A framework for the explicit use of specific systems thinking methodologies in data-driven decision support system development

by

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ABSTRACT

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KEYWORDS: Systems thinking, soft systems thinking, hard systems thinking, critical systems thinking, disclosive systems thinking, pattern matching, decision support systems, data warehousing, framework.

Data-driven decision support systems, such as data warehouses, are extremely costly to develop. Forty one per cent of data warehouse development practitioners have experienced project failures. These projects were either completed after exceeding budget and time limits, or not at all. Some influential data warehousing authors advocate user involvement as a solution, while others focus on technical factors to improve data warehouse success. This study proposes a framework for data warehousing success based on systems thinking methodology.

Systems thinking implies a holistic approach to problem solving. A system is a set of interrelated elements. A systems approach represents a broad view, taking all aspects into account and concentrating on interactions between different parts of the problem. This study investigates the practices of data warehousing professionals from a systems thinking point of view, before proposing a framework for the explicit use of specific systems thinking methodologies in data warehouse development.

Interpretive case study research is used to investigate practices of data warehousing professionals in three different organisations. Pattern matching is used to analyse collected data. This is done by mapping practices to different systems thinking perspectives. However, the theory component of the thesis is not a description of current data warehousing practices from a systems thinking point of view, as in typical interpretive research. The theory component relates more to critical research in that it is meant to change data warehousing practices towards specific systems thinking methodologies.

The proposed framework incorporates three sources of information. These are a literature study on systems thinking philosophy, methodology and practice; a

literature study on data warehousing and data warehousing success factors; and the results of case studies on current practices of data warehousing professionals analysed from a systems thinking perspective. The framework gives a methodological foundation for a holistic approach to data warehousing with maximum user involvement. It views a data warehouse as a system with typical systems characteristics, such as specified objectives relating to the organisation's objectives, an environment, available resources, specified components and effective management.

I declare that

A framework for the explicit use of specific systems thinking methodologies in data-driven decision support system development

is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

R Goede

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CHAPTER 1 INTRODUCTION

1.1 Motivation for the study

Data-driven decision support systems are very expensive to develop. This is due to various factors, including the transformation of different data sources to a single platform and a high level of managerial involvement. The magnitude of the data sources involved requires large capacity hardware resources that are expensive. Another cost factor is that due to the nature of the processes simulated in the data-driven decision support system, involvement of senior management in the problem definition is essential. Markus (2000:43) argues that the implementation of enterprise systems in large corporations have been known to cost over $500 million and because systems are much more tightly integrated than before, failure of one system will have extremely negative consequences for other systems in the organisation.

Data warehouses are typical data-driven decision support systems. Data warehouses integrate various data sources to supply management information in organisations. Many data warehouse projects take longer than originally planned and cost much more than initially budgeted for. The Cutter Consortium reported that 41% of practitioners surveyed have experienced data warehouse failures (Anonymous, 2003:1). Inmon (reported in Ferranti, 1998:1) argues that companies make costly mistakes that cause delays. However, the benefits of successful data warehouses are so significant that the academic research community should search for methods to improve the success rate of data warehouse projects.

The author of this thesis was drawn to systems thinking as a basis for improving data warehouse quality because of the holistic nature of systems thinking. Kevin Strange of Gartner wrote (2001:1): “With respect to the analytical (business intelligence) side of customer relationship management, at least 65% of the efforts are implemented in an unintegrated fashion, based on a function (different efforts by different departments), rather than on a more strategic initiative – the sum is larger than the parts.” Many authors (Mimno, 2001; Eckerson, 2003) argue that business objectives should be central to data warehouse planning and development. This is congruent with the systems approach proposed by Churchman (1968). He advocates that subsystems should work together to achieve the objectives of the system and the

objectives of the subsystem should relate to that of the system. A question worth investigating is whether systems thinking can point practitioners to more successful data warehouse development practices.

This thesis is such a research initiative. The aim of the research is to develop a framework for the explicit use of specific systems thinking methodologies in data warehousing practices. It is assumed that data warehousing practitioners do not know systems thinking methodologies (a valid assumption according to the case study data reported in chapter 5). From data warehousing literature (Kimball *et al.,* 1998; Inmon, 1996), it is clear that the practices of data warehousing professionals can be mapped to systems thinking methodologies. The researcher decided to make this mapping explicit in order to propose methods, in the form of a framework, to improve data warehouse quality.

The development of the framework is seen as a two part process. The first part is to explore current data warehousing practices according to systems thinking methodologies. The second part is to make this mapping explicit in terms of a framework.

1.2 Concepts central to this thesis

Systems thinking and data warehousing have been introduced in section 1.1 as concepts central to the development of the researcher's research presented in this thesis. A short summary of these concepts will suffice for the time being, but they will be dealt with in detail in chapter 3 and chapter 4.

1.2.1 Systems thinking

The term methodology refers to methods for exploring and gaining knowledge about systems. Systems thinking emerged in reaction to reductionism, when Von Bertalanffy (1968:51) advocated an interdisciplinary approach to widen the scope when studying problem situations. A system is a set of interrelated entities, of which no subset is unrelated to any other subset (Kramer & De Smit, 1977:13) and has properties that do not exist in the parts but are found in the whole (Weinberg, 1975:60). Churchman (1968:29) describes systems in terms of their objectives,

environment, resources, components and their management. He argues that a specific system can be identified by its objectives. Different ontological views of systems, which we call methodologies, emerged, namely hard systems, soft systems, critical systems and recently disclosive systems thinking.

Hard systems thinking is a term used by Checkland (1981) as an alternative to "soft systems". From a hard systems thinking perspective social systems are treated like scientific problems. A system is viewed as a hierarchically organised set of elements. When one understands the components of the system, one is able to understand the system as a whole. A system is seen as a true representation of reality. Information systems development, according to a hard approach, is seen as a technical project which can be done outside the context of the environment.

Soft systems thinking adopts a more holistic approach to systems properties when declaring that a system has properties that do not exist in its parts. A system is viewed as a person's perception of the real world. Different views enhance the understanding of the problem situation. User satisfaction is more important than requirements conformation in information systems development. Checkland (1981, 1999) developed a methodology (set of methods) to implement soft systems thinking in solving problems.

Critical systems thinkers believe that the world is not fundamentally harmonious. Therefore, to understand, explain and make possible changes, one must think in terms of contradictions. Different perceptions can be seen as expressions of irreconcilable conflict and power struggle between management and workers, or systems developers and users (Flood & Jackson, 1991a:83). Intervention is central to practising critical systems.

Disclosive systems thinking was introduced by Strijbos (2000) to address the responsibility of people for particular developments. He accentuates the norms for action taken by agents and argues that ethics should be part of the chosen systems methodology. Strijbos warns that ethics is not part of hard, soft, or critical systems thinking. He states that "disclosive systems thinking (and the systems ethics entailed in it) proceed from the normative view that the various systems receive their meaning from the pre-given reality and order of which these systems are a part" (Strijbos, 2000:168). Disclosive systems thinking aims to disclose this intrinsic normativity in order to enrich human life and culture.

