sustains the costs that result from a firm’s actions. Stakeholders include shareholders, employees, managers, customers, suppliers, debt holders, communities, government, and others.

Strategy may be explicit or implicit, i.e., the strategy may have been developed explicitly through a planning process or it may have evolved implicitly through the activities of the various functional departments of the firm. However, it is argued in [Porter, 54] that if the strategy were to allow to evolve by itself, it can rarely be an effective strategy. There are significant benefits to gain through an explicit process of formulating strategy, to ensure that at least the policies of functional departments are coordinated and directed at some common set of goals. Today, increasing emphasis is being placed on strategic planning process.

In [Mintzberg, 56], the concept of deliberate and emergent strategies are introduced, see Figure 29. According to Mintzberg, for a strategy to be perfectly deliberate, at least three conditions must be satisfied. First, there must be existing precise intentions in the organization, articulated at a relatively concrete level of detail, so that there can be no doubt about what is desired before any actions are taken. Second, because organization means collective action, to dispel any possible doubt about whether or not the intentions are
organizational, they must be common to virtually all the actors: either shared as their own or else accepted from leaders, probably in response to some sort of control. Third, these collective intentions must be realized exactly as intended, which means that no external force (market, technological, political, etc.) can have interfered with them. In other words, the environment must be either perfectly predictable, totally benign, or else under the full control of the organization. On the other hand, for a strategy to be perfectly emergent, there must be order – consistency in action over time – in the absence of intention about it.

While we can see that the three conditions for the perfectly deliberate strategy constitute a tall order, so that it is unlikely to find any perfectly deliberate strategies in organization, it is equally difficult to imagine action in the total absence of intention as in the case of the perfectly emergent strategy. In effect, in their pure form, these two types of strategy form the poles of a continuum along which we would expect real-world strategies to fall. The fundamental difference between the two is that while the former focuses on direction and control, i.e., getting desired things done, the latter opens up the notion of strategic learning.

Figure 29. Forms of strategy according to Mintzberg

From the many aspects of strategy, two specific characteristics which are vital for the study of strategy are outlined in [Wit, 77]. These two specific characteristics are:

- **Levels of strategy**: strategy may exist in the different hierarchical levels of an organization tackling different issues under some common causes or objectives. The most widely quoted levels of strategy are the corporate level, business level, and the functional level.
- **The three dimensions of strategy**, namely: the process, content and context dimensions.

These two characteristics are summarized in Figure 30 and they are further described in the subsections that follow since they form the basic framework on which the adequacy of the strategy will be assessed.
3.3.4 Levels of strategy

Strategies can be made for different groupings of individuals and tasks within an organization. The three most commonly quoted levels of strategy in strategic management literature are:

- **Functional level**, which refers to questions regarding specific functional aspects of a company (operational strategy, marketing strategy, financial strategy, and so on).
- **Business level**, which requires the integration of functional level strategies for a distinct set of products and/or services that are intended for a specific group of customers. If the company only operates in one such business, this is the highest level.
- **Corporate level**, which requires the integration of two or more business-level strategies. This is relevant only to those companies that have multi-business.

It is noteworthy that these different levels are made for analytical purposes. In reality, these levels are rather difficult to isolate. However, the ability to differentiate strategies into these different levels can certainly help to put one in the right perspective in either formulating or interpreting the strategies.

3.3.5 Dimensions of strategy

Michael Porter, in his well-known book *Competitive Strategy* (1980) [Porter, 54] states that “The essence of formulating competitive strategy is relating a company to its environment.”

His statement can be broken down into three parts to reflect the three dimensions of strategy, namely, the process, content and context dimensions.

The **process dimension** is reflected by “the essence of formulating” that indicates that there must be a process at play. This dimension, which looks at the *how* of the strategy, i.e., the manner in which the strategies come about, is referred to as the *strategy process*. It looks at, for example, the people involvement in the strategy formulation, the activities carried out prior to the strategy formulation, etc.
The content dimension is reflected by “the competitive strategy” that indicates that the strategy process must result in a strategic “product.” This output of the strategy process is a course of action to be followed by the company that will allow for the fulfillment of the company’s objectives in the face of competitive pressures. Thus, this dimension looks at the what of the strategy (output of the strategy process) and it is referred to as strategy content.

In order for a strategy to be effective, it is necessary that the abstraction level of the strategy content decreases as one goes further down into the organization hierarchy. This is necessary so that the strategy can be effectively transformed into some concrete implementation plan, for example, at the functional level. According to [Andrews, 55], a strategy must be explicit to be effective and specific enough to require some actions and exclude others. To cover in empty phrases (“Our policy is planned profitable growth in any market we can serve well”) and absence of analysis of opportunity or actual determination of corporate strength is worse than to remain silent, for it conveys the illusion of a commitment when none has been made.

The context dimension is reflected by “is relating a company to its environment” that indicates that the strategies are developed to suit varying organizational and environmental contexts. This is due to the fact that despite some common characteristics that may exist across companies, there may exist some characteristics that are unique to particular companies. This dimension, which refers to the set of circumstances under which both the process and content were determined, is referred to as the strategy context.

It is noteworthy that the three dimensions described above are not separate elements of the strategy phenomenon that can be dealt with individually but are the strongly inter-related dimensions of every strategic issues. Every strategy question is by its nature three-dimensional, possessing process, content, and context characteristics; only the understanding of all three dimensions, and their interaction, will provide a real depth understanding of the strategy.

3.3.6 Principle of strategy evaluation

One of the fundamental tenets of science is that a theory can never be proven to be absolutely true. A theory can, however, be declared absolutely false if it fails to stand up to testing. This same fundamental tenet applies equally to strategy, i.e., it is impossible to demonstrate conclusively that a particular strategy is optimal or even to guarantee that it will work. One can, nevertheless, test it for critical flaws. To this end, some broad criteria are given below [Rumelt, 81]:

- **Consistency.** The strategy must not present mutually inconsistent goals and policies.
- **Consonance.** The strategy must represent an adaptive response to the external environment and to the critical changes occurring within it.
- **Advantage.** The strategy must provide for the creation and/or maintenance of a competitive advantage in the selected area of activity.
- **Feasibility.** The strategy neither overtaxes available resources nor creates unsolvable sub-problems.

Similar tests are also outlined in [Porter, 73], in which the following criteria are outlined:

- **Internal Consistency**
Are the goals mutually achievable?
Do the key operating policies address the goals?
Do the key operating policies reinforce each other?

- **Environmental Fit**
  - Do the goals and policies exploit industry opportunities?
  - Do the goals and policies deal with industry threats (including the risk of competitive response) to the degree possible with available resources?
  - Does the timing of the goals and policies reflect the ability of the environment to absorb the actions?
  - Are the goals and policies responsive to broader societal concerns?

- **Resource Fit**
  - Do the goals and policies match the resources available to the company relative to competitors?
  - Does the timing of the goals and policies reflect the organization’s ability to change?

- **Communication and Implementation**
  - Are the goals well understood by key implementers?
  - Is there enough congruence between the goals and policies and the values of the key implementers to insure commitment?
  - Is there sufficient management capability to allow for effective implementation?

Porter argues that a strategy that fails to meet one or more of these criteria is strongly suspect [Porter, 73].

### 3.3.7 Conclusion

In this subsection, some of the major concepts and theories from the school of strategic management that are relevant and applicable to the study of IT strategy are presented. Some of the concepts discussed are summarized below.

*The distinction between efficiency and effectiveness.* It is argued that efficiency in itself is a necessary but not sufficient condition to ensure long-term success of an organization. Strategic management aims to maximize the effectiveness of the entire organization. Similarly, IT strategy should strive to achieve long-term effectiveness and not merely short-term efficiency.

*The distinction between strategic planning and long-range planning.* It is argued that these two concepts differ in their emphasis on the “assumed” environment. Long-range planning assumes a more stable environment where current knowledge about future conditions is sufficiently reliable to ensure the plan's reliability over the duration of its implementation. On the other hand, strategic planning assumes that the environment is continuously changing and therefore an organization must be responsive to a dynamic, changing environment. Strategic planning stresses the importance of making decisions that will ensure the organization's ability to successfully respond to changes in the environment. Thus, strategic planning process often emphasizes the importance of “iteration” to provide some kind of feedback mechanism to adjust the strategy or plan accordingly.

*Different schools of strategic management approach.* Broadly, various schools of thought can be grouped into two fundamentally different approaches to strategy process, namely the planning approach and the incrementalist approach. While the planning approach focuses on
deliberate strategies, the incrementalist approach focuses on emergent strategies. These two types of strategy, in their pure form, form the poles of a continuum along which we would expect real-world strategies to fall. The fundamental difference between the two is that while the former focuses on direction and control, i.e., getting desired things done, the latter opens up the notion of strategic learning.

The different levels and dimensions of strategy. It is important to note that strategies can exist in different levels of an organization hierarchy, namely, the corporate level, the business level, and the functional level. Strategies at different levels may have different focuses although they may have a shared ultimate goal. The ability to differentiate strategies into these different levels analytically can help to put one in the right perspective in either formulating or interpreting the strategies. It is also argued that every strategy question is by its nature three-dimensional, possessing process, content, and context characteristics; only the understanding of all three dimensions, and their interaction, will provide a real depth understanding of the strategy. The three dimensions described above are not separate elements of the strategy phenomenon that can be dealt with individually but are the strongly inter-related dimensions of every strategic issue.

Lastly, some of the underlying principles of strategy evaluation are discussed. The principles include:

- The consistency of the strategy with other goals and policies within an organization.
- The consonance of the strategy with the external environment and to the critical changes occurring within it.
- The competitive advantage that a strategy must provide for an organization.
- The feasibility of the strategy.

3.4 IT strategy and IS theory

3.4.1 Introduction

An information system is generally regarded as an organized combination of people, hardware, software, communication networks, and data resources that collects, transforms, and disseminates information in an organization. Avison and Fitzgerald, editors of the book “Transforming the Business: The IT Contribution” by Moreton and Chester, define information system as the effective design, delivery, use and impact of informational technology (IT) in organizations and society [Moreton & Chester, 4].

This definition reflects the broad and interdisciplinary nature of the subject, covering not only the technological discipline, but also management and other disciplines such as psychology and sociology. The various areas of research activity and research discipline in the domain of IS theory are outlined in [Swanson, 82] based on a review of IS research conducted. About 35 different areas are identified. A few of these areas that are relevant in the context of this thesis are briefly described below.

IS, Strategic Management, and Business Outcomes. Focus is on the relationships of IT investments to business performance (strategic and financial). Research themes include: identifying the effects of IT on business results, determining how to organize, plan, and render
decisions that can enhance the linkage of IS and business strategy, and measuring the contribution of IT to firm performance.

**Information Systems Implementation.** Focus is on the introduction of information systems or IT in organizations. Questions focus on characterization and classification of implementation situations, conceptualization and measurement of constructs, and the identification of factors and contingencies affecting implementation processes and outcomes.

**Organizational Outcomes.** Focus is on the impacts of information systems on organizations (beyond the issue of firms’ financial performance). Questions addressed: mutual structuring or co-evolution of IT and organizational form. Contributions to conceptualization and theory building, or focus on specific effects, including impacts on structure, relationships, tasks, work performance, and personal attitudes.

In the following discussion, the focus will be on the influence Information System theory has on the rethinking of IT strategy, which in turn links to the business strategy of an organization affecting its business outcomes.

### 3.4.2 Evolution of IT/IS and its business impact

Today, we are in the throes of a revolution – the information revolution, which Toffler calls “The Third Wave” following the agricultural and industrial revolutions as major forces shaping the way we live in the civilized world [Toffler, 83]. A review of many literatures on information systems studies revealed that there seems to be a general consensus among IT/IS scholars on the great potential modern IT/IS has on organizations as well as on our society. See for example [Eason, 5], [Moreton & Chester, 4], [Frenzel, 21] and [Thorp, 7].

[Thorp, 7] summarizes the evolution of IT/IS into three stages, namely the automation of work, information management, and business transformation. The impact and benefit of each of these stages are shown in Table 5.

**Table 5. Three stages of IT/IS Evolution**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Impact</th>
<th>Benefit</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation of work</td>
<td>• Getting work done</td>
<td>• Operational efficiency</td>
<td>• Payroll</td>
</tr>
<tr>
<td></td>
<td>• Doing the same things more efficiently</td>
<td></td>
<td>• Check processing</td>
</tr>
<tr>
<td></td>
<td>• Restructuring work and work processes</td>
<td>• Operational and tactical</td>
<td>• Basic order processing</td>
</tr>
<tr>
<td></td>
<td>• Doing things differently</td>
<td>effectiveness</td>
<td>• Basic airline reservation systems</td>
</tr>
<tr>
<td>Information</td>
<td>• Defining the business</td>
<td>• Strategic effectiveness and</td>
<td>• Customer information systems</td>
</tr>
<tr>
<td>management</td>
<td>• Doing different things</td>
<td>positioning</td>
<td>• Airline yield management systems</td>
</tr>
<tr>
<td></td>
<td>• Changing the business/industry rules</td>
<td></td>
<td>• Executive information systems</td>
</tr>
<tr>
<td>Business transformation</td>
<td>• Getting work done</td>
<td>• Operational efficiency</td>
<td>• JIT inventory systems</td>
</tr>
<tr>
<td></td>
<td>• Doing the same things more efficiently</td>
<td></td>
<td>• Electronic commerce</td>
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<tr>
<td></td>
<td>• Restructuring work and work processes</td>
<td>• Operational and tactical</td>
<td>• Customer information systems</td>
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<td>• Doing things differently</td>
<td>effectiveness</td>
<td>• Airline yield management systems</td>
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<td></td>
<td>• Changing the business/industry rules</td>
<td>• Strategic effectiveness and</td>
<td>• Executive information systems</td>
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<td></td>
<td></td>
<td>positioning</td>
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63
Similarly, [Scott Morton, 66] presented a model that summarizes the different levels of IT deployment and its potential business impact. The model was presented in subsection 2.2.3 and is reproduced here for convenience sake.

![Maturity levels of IT deployment and its potential business impact](image)

**Figure 31. Maturity levels of IT deployment and its potential business impact**

Level one is *localized exploitation*, concerned with the exploitation of IT within single business functions such as marketing, accounting, network operation, maintenance or even isolated work tasks within functions. This involves the deployment of IT applications that improve task efficiency and operations, e.g. automation of manual work tasks. Thus, applications achieve some localized function-specific goals without necessarily influencing related areas of operations.

Level two is *internal integration*, which is a logical extension of the first in the sense that IT capabilities are exploited in all the possible activities within the business process. Two types of integration are critical here: technical integration, namely the integration of the different systems and applications using a common IT platform; and the organizational integration of different roles and responsibilities that exploits the technical integration capabilities. In other words, the achievement of consistency concerning the IT platform serves to integrate the organization’s business processes, potentially enhancing efficiency and effectiveness.

Level three is *business process redesign*, involving fundamental reconfiguration of the business using IT as a central lever. Instead of treating the existing business processes as a constraint in the design of optimum IT infrastructure, the business process itself is redesigned to maximally exploit the available IT capabilities to achieve the business goals. This reflects conscious efforts to create an alignment between the IT infrastructure and the business process, rather than to simply superimpose the technology platform on the existing business processes. Business process redesign therefore implies radical changes to the existing processes and is often cross-functional [Davenport, 8]. This is one of the distinct differences between business process redesign and other quality improvement programs that merely based upon existing processes.

Level four is *new business opportunities*, concerned with the repositioning and resizing of the business mission and scope through related products and services as well as introduction of new IT-enabled businesses. This includes reconfiguration of the scope and tasks of the business network involved in the creation and delivery of products and services. The reconfiguration includes the business tasks both within and outside the formal boundaries of a
focal organization and the consequent redesign of this virtual business network through IT capabilities.

3.4.3 Success and failure of IT/IS projects

Despite the increased potential benefits and strategic importance of modern IT/IS, many literatures argued that most organizations have yet to exploit its full potential. In the words of Nobel prize-winning economist Robert Solow, “You can see computer everywhere but in the productivity statistics.”

For example, according to a survey conducted by Standish group in 1995 [Standish group, 3], only about 16% of IT projects actually succeeded, that the projects are completed on time and on budget, with all features and functions specified. About 53% of the projects are completed and operational but over-budget, over the time estimate and with fewer functionality than originally specified. Finally, about 31% of the projects are abandoned.

In yet another study conducted in the USA, it was shown that IT assets went up from 3.7% of all business assets in 1960s to 12.5% in 1980s. However, the rates of improvement in labor productivity and increase in added value actually fell over the same period [Moreton, 4]. A 1996 Gartner Group report by B. Stewart further suggested that the net average return on investment from information technology from 1985 to 1995 was a mere one percent [Stewart, 84]. More about runaway IT projects can be found in [Eason, 5], [Glass, 6], and [Thorп, 7].

Thorp describes the scenario where the increased IT spending has not been able to translate into business value as the “Information Paradox.” In [Thorп, 7], by quoting cases from the real world, he argues that most cases of the information paradox do not result from the technology itself; rather, organizations are still learning how to get the most from IT by reorganizing, redesigning business processes and learning to work in new ways. At the heart of the problem is a fundamental change in how organizations are using information technology and the information provided by that technology. While the application of technology has evolved, and as its impacts have become far more dramatic, most management mind-sets have unfortunately failed to keep pace. The persistence of the industrial mind-set leads to what he calls “magic bullet thinking” about the business capabilities of IT, more specifically, about the power of IT alone to deliver business results. Thus, he attributes the cause of the information paradox to be not so much a technical issue; instead, it is a management challenge to change the traditional mind-set in managing the evolving complexity of IT applications. The notion of “magic bullet thinking” will be further discussed in the next subsection.

Thorp identifies four critical dimensions of the complexity of modern IT applications or systems that are often overlooked by the traditional management mind-set. These four dimensions along with their key elements and the price of forgetting are summarized in Table 6 [Thorп, 7].