1.2.2 Data-driven decision support systems

Inmon (1996:33) defines a data warehouse as a "subject oriented integrated, non-volatile, and time variant collection of data in support of management decisions." Kimball *et al.* (1998:19) simply define a data warehouse as "The queryable source of data in the enterprise." These authors are most influential in data warehousing design methodologies. They differ on various concepts in data warehousing, one of which is the development lifecycle of a data warehouse. Inmon (1996:24) advocates a lifecycle that he calls the CLDS (reverse of SDLC: systems development lifecycle) with the following phases:

1. Implement data warehouse
2. Integrate data
3. Test for bias
4. Program against data
5. Design DSS system
6. Analyse results
7. Understand requirements

This is a data-driven lifecycle methodology. Kimball *et al.* (1998) advocate the use of a requirements-driven lifecycle methodology. Their methodology begins with a data warehouse readiness test. Then user requirements are gathered, followed by modelling, data staging, end-user application design, and maintenance.

Different authors identify success factors in data warehouse design. Ferranti (1998) quotes Inmon: "Building data marts before developing a data warehouse can be one of your biggest mistakes." Mimno (2001) argues that the most important success factor is to make your data warehouse business-driven. He argues that a technology-driven approach is much more likely to fail than a business-driven approach.

1.2.3 Relationship between systems thinking and data-driven decision support systems

Many data warehousing authors such as Kimball *et al.* (1998) and Mallach (2000) advocate user involvement, the inclusion of business sponsors, and the involvement of top management, to increase the success rate of data warehouse systems. A very strong implicit use of soft systems methods surfaces when one examines the

lifecycle of a data warehouse and the recipes for data warehousing success. Markus (2000:44) argues that the development process of business-driven systems, such as data warehouses, looks more like a large-scale organisational development or change management project than it looks like a traditional information systems (IS) project.

One might argue that a technology-driven approach is a hard systems approach, and a business-driven approach is a soft, critical, or disclosive systems thinking approach depending on the characteristics of business objectives. The aim of this research initiative is to apply systems thinking ideas on data warehousing in order to improve data warehousing quality. The first step however, is to understand current practices of data warehousing practitioners from a systems thinking methodology point of view.

1.3 Structure of the thesis

This thesis explores the relationship between philosophy, methodology, and practice, indicated in Figure 1.1. The philosophy layer represents general thinking based on ontological and epistemological assumptions. The works of individual philosophers as well as ideologies are represented by the "philosophy" section of this structure. "Methodology" is seen as general procedures used to explore reality. Section 3.1 explores the definition of "methodology" further. "Practices" represent activities of people in the performance of their daily work. It can be seen both as individual practices as well as common practices typically used by people to perform a specific task.

This thesis aims to demonstrate that the selection of practices followed in a problem situation relates to the methodological and philosophical underpinnings of those practices. In this thesis the structure of philosophy, methodology, and practice is applied independently to two problem situations. Firstly, it is used to support the selection of an unorthodox research methodology used in the empirical part of the research presented in this thesis. Research methodology is presented in chapter two according to this structure. The process regarding the selection of a specific research plan is presented as an application of this structure.

Secondly, it forms the core of the main argument of the thesis that motivations behind practices in data driven decision support systems development are rooted in

specific systems thinking methodologies, which are in turn rooted in specific philosophical ideas. This statement leads to the development of a framework for the use of a specific systems thinking methodology in data driven decision support development. Chapter 3 presents systems thinking according to this structure and chapters 5 and 6 aim to relate data driven decision support development practices to their methodological and philosophical underpinnings.

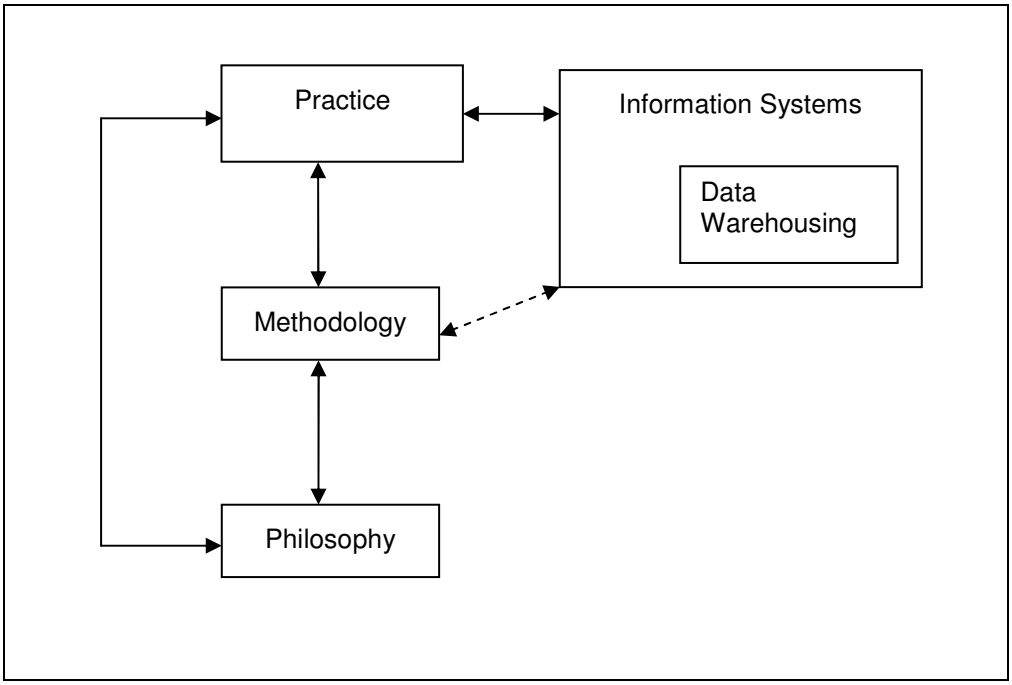


Figure 1.1 The relationship between philosophy, methodology, and practice

1.4 Research objectives

The main objective of this study is to transform the implicit relationship between systems thinking methodologies and data-driven decision support system development practices as reflected in literature and practice, to an explicit relationship. A framework for the use of specific systems thinking methodologies in data-driven decision support system development practices will be set up to encourage the explicit use of practices other than hard systems practices in data-oriented DSS development.

To reach this objective the following sub-objectives need to be achieved:

1. The first sub-objective is to understand data-driven decision support system development practices from a systems thinking point of view. This is done in

order to relate the final framework to the current practices of data-driven decision support system development practitioners. Three aspects need to be investigated to reach this objective:

a. The researcher needs to study systems thinking; this is done by means of a literature study that investigates the relationships between philosophy, methodology and practice of systems thinking and the application thereof in information system development.
b. The researcher needs to study data-driven decision support systems; this is done by means of a literature study on data warehousing and the success factors of data warehousing projects.
c. The researcher needs to explore the systems thinking nature of current practices of data warehousing professionals, even without the professionals being knowledgeable of systems thinking methodologies. This is done by means of case study research.

2. The second sub-objective is to design a framework that models specific systems thinking methodologies in the various stages of the development lifecycle of data-oriented decision support systems explicitly. The framework will be presented according to the systems approach introduced by Churchman (1968).

1.5 Limitations of the study

Data warehouses are investigated as representative of data-driven decision support systems. Mallach (2000:143) describes data warehouses as the primary data-driven decision support system used today. Therefore it is reasonable to limit this study to data warehouses to the exclusion of other data-driven decision support systems. The research cannot however automatically be applied to all data-driven decision support systems.