In order to enhance the success rate of IT-enabled change, Thorп argues that these four dimensions of complexity must be addressed together. He proposes an approach called the “Benefit Realization Approach” that provides a new basis for using information technology to deliver business results more consistently and predictably.
Table 6. The four critical dimensions of complexity

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Key Element</th>
<th>The Price of Forgetting</th>
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<tbody>
<tr>
<td>Linkage</td>
<td>• Alignment with business strategy</td>
<td>• Lack of clear identification and understanding of desired benefits</td>
</tr>
<tr>
<td></td>
<td>• Contribution to benefits</td>
<td>• Lack of clear and measurable contribution to benefits</td>
</tr>
<tr>
<td></td>
<td>• Integration with other initiatives</td>
<td>• Overlap/underlap between initiatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The “project that grew to take over the world”</td>
</tr>
<tr>
<td>Reach</td>
<td>• Areas of organization/supply chain impacted by change</td>
<td>• Understanding scope and depth of change</td>
</tr>
<tr>
<td></td>
<td>• Extent of impact</td>
<td>• Failure to understand cross functional process implications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inappropriate/ineffective accountabilities</td>
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<td></td>
<td></td>
<td>• Scapegoating</td>
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<tr>
<td></td>
<td></td>
<td>• Lack of buy-in</td>
</tr>
<tr>
<td>People</td>
<td>• People affected by change</td>
<td>• Thinking that “one size fits all”</td>
</tr>
<tr>
<td></td>
<td>• Current competencies</td>
<td>• “Done to” not “done with”</td>
</tr>
<tr>
<td></td>
<td>• Attitudes, motivation, know-how</td>
<td>• Steep IT and organizational learning curves</td>
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<tr>
<td></td>
<td>• Readiness for change</td>
<td>• Significantly underestimated training effort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Late, inappropriate, ineffective change management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Resistance to change</td>
</tr>
<tr>
<td>Time</td>
<td>• Time it takes to manage all dimensions to realize benefit</td>
<td>• Unrealistic and unachievable expectations</td>
</tr>
<tr>
<td></td>
<td>• Change in dimensions over time</td>
<td>• Unexpected time lags between delivery of capability and realization of benefits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Not “staying the course”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Not knowing when to quit</td>
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</table>

There are three fundamentals that define the core of his approach. They are:

1. Shift from stand-alone IT project management to business program management. Projects are a structured set of activities concerned with delivering a defined capability to the organization based on an agreed schedule and budget. The focus of projects is on the inputs, costs and time required to produce intermediate outcomes. The capability does not translate into benefit for the organization until it is combined with others delivered by other related projects. On the other hand, programs are structured groupings of projects designed to produce clearly identified business results or other end benefits. “Blended investment program” include many types of projects: IT delivery, training, marketing, organizational change and business process redesign. All these projects are managed and monitored from concept to cash.
2. **Shift from free-for-all competition among projects to disciplined portfolio management.** This involves managing all blended investment programs as part of a portfolio with clear performance objectives to produce a stream of benefits, similar to investment returns. Portfolios are structured groupings of investment programs, composed of investment programs that blend IT investment with related business initiatives, selected by management to achieve defined business results, while meeting clear risk/reward standards.

3. **Shift from traditional project management cycles to full cycle governance.** Full cycle governance is the management process that goes beyond traditional project management. Like program management, it is distinguished by its long time frame that supports management of the benefits realization process from the conception of projects to the harvesting of benefits. It is also distinguished by a process of progressive resource commitment in which resources are committed to programs in small increments.

In order to implement the approach successfully, Thorp argues that organizations must also meet three necessary conditions. They are:

1. **Activist accountability** in order to identify business sponsors with active, continuous ownership of investment programs that produce benefits, as well as the people responsible for specific projects and tasks. Full cycle governance makes business managers clearly accountable for delivering business benefits and IT managers accountable for delivering the right tools and technological capabilities.

2. **Relevant measurement systems** to measure the things that count in the benefits realization process. Full cycle governance requires measurement of new domains of organizational performance, moving beyond the traditional measurement of inputs to measuring outcomes, with a primary focus on key business outcomes.

3. **Proactive management of change** to give people ownership stakes in programs. The major change process must be actively structured and visibly led by senior management. Their leadership role must be shared with program and project managers. The concept of ownership in major investment programs, introduced to sharpen the focus on accountability, includes the idea of ownership in key change initiatives.

3.4.4 **The magic bullet theory of information technology**

The notion of “magic bullet thinking” is first introduced in [Markus & Benjamin, 74]. Markus and Benjamin share a similar view to [Thorp, 7] that many large-scale change management projects involving new information technology (IT) fail for reasons unrelated to technical feasibility and reliability. According to [Markus & Benjamin, 74], it is well known that good technology “implementation” and “change management” techniques can substantially increase the chance of success, despite that, many IT-enabled change projects still fail. This, the failure to employ the best practices in IT-enabled changes, they argue, stems from mistaken beliefs about the cause of change – the belief in IT as a magic bullet.

The magic bullet theory of information technology and organizational change assumes that IT changes people and organization by empowering them to do things they couldn’t do before and by preventing them from working in old, unproductive ways. Thus, when people use the system, desirable organizational changes result. This deeply held belief that IT can cause
change leads to both line managers and IT specialists restricting their own efforts as change agents.

Markus and Benjamin make the following analogy between IT and the magic bullet that always hit its target.

- First, since the magic bullet changes the behavior of people who use IT by enabling new work practices and preventing old ones, users are the intended targets of change.
- Second, IT specialists -- the tool builders -- play the role of designing and building guns. They do not have to worry very much about who is going to aim and fire the gun. After all, magic bullets always hit the right targets.
- Third, if there are gun builders, there must be entrepreneurs -- people who contract for guns with the hope of profiting from their sale. In our analogy, senior line managers usually play this role. They fund IT projects and set objectives for changed user behavior and organizational results. Entrepreneurs often focus more on marketing and profitability than on product characteristics and implementation. If the product doesn’t work as expected, the builders are responsible and will have to take the blame.

The flaw of the magic bullet theory is that it doesn’t tell us who should aim and fire the gun. It assumes that the gun fires itself. In essence, the theory doesn’t tell us who is going to be the change agent responsible for producing the desired outcome with the magic bullet.

People who believe in the theory do not feel a need to learn and practice change management techniques. IT specialists who subscribe to the theory (viewing themselves as “change agents” by virtue of their technology-building role) do not see themselves as responsible for ensuring that users employ the technology to achieve the desired results. Similarly, senior managers (who see themselves as “change agents” for commissioning large-scale IT projects) may also find comfort in the magic bullet theory. It allows them to turn IT projects over to specialists, whom they can blame if the projects don’t have desired results.

The magic bullet theory is seductive to many IT specialists and line managers because it allows them to disembody change ideas, package them as technologies, and distance themselves from the hands-on sport of helping people to change.

Belief in the magic bullet theory can lead to situations in which effective change management techniques are not practiced, and the intended organizational transformation never occurs. The problem stems from the roles and behaviors that the theory prescribes for executives, IT specialists, users, and IT itself. Executives are supposed to define the change idea or devise improved “systems.” IT specialists are supposed to select or build technologies that, when used as expected, will produce the desired results. Users are supposed to use technologies as expected (and not to have competing solutions for organizational problems). IT is supposed to work -- like magic.

3.4.5 Information system as a social-technical system

While the subsection above revealed one of the major causes responsible for the failure of IT/IS projects, another major cause revealed in the literature review is the failure to recognize IS as a social-technical system.
For example, proponents, researchers and scientists from the School of Human Sciences and Information Systems like Eason argued that one of the primary causes of failure in IS/IT project was due to the technology-driven design process [Eason, 5]. There was very little consideration of the broader ramifications of the technology, especially on the social or human aspect of IS. He therefore proposed that the IS design process should be user-driven instead of technology-driven. In his proposed user-centered approach, he put forward a framework for socio-technical design of IT systems which served to integrate both the social as well as the technical aspect of IS. Besides focusing on the stakeholder participation during the design process, the framework also covered other aspects vital to the success of IS implementation such as organization change.

Leading system thinker Checkland also stressed the important of not treating IS as merely a technical system in his well-known book “Systems Thinking, Systems Practice” [Checkland, 85], in which he wrote:

“This drew attention to the nature of information systems, namely that they serve activity systems. Systems analysis aiming at information system design, if it is to make much impact, must first concentrate on the activity system that the information system is to serve. Once the root definition(s) and conceptual model(s) of the activity system are established then the necessary information flows are easily defined by asking for each activity: What information is needed to do it? In what form? From what source? How frequently? Work on information systems which begins by considering information flows will be inadvertently taking as given the present organizational arrangements, which ought to be questioned. But even if the structure is constrained to its present form for some reason, an activity model should still be built first as a route to an information system design which is both economical and elegant.”

3.4.6 Conclusion

In this subsection, the many areas of study in the field of information systems are briefly described. The focus is then shifted to areas that have strong linkage with IT strategy. By describing the various stages of evolution of IT from a mere automation of tasks to business transformation, the new capabilities and the potentials of IT have on organization are highlighted.

Beside this, several previous studies conducted on the impacts of IT on organizations and on the success rates of IT-related projects are presented. The “magic bullet” theory is then introduced to explain some of the underlying causes for the many failed IT projects and the inability of IT to bring about the desired benefits to organizations. The importance of recognizing IS as a social-technical system is also highlighted in this subsection.

Finally, four critical dimensions of the complexity of modern IT applications or systems, namely, linkages, reach, people, and time are discussed. An approach called the “Benefit Realization Approach,” claimed by its proponent to be able to deliver business results more consistently and predictably, is presented.
4 RESEARCH METHODOLOGY

4.1 Introduction

Research in the field of IT/IS is often a multi-disciplinary study and very much a social, rather than a wholly technical, science [Galliers, 86]. Foundations for the study of IT/IS can be found in philosophy and in organizational and behavior sciences, as well as in mathematics and the natural sciences. When conducting research in IT/IS, [Galliers, 86] argues that it is important to draw on these “reference disciplines” and to place one’s particular research topic in this broader context. Information systems are essentially social systems and make sense only in the context of the purpose to which they are being put. This requires us to explore the organizational and societal contexts on the one hand, and the individual context on the other. In addition, the very nature of IT/IS has a profound impact on what constitutes appropriate research and what approaches might reasonably be adopted in undertaking this research.

Since information systems are essentially social systems, many researchers, notably [Walsham, 16] and [Hirschheim, 87] argue for a shift in the research paradigm of information systems towards a “post-positivist” stance. This would mean doing away with the model of research associated with the physical sciences as the sole acceptable approach to information systems research. They argue that the positivist stance, that knowledge is apodeictic (necessarily true or logically certain), needs to be replaced by one that is concerned more with belief about knowledge. In other words, research that produces conclusions that are accepted by the research community as an improvement on our previous level of understanding, (whether these conclusions are incontrovertible or not) is not only acceptable but preferred in our context. In addition, Hirschheim raises the issue of methodological pluralism, which means that there is no one correct method but many alternative research methods in the field of information systems study.

Research methods can be classified in various ways, however one of the most common distinctions is between qualitative and quantitative methods [Myers, 88]. Originally developed in the natural sciences to study natural phenomena, quantitative research methods now well accepted in the social sciences include survey methods, laboratory experiments, formal methods (e.g. econometrics) and numerical methods such as mathematical modeling.

On the other hand, qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomena. Examples of qualitative methods are case study research, action research and ethnography. Qualitative data sources include observation and participants observation, interviews and questionnaires, documents and texts, and the researcher’s impressions and reactions. It should be noted, however, that “qualitative” is not necessary hermeneutics or “interpretive.” Depending on the underlying philosophical assumptions, qualitative research can be positivist, interpretive, or critical (Figure 32).

Although most researchers do either quantitative or qualitative work, some researchers have suggested combining one or more research methods in one study to provide triangulation of data by using multiple sources of evidence. See for example [Ragin, 12], [Gable, 13], [Kaplan, 14] and [Lee, 15]. With triangulation, the potential problem of construct validity can be addressed [Yin, 11].
4.2 Justification for the paradigm and methodology

In the realm of information systems research, many debates have been on the use of positivist versus hermeneutics approach. Positivist generally assumes that reality is objectively given and can be described by measurable properties that are independent of the researcher and his or her instruments. Positivist studies generally attempt to test theory, in an attempt to increase the predictive understanding of phenomena [Myers, 88]. On the other hand, the hermeneutics approach starts out with the assumption that access to reality is only through social constructions such as language, consciousness, and shared meanings. It is the philosophical base of interpretive research that attempts to understand phenomena through the meanings that people assign to them and aims at producing an understanding of the context of information system, and the process whereby the information system influences and is influenced by the context [Walsham, 16].

Both paradigms have their strengths and weaknesses. While proponents of the positivist approach often criticize the lack of rigor and the inability of the hermeneutics approach to generalize to a bigger population, the positivist approach on the other hand, is often criticized for its inability to take into consideration the rich social and organizational context of information system research.

In order to strike a compromise between the two paradigms and to exploit their strengths, a combination of the two was used in the research study that resulted in this thesis.

In the beginning of the study, a qualitative method that took the form of a case study was conducted in order to gain deeper insights into the relationship between people, the organization, and information technology. It was also to help in identifying parameters that could influence the effectiveness of utilities’ IT strategy. This part of the study is mainly based on the hermeneutics approach.

In the later part of the study, a quantitative method (survey combined with statistical analysis in this case) was used to complement the case study to examine the parameters in a larger population and to generalize the findings. Here, statistical tools were used in conducting hypothesis testing and therefore constituted the positivist side of the study.
4.3 **Qualitative method - case study**

The case study was carried out over a period of about six months in cooperation with a mid-size Swedish utility and the Competence Center in Power Engineering at the Royal Institute of Technology, Stockholm. The selected utility for the case study was suitable for the purpose of this research because it had just concluded formulating its IT strategy and had undergone organizational restructuring to adapt to the newly deregulated environment. The selected utility was also in the process of procuring and implementing several IT systems at the time the case study was conducted.

As already mentioned above, the main purpose of this study was to gain deeper insights into the relationship between people, the organization, and information technology, as well as to help in identifying parameters that could influence the effectiveness of the utility’s IT strategy. Apart from this, the study was also to evaluate the strengths and weaknesses of the utility’s existing IT strategy and to provide recommendations for the studied utility to enhance its IT strategy.

In order to guide the data collection and the data analysis stages, the study was preceded by an extensive literature study covering strategic management, information systems, and organization theory. Based on this literature study, a questionnaire was formulated to guide the subsequent interviews, and a framework of evaluation was established. The questionnaire, which consisted of open-ended questions, was adapted to the participants’ backgrounds (education and job responsibilities). The framework of evaluation consisted of criteria that were deemed critical to the success of the IT strategy.

The primary data sources in the study were selected people from the studied organization and relevant documents such as the organization’s IT strategy, SWOT analysis, annual reports, profiling seminar report, etc. The unit of analysis covered people from both the top and the middle management of the organization, as well as line or functional staff. Multiple data sources were used to provide triangulation of data when performing data analysis.

The data collection within the utility was mainly carried out through in-depth inquiries with the identified people and through review and cross-referencing of related documents. Participant observations were also used to provide a more complete picture of the issue being investigated within the studied organizations. All the data collected including notes taken during the inquiries were reviewed by all the respective participants before they were adopted.

The analysis was carried out by using a set of pre-defined criteria established based on concepts and theories from various related disciplines such as strategic management, information systems theory, and organization theory. These criteria represented some of the critical success factors of a strategy. They were grouped under the three dimensions of a strategy put forward by [Wit, 77], namely the strategy process, the strategy content, and the strategy context.

The results of the case study are fully documented in Part A of this thesis. Based on the results obtained in this study, two other contributions were written (included as Part B and Part C in this thesis). By linking the findings and observations from the study with established concepts and theories from other disciplines, Part B argued that the IT strategy of the studied
utility still has much to be desired and its effectiveness could be enhanced by incorporating concepts and theories from other disciplines.

The contribution in Part C is based on a follow-up study conducted in the same utility. The focus of the paper is on the implementation aspect of the IT strategy. In particular, this paper identifies a number of problems related to the implementation, follow-up, and maintenance aspects of the IT strategy and proposes a structured framework to deal with the identified problems.

4.4 Quantitative method – survey with statistical analyses

After the completion of the case study, a quantitative survey was conducted. This part of the study was to further investigate the results and observations obtained in the case study in a larger population of Swedish distribution utilities and attempt to generalize some of the findings.

The objective of the study was aimed at providing insights to the research questions as stated in subsection 1.2, such as: what is the state-of-the-practice of utilities’ existing IT strategies? How much impact do IT strategies have on the utilities’ business activities today, and how should IT strategy be handled to further enhance its effectiveness. To achieve this objective, more specific questions based on factors found to have had impact on the effectiveness of the IT strategy in the case study, were formulated. These questions were further grouped into three groups according to the strategy process, strategy content, and strategy context. Leavitt’s model of an industrial organization that depicted the strong relationship between technology, people, process, and structure also provided the basis for the formulation of the questions.

A total of 230 questionnaires were sent out based on the list obtained from the Swedish Energy Authority, and a total of 52 utilities responded. This gave an overall response rate of 22.6%, and the total sample received was sufficient to satisfy the sample size required for a high precision level of 5% and a confidence level of 95%.

A large percentage of the respondents came from the top management group (about 65% with CEOs & Business Unit Chiefs combined), 24% were IT coordinators or executives responsible for IT within the organizations, while the remaining 21% were either operation engineers, technicians, operation leaders, etc.

In the analysis, national grid operator and firms that generate electricity primarily for their own consumption or with limited external customers were excluded. Distribution utilities were further grouped into two categories according to the number of customers served as follow:

- Small-medium size utility - Utility with a customer base of < 45,000.
- Large size utility - Utility with a customer base of => 45,000.