It was discovered during the initial approaches to the case study organisations that the methodologies of Inmon (1996) and Kimball *et al*. (1998) are dominant in the data warehousing industry in South Africa. This study therefore focusses on these generic methodologies to the exclusion of other specific information systems development methodologies.

Since data warehousing practices rather than data warehousing usage are the focus of the thesis, interviews were conducted with data warehousing practitioners rather than with end-users. The role of the end-users in the final framework is based on reports of the data warehouse team members interviewed.

Acceptance testing of the framework needs to be done through publication in journals and data warehousing specific literature and is viewed as further research.

1.6 Methodology

To reach the research objective, the data warehouse development process must be investigated and the implicit use of specific systems methodologies must be identified. The nature of the study forces the research to focus on techniques that facilitate field studies where the researcher is an active part of the environment. The researcher needs to assess the underlying motivations for the actions of the development team. It is important to understand whether motivations of actions are rooted in hard, soft, critical or disclosive systems thinking. The data warehouse development effort cannot be separated from the business strategy of the organisation. It is therefore required that the practices of the data warehouse development team are investigated in the context of the organisation as a whole. It is clear that interpretive methods must be used as opposed to positivistic methods.

In interpretive methods, the researcher serves as an instrument of observation (Lee, 1999:21). This is in contrast to positivistic methods where the researcher is an objective onlooker who does not influence the situation at all. Lee (1999:22) further argues that positivism and interpretivism are incomplete for information systems (IS) research because the researcher does not influence and is not influenced by the research environment. He argues that IS research should take on another form of research namely “critical social theory (CST)”. CST researchers believe that no researcher can simply be an onlooker, but that the researcher influences and is influenced by the social and technological systems he/she is studying. The researchers must also play a role in the emancipation of the actors in the research environment from unjust and inequitable conditions. Action research introduced by Lewin (1947) is an example of CST research methods.

Three aspects differentiate this study from typical interpretive research case studies. Firstly, in interpretive case studies, theory is typically generated from data or observation. Since the data warehousing practitioners are not knowledgeable on systems thinking methodologies, theory generated from their practices will not reflect systems thinking methodologies. Secondly, in order to identify what to investigate, the researcher needs to create a preliminary mapping between systems thinking and data warehousing practices. This is against the nature of typical interpretive research as described in chapter 2. Thirdly, the aim of the study is to eventually change (improve) the practices of data warehousing professionals, that is, to intervene. From this intervention aspect, one might argue that this research should be classified as critical social theory.

However, the study differs from typical critical methods, such as action research, in that the praxis or intervention is not done as part of the research process. A framework is not proposed to be used to implement a data warehouse and then improved according to the results of the implementation, followed by several repetitions of this cycle. The framework developed in this study is a result of case study data analysis.

This study can be compared with the diagnostic part of action research. Since the hermeneutics of interpretive research is very helpful, the researcher chose to declare this a pluralistic approach incorporating both interpretive and critical methods. Chapter 2 includes a detailed discussion of this argument.

The aim of the case studies is to understand the practices of the data warehousing professionals from systems thinking methodology point of view. Since the case study evidence is analysed through pattern matching (described by Yin, 1994:106), a preliminary mapping had to be developed prior to the first case study. Semi-structured interviews were conducted to gather data, and the answers to questions were mapped to specific systems thinking methodologies according to the preliminary mapping. This mapping was designed from data warehousing literature, combined with systems thinking literature and forms the basis for the case study data analysis. Questions were posed to data warehousing team members on six major data warehousing aspects: data warehouse adoption, data warehouse development methodology, requirements collection, data modelling, data staging (including data quality) and end-user applications. For each question, a typical answer was formulated in terms of each of the systems thinking methodologies investigated. No

other mapping between systems thinking methodologies and data warehousing practices could be found in literature.

The data collected from the case studies was combined with the knowledge gained from the two literature studies to develop the framework for the explicit use of systems thinking methodologies in data warehousing practices. This framework is presented in chapter 6.

1.7 Chapterisation

Chapter 2 gives a discussion on the research methodology used in the context of information systems research. The chapter is organised in terms of the philosophy, methodology, and practice model used throughout this thesis.

Chapter 3 reports on a literature study on systems thinking, in terms of philosophy, methodology and practice. It also investigates the application of systems methodology and practice in information systems development.

Chapter 4 reports on a literature study on data warehousing. This chapter includes a discussion on success factors in data warehousing practices.

Chapter 5 contains the case study reports. It gives a detailed description of the data analysis done in the study. A preliminary mapping of systems thinking methodology on data warehousing practices used in the data analysis of the case study data is discussed. It gives interpreted results of three case studies conducted to study data warehousing practices from a systems thinking point of view. The chapter concludes with an argument for the use of specific systems thinking methodologies based on the case study data analysis results.

Chapter 6 describes the final framework for the explicit use of specific system thinking methodologies in data warehousing practices. The framework is presented according to the systems approach introduced by Churchman (1968). The framework constitutes the conclusion of this thesis. The chapter also includes a summary of the research described in this thesis as well as a critical evaluation of the scientific contribution of the reported research.

CHAPTER 2 RESEARCH METHODOLOGY

2.1 Introduction

The aim of this chapter is to describe the philosophical and methodological foundation of the chosen research plan. Since the plan entails a pluralistic approach, combining different methodologies based on different philosophies, it is necessary to describe these philosophies and methodologies in detail. Both interpretive and critical social research methodologies are involved.

This chapter will illustrate the relationship between philosophy, methodology and practice in social research according to the structure discussed in section 1.3. The development of an information system is viewed as a social activity combining social systems and technology to the benefit of the organisation and society as a whole. The emphasis therefore is on social research. Traditional positivistic views on social research are given to highlight the differences between the research strategies.

Section 2.2 begins with a discussion on different philosophies of social research; positivism is compared to interpretivism and critical social theory. The history of these approaches is briefly discussed to put research methodology in context. The section on philosophy closes with a few remarks on the influence of the different philosophies on information systems research.

Methodology develops from philosophy. Section 2.3 describes positivistic, interpretive and critical social research methodologies. Since the chosen research plan is a combination of interpretive and critical methodologies, these are discussed in detail and in the context of information systems research. Positivistic research methodology is discussed briefly to aid the continuity of the chapter.

From methodology develops practice. Section 2.4 describes positivistic, interpretive and critical research practice. Special attention is given to practices that will form part of the research plan. Once again, positivistic research practices are briefly discussed as part of this chapter.

Section 2.5 deals with specific research problems related to this study. It describes different perspectives considered to solve the problems presented by the specific research question. This is also done from a philosophical, methodological and practical perspective. The section forms the research plan for the study as described in the previous chapter.

2.2 Philosophy and social research

The purpose of research is to discover something about the world. In an epistemological sense, we may argue that all knowledge is discovered or can be tested by well-defined methods. Although new information is sometimes discovered accidentally, it can be verified by the application of methods. Hughes (1990:10) argues that it is not easy to say exactly what these methods or procedures are. One may identify procedures such as experiments, hypothesis-testing, public scrutiny and many others. When these methods are seen as a set, one can ask why one set of methods is used in preference to another. One should ask why a set of methods is superior to another. These answers are to be found in the underlying epistemological and ontological assumptions of each set of methods.