All the statistical analyses in this report were performed by using a combination of the statistical analysis tool included in Microsoft Excel and a commercial statistical software available from Texasoft. All statistical tests were performed with a 95% confidence interval (C.I.), which meant that a p-value of less than 0.05 was considered statistically significant.
Examples of statistical tests used in the analyses included Independent Group t-test, Paired t-test (Repeated Measures), F-test, Pearson's Correlation Analysis, and Chi-square.

The results of this part of the study are fully documented in Part D of this thesis. By combining the results from the qualitative and quantitative study, three other contributions were written, i.e. Part E, Part F, and Part G.

Part E and Part F shared the same theme basically except that they were structured and presented in such a way to suit the different audiences in two conferences. Apart from presenting the results of the study and linking them to theories and concepts drawn from the various disciplines of study, Part E and Part F also proposed a system approach to manage IT strategy in order to enhance its effectiveness.

Part G can be seen as an application of part of the concepts put forward in this thesis. By combining the technical knowledge gained from the author’s study in the DA/DSM area with a framework for industrial analysis provided by [Porter, 54], this paper demonstrates the importance of not to be overly technology-driven in making IT-enabled strategic investment or decision. It is important to see the technology in the overall context in which it is to be deployed.

4.5 **Ethical considerations**

Throughout this study, there has been an understanding between the researcher and the various parties who participated in the study that certain information disclosed or made available to the researcher would not be released to a third party without the consent of the information providers. Therefore names of persons and organizations are excluded from this thesis where necessary.

Also, the results of the case study have been verified by all the respective participants before they were finally adopted. This is to avoid misinterpretation of the information obtained whether from the interviews or from other sources.

4.6 **Conclusion**

In this section, the various research methods appropriate for information systems research is briefly introduced. Broadly, these methods can be classified under two categories: qualitative and quantitative methods. A discussion on the underlying paradigm or philosophy, namely, the hermeneutics and the positivist approach, and their respective strengths and weaknesses with regard to information systems research is presented.

Basically, proponents of the positivist approach often criticize the lack of rigor and the inability of the hermeneutics approach to generalize to a bigger population. The positivist approach on the other hand, is often criticized for its inability to take into consideration the rich social and organizational context of information system research.

Finally, the research methods used in the conduct of this thesis work is introduced and described in more detail. The research methodology used is a combination of case study and quantitative survey. The justification for this is primarily to exploit the strengths from both the methods. While the case study (a qualitative method) provides an opportunity to gain deeper insights into the relationship between people, the organization, and information
technology, as well as helps to identify parameters that can influence the effectiveness of the IT strategy, the quantitative method (survey combined with statistical analysis) complements it with the ability to examine the parameters in a larger population and to generalize the findings.

5 SUMMARIES OF INCLUDED PARTS

Part A: The Essence of IT Strategy For Electric Utilities

This report fully documented the conduct, the analyses, and the results of the initial case study conducted in a Swedish electric utility. The purpose of the study was to evaluate the strengths and weaknesses, as well as the adequacy of the existing IT strategy in addressing the growing needs of a utility in a fast changing business environment. It was also to help in identifying the vital parameters that could influence the effectiveness of the strategy.

The analyses were carried out based on a set of well-defined criteria drawn from several disciplines of study such as strategic management, information systems, and organizational study. Sample of the criteria is listed below.

Criteria from a strategy process perspective:

- Was there a SWOT (Strength, Weakness, Opportunities, Threats) analysis done prior to the formulation of the strategy?
- Was there any business process analysis done prior the formulation of the strategy?
- Has the process managed to garner firm commitment from top management?
- Did the process involve the critical mass of the organization, i.e., people from the different levels of the organization?
- Has the process created an increased awareness of the potential of IT within the organization?

Criteria from a strategy content perspective:

- Did the strategy identify and relate to the business objectives?
- Did the strategy provide direction and guidance to and adequately address the needs of the different levels (e.g. the functional level, business level, and the corporate level) that exist in the organization?
- Did the strategy identify and prioritize strategic areas where IT support is needed?
- Did the strategy identify the role and responsibility of individuals within the organization with regard to the development, maintenance, and utilization of IT resources?
- Did the strategy identify the existing and future resources required for the development of IT within the organization? (E.g. IT systems, personnel, training, etc.)
- Did the strategy identify the strengths and weakness of existing IT systems, business processes, etc.?
- Did the strategy identify the critical information exchanges between various business processes that are necessary to support the business activities?
- Did the strategy provide an overall strategic IT systems architecture based on the information exchange needs?
- Were the purposes and the contents of the strategy sufficiently clear (either in words or in practice) to the different levels that exist in the organization?
Criteria from a strategy context perspective:

- Did the strategy take into consideration the business environment (both internal and external) of the organization?

Based on the analyses, the following conclusions were drawn.

From the strategy process dimension, it was found that beside the inputs from the SWOT analysis, the “profiling” seminar that was held prior to the formulation of the IT strategy has contributed to the betterment of the IT strategy. The purpose of the seminar was to provide a forum for the enlightenment of the various problem areas, to define the problems and to identify the causes so that concrete measures and plans could be devised and carried out.

The results of the seminar have provided a rather good description of the “internal” business environment with regards to the use of IT within the organization. Several problems identified in this seminar, for instance, the lack of coordination in IT-related activities and the lack of IT competence, have been addressed by the IT strategy. The “profiling” seminar, however, fell short of relating to the “external” environment, for example, how deregulation in the industry could affect the business activities or processes, and how to exploit the development in IT to tame some of the threats and to take advantages of the opportunities caused by deregulation.

The absence of a business process analysis to identify critical processes that may be reengineered with the introduction of IT further limited the strengths of the IT strategy. Performing a business process analysis prior to the formulation of IT strategy is a way to relate IT to a firm’s business. A business process analysis is often necessary to help in identifying the workflow or activities of various business processes, the various needs of information exchanges, and the coordination between processes. It is also to identify the weaknesses of the existing processes and explore how IT could help to streamline the processes.

The results also showed that despite the fact that the formulation of the IT strategy was initiated by the top management, there was a lack of commitment on the part of the top management toward the IT strategy especially on the follow-up activities identified. These activities were given very low priority and most of them were either delayed or stalled. The top management also failed to allocate adequate resources and grant the status necessary for the IT council to function properly. As a result, the IT council, which was central to the successful implementation of the IT strategy, was rendered almost inoperative.

There was also a lack of communication within the organization to disseminate information regarding the purpose, scope, and the applicability of the IT strategy. As a result, there was much confusion among people in the organization that has resulted in different interpretation of the IT strategy.

From the strategy contents dimension, there was little doubt that the existing IT strategy would not be able to address all the needs of the various business areas. The strategy focused primarily on achieving uniformity (in common application software, user interface, etc.), division of roles and responsibilities of the IT organization, and competence developments. It did not identify business processes within the various business areas that could be reengineered to be more effective. Neither did the strategy identify new business opportunities.
made possible by the development in IT today such as the introduction of IT-enabled value-added services.

Furthermore, the strategy did not address one of the major issues identified in the “profiling” seminar, i.e., the systems integration issue. The IT strategy did not address the need for an architectural platform or identify any promising technology such as middleware, etc., that could help to achieve the objective of an integrated environment.

Although it was stated in the IT strategy document that “The organization’s IT activities shall be driven in accordance with the organization’s vision, business concept and strategies and be a support for the business activities” and the “driving force behind the IT strategy is to meet the market’s needs by offering products and services that can fulfill the existing and future needs,” it was difficult to trace the coupling between the business strategies and the IT strategy, except in the issue regarding competence development.

From the very general nature of the IT strategy contents, the IT strategy seemed to be a strategy at the corporate level. However, this was not made clear and consequently resulted in a lot of confusion and dissatisfaction.

From the context dimension, the strategy has taken into consideration quite a number of “internal” factors, due to the inputs from the “profiling” seminar. However, it has not taken enough consideration to the “external” factors, for example, how deregulation in the power industry could affect the business activities or processes, and how to exploit the development in IT to arrest some of the threats and to take advantage of the opportunities caused by deregulation.

To summarize, this report has identified some of the strengths and weaknesses of the studied utility’s IT strategy and the underlying attributing factors. Beside the widely recognized factors such as communications and generation of commitment among all levels of the organization that were deemed to be instrumental to the success of strategies, the study also identified the importance of a business process analysis. Business process analysis can be seen as a way to bridge the gap between IT and business strategy and to allow IT to effectively enhance organizational effectiveness through process change.

Part B: Utility IT Strategy - An Evaluation By Case Study

This paper is based on the findings and observations obtained in the case study described in the report in Part A. In presenting the evaluation of the study, the paper argues that the IT strategy of the studied utility still has much to be desired. The many weaknesses identified reflected the ineffectiveness of the strategy.

By linking the findings and observations with concepts and theories from other schools of study such as strategic management, organizational study, and information systems, this paper further argues that much can be learned from these disciplines in enhancing the effectiveness of utility’s IT strategy. Concepts and theories drawn from these related disciplines can very well provide a basic framework towards a more effective IT strategy.

For example, an understanding of the characteristics of strategy highlighted in the paper, namely the three dimensions of strategy (process, content, and context dimensions) and the
different levels of strategy (corporate, business, and functional levels), is vital both in formulating and analyzing strategy. It not only provides the right perspective, but also provides a systematic way to handle such complex issues as strategy.

In order to exploit the full potential of IT, the paper also argues that it is necessary for an organization to treat IT as a strategic issue instead of viewing it as just a supporting function as it has been traditionally. This is in view of the increasing impact that IT has on an organization’s business activities and the proliferation of IT into virtually all business processes. This requires redefinition of the roles and responsibilities of all those involved in IT related activities, including top management. Management must be involved actively and be responsible for IT issues concerning common needs of the organization instead of simply delegating these issues to their subordinates.

Traditionally, IT-function within a utility has been viewed in most cases as a support activity concerned with the utilization of its resources for providing required level of information support. The level of IT-resources has been typically based on administrative cost considerations rather than on strategic objectives that could potentially reshape the organization’s strategic thrusts. This traditional view of IT’s role is largely reactive, i.e. a response to existing business strategy and processes, but not a critical factor in shaping the business strategy or processes. A more forth-coming approach is to view IT as a strategic resource and to position IT in a proactive role where the competitive strategy is not viewed as a prior given, but rather as something that should be challenged, extended, and perhaps modified, in light of emerging technologies and applications. The firm’s competitive strategy must be defined with a view of the capability and potential of IT today, and it has to be defined first prior to the formulation of IT strategy so that the IT strategy can be aligned with the business objectives. Two frameworks for the formulation of a firm’s competitive strategy, one by [Porter, 89] and another by [Miles & Snow, 90], are presented and discussed.

Porter presented four strategy types based on competitive advantage and scope as shown in Figure 33. He argued that it is important for a firm to make a choice if it is to attain a competitive advantage. A firm that failed to position itself or got “stuck in the middle” possesses no competitive strategy.

![Figure 33. Generic Strategies by Michael E. Porter](image)

Miles and Snow put forward four strategic types of organizations, namely: Defenders, Analyzers, Prospectors and Reactors.
Defenders basically define their entrepreneurial problem as *how to seal off a portion of the total market to create a stable set of products and customers*. Prospectors, on the other hand, define their entrepreneurial problem as *how to locate and develop product and market opportunities*. Between these two extremes lies the analyzer. The entrepreneurial problem of analyzer is *how to locate and exploit new product and market opportunities while maintaining a firm core of traditional products and customers*. While the defender, prospector, and the analyzer can all be considered proactive with respect to their environment, the reactor exhibits a pattern of adjustment to the environment that is both inconsistent and unstable. As a consequence, reactors exist in a state of almost perpetual instability. One of the primary reasons for an organization ended up as a reactor is, according to Miles and Snow, that top management may not have clearly articulated the organization’s strategy.

By relating to a study reported in [Gupta, 91], the paper also highlighted the strong correlation between a firm’s competitive strategy and the management of IT within a firm. Beside this, the firm’s competitive strategy also influences the firm’s view on its IT infrastructure. This in turn has a bearing on the firm’s IT investment [Broadbent, 92].

Finally, the need for business processes to be redesigned to adapt to the enhanced functionality of IT in order to achieve radical improvement in productivity is stressed. Otherwise, the improvement is likely to be minimal. Conducting a business process analysis is seen as a way to achieve this. The results of this analysis are important inputs to the IT strategy and have strong impact on its content.

**Part C: IT Strategy for Electric Utilities - From a Paper Tiger to an Effective Management Tool**

In Part A and Part B, the focus has been on the various aspects of the strategy process, the strategy content, and the strategy context that are considered vital for an effective IT strategy. Little has been mentioned about the implementation aspect of the IT strategy.

This paper (Part C) focuses on the implementation aspect, namely, the process of transforming the IT strategy into an IT plan and operationalize it subsequently. This paper is based on a follow-up study conducted in the same utility.

In particular, this paper identifies a number of problems related to the implementation, follow-up, and maintenance aspects of Information Technology (IT) strategies and proposes a structured framework to deal with the identified problems. Some of the problems identified in this follow-up study are given below:

1. A *poor coupling between the business strategy and the IT strategy*. This lack of coupling may surface in any stage of the total strategy process, which is an iterative process including strategy formulation, strategic planning, implementation, follow-up and assessment, and also strategy maintenance. However the discussion here focuses on the problems arising in the implementation, follow-up and assessment stage. In the studied utilities, the lack of coupling was primarily caused by the following factors:

   - Absence of business process analysis during the strategy formulation.
   - Different owners of IT strategy and business strategy and the lack of coordination between them. The business strategy was owned by the top management group while
the IT strategy was entirely delegated to an IT council that neither had the authority, status, nor the resources required to carry out its tasks.

2. **A poor coupling between the IT strategy and IT related decisions.** It was observed that the IT strategy has little impact on IT decisions made within the studied utilities. IT related decisions were still being made with little regard to the IT strategy. This was clearly reflected in the procurement of an IT-system in the studied utility in which the IT strategy played little or no role at all. Another example was the procurement of different SCADA systems by two different business areas within the utility. The lack of this coupling was caused by several factors, the most pertinent ones being the lack of clear division of roles and responsibilities and the absence of an operational framework for the IT process to complement the roles and responsibilities defined. Despite the attempt of the existing IT strategy to define the roles and responsibilities of the various parties involved, confusions still exist with regard to the operational aspect.

3. **Lack of overall direction for future development of IT-systems.** The main cause of this problem was that the studied utility did not have any document describing its IT systems and information structure architecture (neither existing nor target architecture). System architecture, i.e., a description of how functionality and information is packaged into components, and how these components interact, is very useful in providing a comprehensible abstraction of a complex system and information structure. It can facilitate a better understanding of the characteristics of an organization’s IT infrastructure. The desired target architecture sets a goal for the organization to migrate towards and provides the basis for decision making concerning future IT projects. It can also be used as a reference document and as input to the IT council in carrying out its tasks.

To overcome these identified problems, this paper highlights the importance of seeing the strategy process as a totality (see Figure 34). The formulation of an IT strategy is just the first step of an iterative process. A good IT strategy is a pre-requisite, but in itself, is not sufficient in achieving the business objectives. To better achieve the objectives, the strategy needs to be transformed into an IT plan through a strategic planning process. The implementation of the IT plan needs to be monitored, coordinated, and assessed. The assessment provides the basis for the review of the IT strategy.

![Figure 34. The total strategy process](image-url)

Apart from defining the roles and responsibilities of the various parties (top management, IT council, IT department, and business managers) more clearly, the paper also proposes an
operational framework to manage the IT processes more effectively. This operational framework, which takes the form of a process model, is meant to counter the problems observed in the study (see Figure 35). This model is currently being implemented at the studied utility.

![Figure 35. An operational process model](image)

The different stages of the process model are described below:

**Referral.** To ensure that all the IT related issues are “brought up to the table,” they should be referred to the IT council by the respective business managers for consideration. The council should provide its opinion based on the IT plan, its understanding of the IT infrastructure, and its insights into other planned and on-going projects.

**Decision.** Since the IT council does not has the mandate to make decisions, its statement of opinion is given to the respective business manager. The business manager will then make his/her decision by taking into consideration the opinion provided.

**Follow-up.** Should any decision result in a project, the IT council should then actively follow-up on the development of the project until the project is finished. This is done through the support provided by the IT department.

Finally, to provide an overall direction for the future development of IT systems, it is proposed that a description of the system architecture be included as part of the IT planning document. The purpose of this architecture description is to help in visualizing the system and information structure and thereby providing direction to the future development of IT systems. For example, the description can give end-users a better understanding of the organization’s IT environment, provide guidance to system administrators, and can be used by the IT advisory council to determine whether a proposed activity is in compliance with the intentions of the IT strategy or not.

**Part D: IT Strategy and Electric Utilities - A Survey Analysis**

This report provides full documentation of the conduct, the analyses, and the results of the quantitative survey combined with statistical analyses carried out after the exploratory case study. The survey was aimed at investigating the results and observations obtained in the exploratory case study further in a larger population of Swedish distribution utilities and attempt to generalize some of the findings.

The objective of the study was to provide insights into the state-of-the-practice of utilities’ existing IT strategies, the impact IT strategies have on the utilities business activities, and also on how IT strategy should be handled to further enhance its effectiveness. To achieve this objective, the questions in the survey were centered on factors related to the strategy process,
content, and context that were found to have had impact on the effectiveness of the IT strategy in the case study. Leavitt’s model of an industrial organization described in subsection 3.2.2, which depicted the strong relationship between technology, people, process, and structure also provided the basis for the formulation of the questions.

In particular, this survey strove to shed some light on the following questions:

- How satisfied are utilities towards their present IT strategy?
- What are the factors that could contribute to a good and effective IT strategy?
- How important is it to involve consultant and the various levels of an organization in the IT strategy process?
- How important is the communication process in the IT strategy process?
- How much impact does existing IT strategy have on utilities?
- What considerations (with reference to the Leavitt’s model) have been given to existing IT strategy and should it be different in future IT strategy undertakings?

A total of 230 questionnaires were sent out based on the list obtained from the Swedish Energy Authority and a total of 52 utilities responded. This gave an overall response rate of 22.6%, and the total sample received was sufficient to satisfy the sample size required for a high precision level of 5% and a confidence level of 95%.