The application of a specific research method is an acquired skill that can be mastered through experience. For each problem situation or research question, the appropriate set of methods should be selected and applied. Science is dependent on the use of methods to acquire knowledge. Hughes (1990:11) states “every research tool or procedure is inextricably embedded in commitments to particular versions of the world and to knowing that world.” This implies that any method’s effectiveness is ultimately dependent on epistemological justification. Different philosophers’ epistemological views led to different stances on research models.

Positivism, interpretivism and critical social theory are henceforth viewed as different research models based on conflicting epistemological and ontological views.

2.2.1 Positivism

Positivism has been criticised so often by social scientists, that it is difficult to give an unbiased description of the model. Positivism is known as the ”natural scientists' model” of research (Lee, 1999:12).

May (1993:4) raises the following argument to illustrate positivistic thought: “We may argue that people react to their environment much as molecules which become ‘excited’ when heat is applied to a liquid. Clearly, science does not have then to ask the molecules what they think. So is it necessary that we, as social scientists ask people? We may of course, be interested in people's opinions in terms of their reactions to events that affect their lives, but only in so far as they are reacting and we wish to explain and predict their behaviour accordingly.”

The epistemological roots of positivism can be traced to the work of Bacon (1561-1626) and Descartes (1596-1650). Bacon succeeded in establishing the experiment as basis for new scientific theory. Descartes established mathematics as the fundamental instrument in scientific research.

Comte (1798-1857) extended Bacon's ideas to social sciences. He set out to develop his system of positivism, designed to revamp society for the sake of all classes, believing that his system would guarantee international peace and avoid economic dissension. Society's salvation was to be contingent upon scientific knowledge (Comte, 1896:18). Comte (1896:17) claimed that society, including values and beliefs, could be studied with the same methods used by natural science research. The basic principle of positivism is to focus on the fact, or the given, and to ignore everything else. Research is conducted firstly by accepting given facts of the phenomenon, secondly by determining laws that govern the phenomenon and finally by forecasting future phenomena according to these laws (Störig, 1959:95).

Popper (1902-1994) aimed to unify the methods used in natural and social sciences (Stokes, 1998:76). Popper (1972) assumed that facts can be gathered in the social sciences exactly the same way as in natural sciences, and that the subject matter of all sciences is essentially the same. Popper conceded that objectivity is much harder to achieve in social sciences than in natural sciences. He stated that objectivity in a social sense, means “the realising that the action was objectively appropriate to the situation” (quoted in Checkland, 1981:266).

Durkheim (1858-1917) accepted that society was a moral phenomenon and focussed his studies on groups rather than individuals. He wanted to show that society constituted a moral consciousness that was expressed in religion, in law, in the division of labour and in institutionalisation itself (Hughes, 1990:24). He attempted to prove this hypothesis, using the traditional methods of natural sciences, without reducing the moral and human nature of the social situation under investigation.

Durkheim (1985:21) stated that the social scientist must study social phenomena in the same state of mind as the physicist, chemist or physiologist when he probes into a still unexplored region of the scientific domain. He viewed a social environment in terms of cause and effect and the role of the sociologist as that of a physician. Like the physician who applies scientific findings to distinguish between sickness and health, diagnoses the cause of the sickness and develops remedial treatment for it, he uses scientific knowledge to diagnose or determine the cause of social problems and to develop solutions (Giddens, 1978:11).

Although there are many differences among positivist philosophers, such as Comte and Durkheim, Giddens (1974:2) identifies the following claims or perspectives that make up positivistic philosophy:

- Reality consists in what is available to the senses.
- Science constitutes a framework by which any form of knowledge can be determined.
- The natural and human sciences share common logical and methodological foundations, and methods of natural sciences can be applied in social sciences.
- There is a fundamental distinction between fact and value. Science deals with facts, while values belong to an entirely different order of discourse beyond the remit of science.

These philosophical assumptions led to the development of empiricism as research methodology for social research. Positivistic research methodology is discussed in section 2.3.1.

2.2.2 Interpretivism (phenomenological approaches)

People create and attach their own meanings to the world around them and to the behaviour they manifest in that world (Schutz, 1962:33). Phenomenologists call this world of created meanings and consciousness the "life world". They argue that, unlike atoms, molecules and electrons which have no meaning to each other, people do mean something to one another. These created meanings may be subjective, but they are an integral part of the subject matter of the social scientist. Lee (1999:347) argues that the study of the subjective meaning human subjects attach to behaviour, requires procedures that have no counterparts among those of the natural sciences. Interpretivism focusses on the world of meaning and methods of studying it.

The German philosopher Wilhelm Dilthey (1831-1911) moved away from a positivistic view of history towards an "irrational" understanding of life and history (Störig, 1959:197). According to Dilthey (1989a:66), it is not possible to understand the behaviour of people with reason only; it requires all our spiritual ability.

The above view was particularly important in the translation of Bible texts. One cannot apply linguistic rules only when translating Bible texts. Different parts need to be related in order to discover the original meaning of the wider social context in which they were originally produced. The translation of ancient texts requires an in-depth knowledge of the history and society of the time. The discipline, some calls it an art, of interpreting texts is known as hermeneutics (Kaiser & Silva, 1994:13). Hermeneutics is the discipline of searching for meaning.

Dilthey expanded these hermeneutic ideas to a relativistic view on history. He argued that "history was not simply the succession of events one after the another, but expressed the spirituality of social life as expressed in social institutions, law, literature, government, morality, values, and more" (Hughes, 1990:90). To study history and human behaviour, required a well-grounded method of inquiry different from positivistic methods. Hughes (1990:90) states that "The method recognises the actions, events and artefacts from *within* human life; not as the observation of some external reality". This is in sharp contrast to the positivistic method described in the previous section. According to Dilthey (1989b:80), one could only understand human behaviour through the apprehension of their inner meaning; the meaning that led to their production.

Today, hermeneutics is the interpretation of human and organisational behaviour. It is common to most interpretive approaches. The motivation behind it is that reading a text provides the model for reading human behaviour. To illustrate this, Lee (1999:17) gives an example. Consider the ten words in figure 2.1 and the sentences formed by these words.

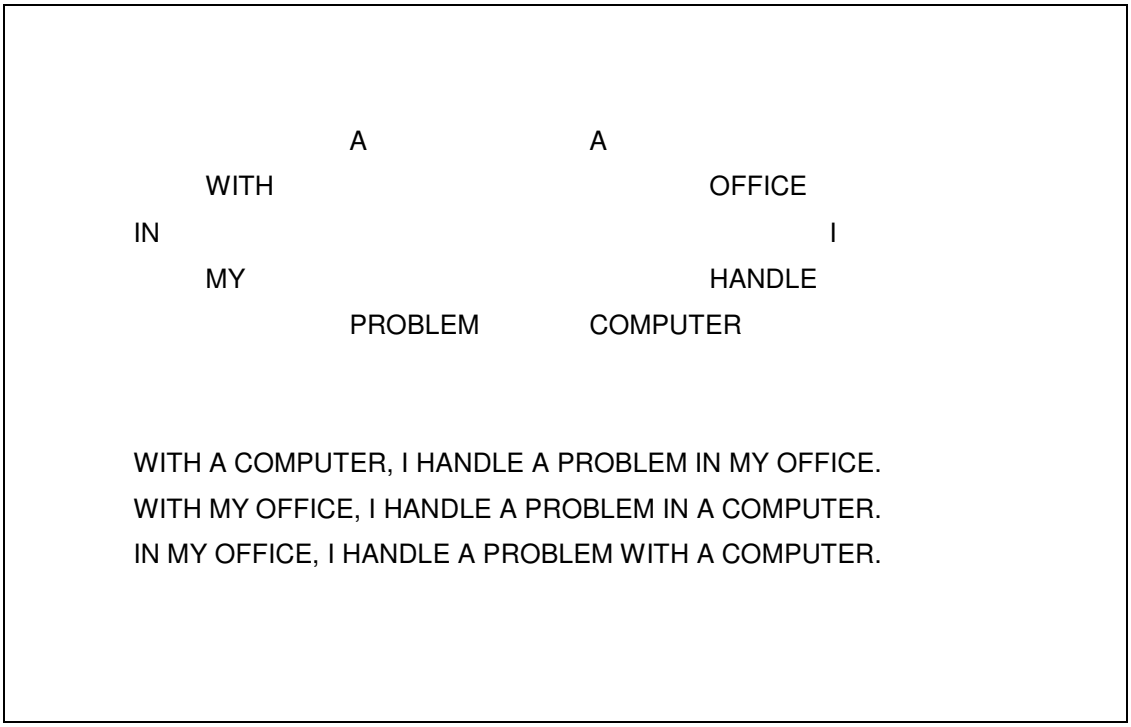


Figure 2.1 Reading a text as a model for reading human behaviour (Lee, 1999:17)

Although the same ten words are used in the three sentences in the figure, they each have a very different meaning. The meaning of an individual word and the meaning of a sentence as a whole are mutually dependent. A reader forms his/her understanding of both simultaneously. Lee applies the same method to human behaviour by arguing that the same publicly observable behaviour can have different meanings in different organisational arrangements. He states that "the meaning of an individual action and the meaning and the organisational setting as a whole are mutually dependent and, as an interpretive researcher, I form my understanding of both simultaneously".

Kuhn gives an illustration of this process (quoted in Bernstein, 1985:132). "When reading the works of an important thinker, look first for the apparent absurdities in the text and ask yourself how a sensible person could have written them. When you find an answer… when those passages make sense, then you may find that more central

passages, ones you previously thought you understood have changed their meaning." The process of switching between words and whole sentences to understand the meaning of the words in the context of the sentence, is known as the hermeneutic circle.

The same process is used to make sense of individual behaviour as part of organisational behaviour, or to make sense of an individual's single action as part of a behavioural pattern. The hermeneutic circle forms the basis of interpretive methodology used in social sciences. Interpretive methodology is discussed in section 2.3.2.

2.2.3 Critical social theory

Critical social research is underpinned by a critical–dialectical perspective, which attempts to dig beneath the surface of historically specific, oppressive, social structures (Harvey, 1990:1). Critical social theorists see knowledge as being structured by existing sets of social relations that are oppressive. This can be class, gender or race oppression. "Knowledge is critique… It is a dynamic process not a static entity…It is the process of moving towards the understanding of the world and of the knowledge which structures our perceptions of the world" (Harvey, 1990:3)

The first volume of *Capital* by Karl Heinrich Marx (1818-1883) is one of the first attempts to perform critical social research. Marx (1930) drew the attention of the world by highlighting the oppressive nature of capitalism. He identified economic processes as the underpinning of the oppression. From a philosophical point of view, Marx accepted the Hegelian dialectic, which stated that every thesis contains its own antithesis, its negation, opposite, or contradiction, and that the two conflicting forces merge to produce a synthesis, a new and greater reality (Sahakian, 1968:247). Marx applied this principle to socio-economic history and identified two conflicting classes (the bourgeoisie and the proletariat). He argued that there is a constant, irreconcilable conflict between these two classes, which can be resolved only when the proletariat revolts and overthrows the capitalist class, thereby establishing a classless society where all are equal; a dictatorship of the proletariat (Sahakian, 1968:248).

Midgley (2000:88) distinguishes between process philosophy and content philosophy: “Content philosophy presents a theory specifying exactly what counts as a knowledge generating system, while process philosophy allows for a variety of possible knowledge generating systems (with the proviso that there are sentient beings identified as part of them). Also content philosophy is mono-theoretical (proposing a single theory to account for the existence of knowledge), while process philosophy allows for theoretical pluralism in relation to many different possible first- and second-order boundary judgments that can be made”.

Midgley (2000:93) shows that Marx’s work can be seen as a process philosophy in that Marx is drawing boundaries around the economic and social bodies, effectively excluding the ecosystems of which societies are a part. Midgley (2000) also shows that Habermas and Foucault can be viewed as process philosophers. Midgley’s aim is to use systemic characteristics, such as boundary judgement, to form a methodology for critical social theory which he calls systemic intervention.

Giddens (1976:54) also identifies Habermas along with Gademer and Apel as influential in the development of critical social theory. The work of Jürgen Habermas is also discussed in chapter 3 as part of the discussion of philosophy as underpinning of critical systems thinking. Critical systems thinking can be directly linked to critical social theory.

Habermas aims to restore the value of direct and pure communication through language (Habermas, 1984:101). Language gives participants in debate the freedom to question the intelligibility, truth, rightness and/or sincerity of any statement. Habermas argues that economic forces have created a situation where pressures for instrumental reasoning are creating a distortion of local speech situations so that arguments around truth claims are still possible, but arguments about rightness have become marginalised (Midgley, 2000:95).

The work of Habermas can be seen as a reaction against the “scientisation of politics”, in which the laws of science is applied to politics. McCarthy (1978:1) states that Habermas’ “theory of society conceived with practical intent” emerges from extended reflections on the nature of cognition, the structure of social inquiry, the normative basis of social interaction, and the political, economic and socio-cultural tendencies of the age. This is done in opposition to positivistic methods that,

according to Habermas, conceals the scientist's commitment to technological rationality behind the façade of value-freedom.

Zygmund Bauman extended Habermas' ideas on critical hermeneutics in his work *Towards a Critical Sociology (1976)*. He states that emancipatory reason does not struggle with common sense but with the social reality that underlies it (Harvey, 1990:16).

In critique of Habermas, Turner (1987:161) argues that there are invariant properties in situations that Habermas and Marx cannot wish away with their utopias, referring to Habermas' utopian view of communicative action and Marx's utopia of economic equality. Giddens' structuration theory also accepts social and material constraints that any individual agent may be unable to change (Cohen, 1987:285).

Habermas' ideas are generally accepted as underpinning to current critical social research methodologies. Flood and Jackson (1991a:131) quotes Habermas (1974:32) on the relationship between theory and practice: "The mediation of theory and praxis can only be classified if to begin we distinguish three functions, which are measured in terms of different criteria; the formation and extension of critical theorems, which can stand up to scientific discourse; the organisation of processes of enlightenment, in which such theorems are applied and can be tested in an unique manner by initiation of processes of reflection carried on within certain groups towards which these processes have been directed; and the selection of appropriate strategies, the solution of tactical questions, and the conduct of political struggle."