A large percentage of the respondents came from the top management group (about 65% with CEOs and Business Unit Chiefs combined), 24% were IT coordinators or executives responsible for IT within the organizations, while the remaining 21% were either operation engineers, technicians, or operation leaders, (see Figure 36).

![Respondents Profile](image)

**Figure 36. Respondents profile**

All statistical tests in the analyses were performed with a 95% confidence interval (C.I.), which means that a p-value of less than 0.05 is considered statistically significant. Furthermore, utilities were categorized into two groups based on their respective customer size in the analyses, namely “small-medium” and “large” utility, which denote utility with a customer base of less than 45,000 and a customer base of 45,000 or more respectively. The purpose of this categorization was to investigate if there was any difference between the two groups in handling issues raised in this study.
In the following, a summary of the main findings is provided.

1. About 45% of the utilities surveyed already have an IT strategy in place.
2. Utilities with a large customer base are more likely to have an IT strategy than utilities with a smaller customer base ($p^2=0.006$).
3. About 68% of utilities are not satisfied with their existing IT strategy.
4. Existing IT strategy has only moderate impact on the utility’s business strategy, tasks, roles and responsibility of its people, and relationship with its customers. There is little impact on the organization's structure and the relationship with its suppliers.
5. The degree of involvement in the IT strategy process and the understanding of the strategy is highest for the top management group, followed by the middle management group and lowest for the line and functional staff.
6. For the top and middle management group, no significant difference is found in the degree of involvement and understanding of the IT strategy between large and small-medium utilities and also between utilities “satisfied” with their IT strategy and those “not so satisfied.”
7. However, significant difference is found in the degree of communication and understanding by the line or functional staff between the “satisfied” and “not so satisfied” groups ($p=0.0172$). The mean for the “satisfied” group is significantly higher than that of the “not so satisfied” groups. There is a positive correlation between the degree of understanding by the line or functional staff and the degree of satisfaction.
8. By comparing the “existing” practice and the “should be” scenario, there is conclusive evidence that shows a strong desire to increase the degree of involvement and the communication and understanding by the middle management group as well as the line and functional staff in the future IT strategy process.
9. Only about 58% of the IT strategy formulated involved the service of consultants. There is not enough evidence to suggest that the consultants’ involvement necessarily increases the satisfaction level of utilities towards their IT strategies. This may imply that there is a need for consultants to change their approach in assisting utilities to formulate their IT strategies.
10. The following process related factors are found to have statistical significant relationship with the overall satisfaction level of the process in formulating IT strategies.
   - Degree of middle management involvement: The correlation is positive and moderate ($p=0.007$, c.c.$^3=0.596$).
   - Degree of how well IT strategy was communicated and explained to top management group: The correlation is positive and moderate ($p=0.003$, c.c.=0.650).
   - Degree of how well IT strategy was communicated and explained to middle management: The correlation is positive and moderate ($p=0.003$, c.c.=0.642).

$^2$ $p = p$-value in statistics
$^3$ c.c. = correlation coefficient
• Degree of how well IT strategy purpose, scope, utilization, etc., was understood by top management group: The correlation is positive and strong (p=<0.001, c.c.=0.777).

• Degree of how well IT strategy purpose, scope, utilization, etc., was understood by middle management: The correlation is positive and moderate (p=0.029, c.c.=0.501).

• Degree of how well IT strategy purpose, scope, utilization, etc., was understood by line or functional staff: The correlation is positive and moderate (p=0.014, c.c.=0.569).

11. The degree of consideration given by existing IT strategy to the four vital variables of an organization as postulated by Professor Leavitt is in the following order: technology, tasks or processes, people, and structure. No significant difference is found in the means of these considerations between large and small-medium utilities.

12. However, there is very strong evidence that this pattern is about to change. The likely order of consideration for future IT strategy will be tasks or processes, people, technology, and structure.

13. About 74% of the existing IT strategies are explicit, i.e., strategy is documented and is available to all the people in the organization.

14. Results of the analysis fail to find conclusive evidence to support one of our hypothesis that an explicit strategy would increase the satisfaction level towards the IT strategy.

15. It appears that the communication and understanding of the IT strategy is more significant than merely making the strategy explicit. In other words, even if the strategy is made explicit, it may not enhance the satisfaction level if no effort is made to explain the strategy so that people really understand its objectives, scope, and utilization, etc.

16. There is a significant difference in the degree of consideration given to the changing business environment by existing IT strategy between utilities with large customer bases and utilities with smaller customer bases (p=0.0056). The IT strategy of larger utilities pay significantly more consideration to the changing business environment than smaller utilities. This is consistent with the observation that larger utilities are generally more active and aggressive in the newly liberalized electricity industry than the smaller ones.

Part E: A System Approach towards Effective IT Strategy for Modern Electric Utilities

Part F: A Framework towards Effective IT Strategy for Modern Electric Utilities

Both these papers (Part E and Part F) basically share the same theme except that they were structured and presented in such a way to suit the different audiences in the two conferences. The first paper (Part E) that was presented in the Portland International Conference on Management of Engineering and Technology (PICMET), focuses more on providing theoretical backgrounds and on presenting the research findings in a format commonly used in such forums where the audience came mostly from academia and research institutions. The second paper (Part F) that was presented at the 15th International Conference of Electricity Distribution (CIRED) 99 and focused on describing the characteristics of existing IT strategies, in particular the strengths and weaknesses identified in the study, within a theoretical framework. The audience consisted mainly of people from the utility industry.
In essence, both the papers combine the results and findings obtained from the case study as well as the quantitative survey, linking them to theories and concepts drawn from the various disciplines of study, and proposing a system approach to manage IT strategy in order to enhance its effectiveness.

The papers conclude that electric utilities are far from being satisfied with their existing IT strategy. There is evidence that existing IT strategies focus considerably on technology aspects but less on other organizational elements that are vital in enhancing the strategies’ effectiveness and in achieving a firm's ultimate objectives. Weaknesses identified in the studies, which have been linked to the lack of consideration for other vital organizational elements such as tasks/processes, people, and structure as postulated in the Leavitt’s model, demonstrate the importance of considering them in parallel, apart from technology. From the survey, there is strong statistical evidence that there is a strong desire among utilities for future IT strategies to be more balanced, i.e., more consideration to be given to other organizational elements besides technology.

In order to overcome the weaknesses of existing IT strategy and to enhance its effectiveness in achieving organizational goals, the papers propose a framework that adopts a system approach to manage future IT strategy undertakings (see Figure 37). The proposed framework draws not only from the insights gained from the case study and the survey conducted, but also synthesizes concepts and theories from various related disciplines, such as strategic management, organization theories, and information systems. While the framework does not guarantee the success of IT strategy, it at least helps utilities to avoid some of the common pitfalls identified in this study.

**Figure 37. A system approach to IT strategy**

In essence, the proposed framework emphasizes the need to take into consideration the four interacting elements within an industrial organization as postulated in the Leavitt model, i.e., the tasks or processes, the people, the technology, and the structure of the organization. The
IT strategy should be more balanced and should not be overly focused on technology. In addition, a management process element, which can be seen as the glue that holds an organization together, is added. An example of management process is the appraisal or the reward system of an organization. This framework requires utilities to consider and incorporate all these elements into their IT strategy.

The framework also recognizes the different levels in which an IT strategy can exist, namely, the corporate level, the business level, and the functional level. This differentiation is important because IT strategy may have different objectives at different levels. Without this differentiation, people in the organization may be confused with regard to the purpose, scope and utilization of the IT strategy. This was found to be the case in the utility where the case study was conducted.

To ensure the effectiveness of the strategy, the framework also provides guidelines on the requirements of the strategy process, strategy content, and the strategy context. For example, in the strategy process dimension, it is recommended to have inputs from SWOT analysis and to perform a business process analysis to identify the critical business processes in which the enhanced capabilities of IT can be exploited. This is one way to establish the linkage between IT strategy with business strategy and processes. These recommendations are apart from the other fundamental requirements such as to involve the critical mass of the organization, improve communication, and generation of commitment.

In the strategy content dimension, it is important that the strategy be business-driven instead of technology-driven. The strategy should be consistent with other strategy or policy that a firm might have, and should be feasible within the available resources and time frame specified.

In the strategy context dimension, the IT strategy must take into consideration both the external as well as the internal environment of the firm. The external environment has two parts: the industry environment that includes those elements that directly affect the organization’s major operation, and societal environment that includes the more general forces such as economic, socio-cultural, technological, and political-legal forces. On the other hand, the internal environment includes the structure, culture, and resources of the organization. Finally, a checklist for the final strategy document is also provided to ensure important aspects are not overlooked.

The implications of the approach proposed are also discussed in the papers. For example, the proposed approach not only makes future IT strategy more complex by having to relate to other organizational elements, it also requires that future IT strategy becomes a central issue of the management due to its impacts on the organization as a whole. Also, if consultants are hired to assist in the formulation of the strategy, the scope of works should not be restricted to only the technology aspect for the strategy to be effective. Furthermore, practitioners and consultants must also increase their knowledge, skills, and competence in dealing with this increase in complexity.