Critical social research methodology is discussed in section 2.3.3.

2.2.4 Models applied to information systems

Before one can investigate the philosophy of information systems (IS) research, one needs to form an opinion on what IS is. In this thesis, IS is viewed as a social phenomena and the following definition is accepted: "Information systems is an inter-disciplinary field of scholarly inquiry, where information, information systems and the integration thereof with the organisation is studied in order to benefit the total system (technology, people, organisation and society)" (Du Plooy *et al.*, 1993:01). The acceptance of this definition also leads to a holistic view on Information Systems.

Information systems research is also classified as positivistic, interpretive or critical. Klein and Myers (1999:69) give guidelines for the classification of research methods. They argue that IS research is positivistic when there is evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from a representative sample to a stated population. One can classify IS research as critical if the main task is seen as one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light. Critical research seeks to be emancipatory in that it aims to help eliminate the causes of unwarranted alienation and domination and thereby enhances the opportunities for realising human potential (Klein & Myers, 1999:69). Finally, IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions, such as language, consciousness, shared meanings, documents, tools, and other artefacts. Interpretive research does not predefine dependent and independent variables but focusses on the complexity of human sense making as the situation emerges (Klein & Myers, 1999:69).

Walsham (1995a) studied the acceptance of interpretive methods in IS research. He describes interpretive research as studies where the researcher interacts with the human subjects of the enquiry, changing the perceptions of both parties. Walsham (1995a:378) quotes the senior editor for theory and research of *MIS quarterly* (DeSanctis, 1993:vii) who wrote: "On the empirical side, we welcome research based on positivist, interpretive, or integrated methods. Traditionally, *MIS Quarterly* has emphasised positivist research methods. Though we remain strong in our commitment to hypothesis testing and quantitative data analysis, we would like to stress our interest in research that applies interpretive techniques, such as case studies, textual analysis, ethnography and participant-observation."

Ngwenyama, Truex and Davis held a panel discussion on "Assessing Critical Social Theory Research in Information Systems" at the International Federation for Information Processing (IFIP) work group 8.2 meeting in 1997 (Boudreau, 1997:1). They described critical social theory's main goal as the improvement of human condition. Where traditional social theorists contribute to the preservation of the status quo, critical social theorists seek to emancipate people. It is assumed that all social knowledge is value laden, and that all scientific knowledge is a social construction. The panel stressed that traditional methods do not challenge reigning

assumptions. The panel accepted Habermas' ideas that there is no such thing as a set of methods for critical social theory, but the panel agreed that the method used should address the researcher's underlying assumptions, as well as those of the sponsor and the organisational actors. Action research and structuration theory can be used as methods for conducting critical social research in IS. A large number of papers using action research have been published in leading information systems journals, for example, Mumby (1987, 1988), Forester (1992, 1993), and Ngwenyama and Lee (1997). The *Management Information Quarterly* recently issued a call for papers to be published in a special issue, to generate standards for the use of critical social research methods in IS research.

Myers (1997:241) states that IS research can be classified as quantitative and qualitative. According to his classification, "**Quantitative research methods** were originally developed in the natural sciences to study natural phenomena. Examples of quantitative methods now well accepted in the social sciences include survey methods, laboratory experiments, formal methods (e.g. econometrics) and numerical methods such as mathematical modelling. **Qualitative research methods** were developed in the social sciences to enable researchers to study social and cultural phenomena. Examples of qualitative methods are action research, case study research and ethnography. Qualitative data sources include observation and participant observation (fieldwork), interviews and questionnaires, documents and texts, and the researcher's impressions and reactions."

Qualitative research can be done from a positivistic, interpretive, or critical social perspective. According to Myers (1997:241), "Qualitative" is not a synonym for "interpretive". The fact that qualitative methods are used, does not mean that the research is interpretive. He argues that action research can be positivistic (Clark, 1972), interpretive (Elden & Chisholm, 1993), or critical (Carr & Kemmis, 1986).

2.3 Methodologies in social research

Methodology can be viewed as the interface between methodical practice, substantive theory and epistemological underpinnings (Harvey, 1990:1). Harvey argues that, although certain data collection methods lend themselves more towards positivistic, interpretive or critical epistemological perspectives, the methods are not inherently positivistic, interpretive or critical. It is therefore an oversimplification to

relate all quantitative research methods to positivistic methodology and all qualitative methods to interpretive methodology. Methodology is discussed as a foundation for research practice. It is shown that practices cannot simply be merged without considering the methodological differences between these practices. Since this study proposes such a merged strategy, it is important to show that methodological issues were investigated.

2.3.1 Positivistic social research methodology

This section begins with a short description of the most frequently used terminology in positivistic research methodology.

In a prescribed work to human sciences students called *Empirical Research Methods for the human sciences* by Behr (1983:5); research is defined as "the systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relationship among natural phenomena." In this definition, the term empirical means that which is verifiable through observation. A hypothesis is a statement about the relation between two variables, which implies that its truth can be tested and which can be accepted or rejected at a certain level of probability.

Sampling is used to reduce the size of the population to a manageable number. The size of the sample depends on the nature of the problem and the aim is to obtain the minimum sample size that will accurately represent the population being surveyed. Results obtained from the sample are valid (to a certain degree of probability) for the population as a whole if the sample is large enough.

Statistical measurements such as mode, median, mean and standard deviation are used to analyse data. Correlation and regression are used to analyse relationships in the data.

Empirical methods are most important in acquiring new knowledge in positivistic philosophies. They require observation of data that is free of judgement, interpretation or other subjective operations. Hughes (1990:36) states that "positivists argued that the basis of science lies in a theoretically neutral observation language with is both ontologically and epistemologically primary. That is, statements

made in this privileged language are directly verifiable as true or false by simply looking at the 'facts' of the world."

Logical positivism added a logical character to the empirical. Mathematics can be used to add structure to the empirical facts. Statements are true or false depending on the manipulation of symbols. The role of logical manipulation in science increased and many of the best theories can be applied across many different test situations. Popper's theory of falsification (1957) played a very important role in the development of scientific method. According to Popper, theories can only be proven to be false and good theories are those that withstand various attempts to disprove them.

Requirements for objective observation of the natural sciences had to be adapted in order to succeed in the social sciences. Some human traits, such as mental state, are impossible to observe with natural science's objective observation methods. However, a person's mental state does lead to certain outward behaviour, such as smiling, clenching of fists and wide-eyed glaring. Mental phenomena could then be observed by studying the corresponding outward behavioural display which is used as an index of different mental states. Hughes (1990:40) argues that this approach is successful for simple mental states, such as anger, pleasure and pain, but more sophisticated mental states, such as desire for wealth or status, or the belief in democracy, posed difficulties for such an approach. The observer needed other tools to report on the values of people. These tools, such as attitude scales and questionnaires, still allowed the observer to be objective in his/her observation of value-based phenomena.

Tools, such as variables and Lazarsfeld's indicators, were used to form a scientific language for social research. The language of social science observation had to consist of terms objectively defined and had to be generalisable and, if possible, quantifiable (Hughes, 1990:41).

A discussion of Behr (1983:10) on the problems and limitations peculiar to empirical research in the human sciences is quoted in totality to ensure accuracy: "It needs to be pointed out that research in the human sciences (education, criminology, psychology, social work, etc.) cannot be carried out with the same precision as in the case of the natural sciences. In the human sciences, unlike the natural sciences, the

research worker has to be content with many variables that interact with one another in subtle and diverse ways."

This is not a complete discussion on positivistic social research methodology. The study reported on in this thesis, does not involve any positivistic research methodology and the above discussion is included only to illustrate the influence of positivistic philosophy on empirical research methodology.

2.3.2 Interpretive social research methodology

The award winning paper of Klein and Myers (1999:67) on principles for conducting and evaluating interpretive field studies in information systems, became the accepted standard for interpretive research in information systems. This section on interpretive social research methodology focusses on the work of Klein and Myers (1999). Their principles are summarised in table 2.1. Klein and Myers (1999) stress that case study research is not automatically interpretive; it can be positivistic, interpretive or critical. They repeat the argument for action research, referring to Clark (1972) as positivistic, Elden and Chisholm (1993) as interpretive and Carr and Kemmis (1986) as critical. The seven principles that identify case study research as interpretive are now discussed individually.

1	**The fundamental principle of the hermeneutic circle** This principle suggests that all human understanding is achieved by iteration between the interdependent meaning of parts and the whole they form. This principle of human understanding is fundamental to all the other principles.
2	**The principle of contextualisation** Requires critical reflection on the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.
3	**The principle of interaction between the researchers and the subjects** Requires a critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and the participants.

4	**The principle of abstraction and generalisation** Requires relating the idiographic detail revealed by the data interpretation through the application of principles one and two to the theoretical general concepts that describe the nature of human understanding and social action.
5	**The principle of dialogical reasoning** Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tells") with subsequent cycles of revision.
6	**The principle of multiple interpretations** Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the sequence of events under study. They are similar to multiple witness account, even if all tell it as they saw it.
7	**The principle of suspicion** Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.

Table 2-1 Summary of principles for interpretive field research (Klein & Myers, 1999:72)

2.3.2.1 The fundamental principle of the hermeneutic circle

Hermeneutics as philosophy was discussed in section 2.2. The hermeneutic circle depicts the interaction between the whole and its parts. It focusses on the constant movement between the individual parts and the whole. In case study research, the whole consists of the shared meanings from the interactions between the researcher's and the participants' understanding of the problem situation. The parts are the individual understanding of the researcher and the participants of the problem situation.

2.3.2.2 The principle of contextualisation

Contextualisation is the process of understanding the historical context of the current situation. The reason why the interpretive researcher studies the context differs from the positivistic search for repeating patterns, since the interpretive researcher believes that the organisation is dynamic. A better understanding of the current situation is achieved by studying the road that was taken by the organisation to reach the present state. The historical context must be reflected in the results of the case study research.

2.3.2.3 The principle of interaction between the researchers and the subjects

Data are produced as a result of the social interaction between the participants and the researcher. The participants are, just as the researcher, interpreting the events they account for. The researcher should be aware of this and compensate by using secondary sources, for example historical documentation, to verify the interpretation of specific concepts. The researcher should be aware of the fact that the interaction between himself/herself and the participant may also change the interpretation of the participant. The researcher might, just by asking a specific question, alter the participant's perception of the situation under investigation.

2.3.2.4 The principle of abstraction and generalisation

Theoretical abstractions are made from individual events. Walsham (1995b:77) refers to grounded theory, developed by Glaser and Strauss (1967), as a method to be used in the generalisation of case study data. Grounded theory is discussed in detail in section 2.4.2.3. Other methods include Latour's actor-network theory and Giddens' theory of Structuration. Giddens' theory of structuration is discussed briefly in section 2.4.2.4. The methods proposed by Yin (1994) as described in section 2.4.2.1, may also be used to achieve generalisation.

2.3.2.5 The principle of dialogical reasoning

This principle requires the researcher to confront his/her own preconceptions and prejudices that guided the original research plan. The researcher must be aware of his/her own history that led to the specific research design. This principle also requires the researcher to identify the specific form of interpretivism he/she prefers and the philosophical foundations thereof.

2.3.2.6 The principle of multiple interpretations

The researcher should identify multiple interpretations by different actors in the organisation and the reasons behind them. Although contradictions are not always present, the researcher should be sensitive to conflicting interpretations. The researcher needs to probe beneath the surface.

2.3.2.7 The principle of suspicion

This principle requires even further critical thinking in that the researcher should be aware of the socially created distortions and psychopathological delusions. The power struggle in the situation should be identified. The actors in the situation are limited by social structures and economic conditions in reaching their goals. These limitations should be exposed by the researcher.

Klein and Myers (1999:78) stress that the above principles are parts of a whole and should be viewed collectively, as well as individually. The research results affect the role of each individual principle in the research design. The realisation of these principles in the study reported in this thesis, is described in section 2.5.

2.3.3 Critical social research methodology

Critical social research methodology describes methods based on the changing of oppressive structures. It regards positivistic scientific method as unsatisfactory because it deals with surface appearances only, while critical social theory aims to cut through these surface appearances (Harvey, 1990:19). In this section, the general elements of critical social theory are discussed, followed by some notes on intervention.

Although critical social research is verified in different methods, shared elements can be identified. Harvey (1990:19) identified the following elements: abstraction, totality, essence, praxis, ideology, structure, history, and deconstruction and reconstruction. These elements should not be viewed as discrete units but rather as parts of a process that relies on all the elements. This discussion follows Harvey (1990).

2.3.3.1 Abstraction

In methods following an interpretive approach, science begins with factual interpretations and abstractions from them. Theories are based on reality. Critical social theory accepts that facts cannot exist independently from reality and works from abstract to concrete. It starts with abstract generalisations and then investigates them in reality. It involves an understanding of the general use of a concept, as well as a study into the underpinning structures which specify the nature

of the abstract concepts. It aims to reveal underlying structures that are otherwise taken for granted. These structures specify the nature of the abstract concepts which have themselves been assimilated uncritically onto the prevailing conceptualisation.

2.3.3.2 Totality

Totality refers to the view that social phenomena are interrelated to form a total whole. Social phenomena should not be investigated in isolation but always as part of a larger context. In a research environment, the researcher aims to relate the empirical detail to a structural and historical whole. This implies three things: that social relations are history specific, that there are structural relations that operate within that historical moment and finally, that the determinacy of historical specific structure and phenomenal forms are interrelated.

2.3.3.3 Essence

Essence refers to the fundamental element of the analytical process. Positivistic research views essence as bordering on the metaphysical, while interpretive research seeks the essence in the understanding of the interactive processes. Critical social researchers view essence as a fundamental concept that can be used as the key to unlocking the deconstructive process.

2.3.3.4 Praxis

According to Harvey (1990:22), praxis means practical reflective activity. It is activity that changes the world. The critical social researcher is not only interested in understanding the world; he/she aims to change the world. It is not the actions of an individual that is of interest but rather the actions that change the social formations. The individual subjects are studied for their potential for developing group action. Knowledge changes not simply as a result of reflection but as a result of action. Knowledge is not static, since we transform our knowledge through what we do; it exists in our everyday lives.