Part G: Powerline Telecommunications - A Worthwhile Strategic Investment?

While all the above reports and papers focus on identifying the parameters that are critical to the effectiveness of IT strategies and on proposing a new approach to manage future IT
strategy undertakings, this paper (Part G) demonstrates the importance of not being overly technology-driven in making IT-enabled strategic investments or decisions. It is important to see the technology in the overall context in which it is to be deployed. In other words, this paper can be seen as an application of some of the concepts put forward in the earlier parts.

The recent breakthrough in PLT (Powerline Telecommunications) technology that has enabled high-speed access to the Internet via existing low voltage electric distribution lines has created a lot of hypes and excitement in the electric utility industry. The new technology offers many advantages to modern users of information compared with the traditional way of accessing information via analog modem technology. It also comes at a time when the development of the Internet and the deregulation of the telecommunication and the energy industry have virtually created a new emerging market where it can be utilized. Many electric utilities are contemplating investing in this technology to have a share in the emerging Internet market. One of the motivation factors for this is to broaden the revenue base to compensate for the decreasing revenue after deregulation caused by increased competition and stagnant growth in the energy market. Another factor is to provide additional value-added services to improve customers’ loyalty to avoid them from changing to another supplier.

This paper analyses how worthwhile this breakthrough technology (PLT) is for electric utilities as a potential strategic investment. The analysis is done by performing an in-depth evaluation of two emerging technologies that serve the same market, namely, the “broadband” Powerline Telecommunication Technology (PLT) and the ADSL (Asymmetric Digital Subscriber Lines) technology, using a well-established framework for industrial analysis introduced by Porter [Porter, 54]. The evaluation is not purely based on technical aspects, but also on other “softer” issues including:

- The nature of benefits that includes both performance and cost benefits.
- The state-of-the-art required to yield significant benefits, that is, the technological performance demanded by customer’s applications of the product.
- The life-cycle-cost (LCC) of introducing the technology.
- The support services required to sustain the technology, including competence and personnel.
- Cost of obsolescence and standardization. This is the perception that the technology will become obsolete with the successive generations of technology and development.
- The users’ perceptions of technological change that include, among others, how comfortable and experience the users are in using a certain new technology.

Based on the analysis, the paper argues that despite the many potential advantages claimed by PLT vendors, the technology is still not yet “ripe” for utilities to make hefty investments. This is due to a number of reasons. It would be difficult for utilities to justify their investment into PLT today in order to become an active player in the emerging data and telecommunication industry. This is especially the case in developed countries like Sweden where telecom networks have almost a 100% reach. ADSL, especially the newly specified ADSL Lite version, possesses more competitive advantages than PLT when taking all the “softer” issues mentioned above into consideration.

Nevertheless, utilities may resort to small-scale deployment in selected areas by cooperating with other partners, e.g. a telecom operator, to reduce the risk. In this case, the strategy should be one of "lock in – lock out" i.e. lock in the end users to the power utility and lock out other
operators who will deploy alternative broadband access solutions such as the ADSL in the near future.

Having said this, it does not mean that PLT will have little or no future at all. In order to create a better future, PLT systems may need another breakthrough to integrate different applications and services together (both utility specific and value-added services) and to exploit the miles of electrical wiring present in every household, turning it into a ubiquitous network transparent to the users. All these must happen fast before the market is capture by other operators deploying different technologies.

6 CONCLUSIONS AND IMPLICATIONS

Together, deregulation, new technology, and the Internet are rapidly transforming how companies (including utilities) define and manage their business. Although electric utilities have a long tradition of using information technology (IT), the role of IT has often been treated as merely a supporting tool. With the recent advancement in IT that has enhanced the capabilities of IT considerably, there is a need for utilities to change their traditional mindset about IT and start to view IT as a strategic tool that can help them to position themselves in the new market environment and to achieve their organizational goals more effectively.

One fundamental requirement that can help utilities to better utilize the enhanced capabilities of modern IT is to have an effective IT strategy to manage the developments, acquisitions, and the utilization of IT systems within the organization. Essentially, an IT strategy should be able to ensure successful implementation of IT related programs and bring about the desired benefits and competitive advantage to the organization.

While many utilities are aware of the potential impact of IT on their business activities and the need for an IT strategy to help them better manage this fast evolving technology, questions concerning the effectiveness of IT strategy have remained largely unexplored. Through a combination of an in-depth case study and a quantitative survey, this research study has provided insights and enhanced our knowledge into this often “taken for granted” and relatively unexplored territory.

Apart from identifying the current state-of-the-practice of how IT is managed in electric utilities and its related weaknesses, the main contributions of this thesis are the identification and bringing to the surface the crucial parameters affecting the effectiveness of IT strategies, as well as proposing a framework towards formulating a more effective IT strategy.

Based on the results obtained in this study, it can be concluded that existing IT strategy within electric utilities, formulated with the traditional mindset of the industrial-age that focused primarily on technology, is inadequate and ineffective in dealing with today's IT which has a broader implication on an organization's business activities. This is reflected in the results obtained; electric utilities are far from being satisfied with their existing IT strategy today. So far, IT strategy has not produced any significant impact on their business activities. There is evidence that existing IT strategies focus considerably on the technology aspect but less on other organizational elements that are vital in achieving a firm's ultimate objectives, such as tasks/processes, people, and structure as postulated by [Leavitt, 60]. Weaknesses found in
existing IT strategies identified in this study can be linked to the lack of consideration for these elements.

In order to overcome the weaknesses of existing IT strategy and to enhance its effectiveness in achieving organizational goals, a framework that adopts a system approach to manage future IT strategy undertakings is proposed. The proposed framework draws not only from the insights gained from the case study and the survey conducted, but also synthesizes concepts and theories from various related disciplines, such as strategic management, organization theories, and information systems.

The proposed framework requires utilities to think holistically and not overly focused on technology. Apart from emphasizing on the importance of taking into consideration the various inter-related elements within an organization, the framework also provides guidelines on the requirements of the strategy process, the strategy content, and the strategy context. The parameters found to have an impact on the effectiveness of IT strategies in this study provide the basis of these requirements.

The system approach called for in this thesis has several implications. It not only makes future IT strategy undertakings more complex by having to relate and include other organizational elements, it also requires that future IT strategies become a central issue of the management due to its impacts on the organization and the business as a whole. Furthermore, if IT consultants are hired to assist in the formulation of the IT strategy, the scope of works should not be restricted to only the technological aspect. They should be allowed to look into and take into consideration other business and organizational aspects where IT could have an impact in order for the resulted strategy to be effective. In view of this, practitioners and consultants must also increase their knowledge, skills, and competence in dealing with this increase in complexity.

Finally, it is also emphasized in the thesis that having a good IT strategy is just the first step of an iterative process. A good IT strategy is a pre-requisite, but in itself, it is not sufficient in achieving the business objectives. To achieve the objectives, the strategy needs to be transformed into an IT plan through a strategic planning process. The implementation of the IT plan needs to be monitored, coordinated, and assessed. The assessment in turn provides the basis for the review of the IT strategy. Therefore, utilities must see the IT strategy process in its totality and must allocate adequate resources to sustain the whole process until the benefits or the objectives are achieved.

7 FURTHER WORKS

So far, this thesis has provided insights into the state-of-the-practice of how IT is managed in electric utilities and has identified its related strengths and weaknesses. Factors that are found to have significant impact on the effectiveness of IT strategy are identified and a framework is proposed to enhance the effectiveness of future IT strategy.

The thesis has not addressed the issue of how the proposed framework may be implemented in a real organization setting in total, although part of the concepts has been implemented in a utility. As in the case of many other good management principles, the transformation of the proposed framework into desired practice is often a major challenge.
There are a number of factors that can impede the transformation process. One of the primary factors is the availability and the allocation of resources to the process. Resources are becoming increasingly scarce commodities in many organizations including electric utilities.

On the one hand, the proposed framework demands more resources due to its increased complexity and its scope. On the other hand, deregulation of the utility industry has caused many utilities to “down-sizing” their organizations to reduce cost and at the same time, they are expected to increase their efficiency and responsiveness to customers’ needs. The process of transforming a utility from a relatively static and monopolistic market to a more dynamic and competitive environment is not an easy task. It demands a lot of resources to be spent on education, retraining and restructuring to adapt to the new environment. Many utility executives already find themselves on the threshold of their ability to take in more changes. Even though utilities can take in external resources such as consultants to help in the process, to be effective the process still requires active involvement of people within the organization.

One possible way to alleviate this dilemma is to integrate the IT strategy process into the business strategy process. Most utilities already have a well-established process commonly known as the “strategic planning cycle” where major business issues are discussed and goals and objectives set. It may be advantageous to integrate the IT strategy process into this process as IT is increasingly becoming an integral and inseparable part of the business process. In this way, the demands for resources may be lessened.

Further work that arises from this thesis includes investigating issues concerning the implementation of the proposed framework and the feasibility of integrating the IT strategy process into the existing “strategic planning cycle” of utilities.
8 SELECTED REFERENCES