2.3.3.5 Ideology

The ideology of social structures is more than the norms and values of the individuals of the social structure. Two different views of the nature of ideology exist, i.e. a positive and a negative view. It can be seen as the *Weltanschauung* or the worldview

underlying the social structure. The positive view of ideology sees it as false consciousness which hides the interests of dominant groups from themselves. Ideology can be engaged and transcended. According to the negative view of ideology, it cannot be detached from the material conditions of their production; it is constantly reaffirmed through everyday practice. The nature of the ideology needs to be revealed by the researcher through the identification of the essence of social relations and the separation of this essence from structural forms through a process of dialectical deconstruction and reconstruction.

2.3.3.6 Structure

Structure is seen by the critical social researcher as more than the sum of the elements. It is viewed holistically as a complex set of interrelated elements which are interdependent and which can be conceived adequately only in terms of the complete structure. This implies that parts conform to intrinsic laws which determine the nature of the structure and the parts. The structure is thus capable of transformational procedures. Being self-regulating, the structure makes no appeals beyond itself to validate transformational procedures. Harvey (1990:25) uses language as an example of such a structure. It is a relational whole with grammatical rules which can transform fundamental sentences into a wide variety of forms, while retaining them within its structure and transforming them with no reference to an outside reality.

2.3.3.7 History

According to Harvey (1990:26), history refers to both the reconstructed account of past events and the process by which this reconstruction is made. The view of the nature of history influences the constructed history. Following the discussion on abstraction, critical social research involves the grounding of a generalised theory in history, as well as the exposure of the essential nature of structural relations which manifests them historically. The construction of history is seen as the result of an active interpretation of the available archaeological, documentary, or oral evidence. Critical research history is not so much interested in the historical facts as in the circumstances within which it occurred. It investigates the social and political contexts, addresses the economic constraints and engages the taken-for-granted ideological factors. It also takes the situation of the researcher into account.

2.3.3.8 Deconstruction and reconstruction

The critical researcher aims to deconstruct the situation into abstract concepts in order to study the interrelations between the concepts with the purpose of discovering the key to the structure of the situation. It is a constant process of moving backwards and forwards between abstract concept and concrete data; between social totalities and particular phenomena; between current structures and historical development; between surface appearance and essence; between reflection and practice (Harvey, 1990:31). The researcher is constantly aiming beyond surface appearances. The core concept is identified through the deconstruction of the problem situation into concepts through investigation of the different elements of the situation. The core concept is used to reconstruct the situation. If this reconstruction does not fit reality, further analysis of the core concept is needed. A study of the essence and history of the structures in the situation leads to the identification of the core concept. This is an ongoing process to expose the ideology underpinning the situation in order to identify the oppressive mechanism, which requires change.

2.3.3.9 Intervention

Although Harvey (1990) does not explicitly refer to the term intervention, it can be associated with the term of praxis. The purpose of critical research is to enable the researcher to intervene in an oppressing situation. The above discussion of the critical social theory, based on the work of Harvey (1990), is very much focussed on the emancipatory actions of the researcher in an oppressing situation (class, gender or racial oppression). Midgley (2000) uses an approach of systemic intervention which includes similar elements (although not identified as such) to bring about positive changes in situations. His work is based on the philosophy of Habermas and forms a methodology for change in problem situations.

2.4 Social research practice

From philosophy and methodology one moves to research practice. This section aims to describe typical research practices in positivistic, interpretive and critical social research. The specific problem situation of this thesis is taken into account

and serves as indicator to the level of detail given on practices from the three different perspectives.

2.4.1 Positivistic social research practice

This section contains a very brief discussion on positivistic research practice. Because the researcher accepts the social approach to information systems, the use of quantitative methods is unlikely. However, some discussion is necessary to aid the argumentative flow of the chapter.

Interviews can be used in positivistic research practice, but Behr (1983:146) points out that there is no room for debate and arguments between the interviewer and the subject. Behr (1983) argues that "one of the main disadvantages of this approach [unstructured interviews] is that it is difficult to compare the data obtained from the various respondents so as to arrive at reliable generalisations. Nevertheless, an experienced interviewer can use this approach to great advantage."

Behr (1983:150) states that the questionnaire technique is the main source of data collection in research studies in education. A questionnaire is a document distributed to the respondent and completed and returned by himself/herself in his/her own time. Questions should be carefully designed to assure statistical usability of the answers. Various statistical tools, such as Likert-type scales ("strongly agree", "agree", "undecided", "disagree", "strongly disagree"), are used to assess the respondent's attitude towards a specific statement. Statistical measures, such as mean and variance, are used to analyse the data. Good questionnaires include crosscheck questions to test the consistency of the respondent on a specific issue.

The key difference between positivistic research practice on the one hand and interpretive and critical social research practice on the other hand, is the objectivity of the researcher. Positivistic research practice requires and is designed to ensure that the researcher is objective in his research activity. This implies that the researcher does not influence the research environment in the data collection activity. Interpretive methods allow for the personal interpretations of the researcher, and the researcher is encouraged to learn as much as possible from the research environment in order to give a reliable interpretation of the environment. Critical researchers are not only interpreting the data in the environment but are also

designing and affecting change in the problem environment (typically an organisation).

Another key difference between positivistic research practice and the other two approaches is the reduction of the problem situation through sampling. Positivistic methods assume that a sample, if carefully selected, represents the population, while interpretive and critical methods study the problem situation as a whole.

2.4.2 Interpretive social research practice

This discussion of interpretive social research methodology focusses on case study research. This is mainly because the researcher has chosen case study research for the specific research problem, but also because it is the most commonly used qualitative research method in information systems (Orlikowski & Baroudi, 1991). Case study research practice is discussed with acceptance of the principles for conducting interpretive field studies (Klein & Myers, 1999) as discussed in the previous section. The section begins with a discussion on the data collection and analysis practices in case studies (mostly according to the paper by Walsham (1995b) on case studies in IS research). A short discussion of ethnography is given for argumentative purposes. Since theory generation is central to science, generalisation is a central part of interpretive research practice. Grounded theory is discussed in detail as generalisation method. An application of Giddens' structuration theory is discussed briefly.

2.4.2.1 Case study research practices

The researcher has to decide on his/her role in the organisation under study. The researcher can choose to be an outside observer, or can play an active role in the organisation through participant observation or action research. In neither of these roles should the researcher be seen as objective, since the collection of data involves the researcher's own subjectivity (Walsham, 1995b:77). Walsham further argues that the researcher, irrespective of the selected role, influences the interpretations of those being researched. In this study, the researcher chose to be an outside observer and this discussion will be focussed on this type of case study.

The role of an outside observer has advantages and disadvantages. The personnel in the field organisation view the researcher as an outsider. The researcher does not have any personal stake in the outcome of the investigation, and this opens up the communication channels. The main disadvantage of the role as outside observer, is that one is not always present in the organisation.

Data collection

In interpretive case studies, interviews are the main source of data collection. Other data sources include documentation, direct observation, and physical artefacts. The design of the interviews for the case studies of this study is discussed in section 2.5.3.1, considering practical aspects with regard to this study. Walsham (1995b:78) states that interview style varies between individuals, depending on personality, but one key issue for all interviewers is the balance to be struck between excessive passivity and over-direction. A key decision needs to be taken on the data capture methods used in the interviews. Tape recordings of the interviews are recommended, if acceptable to the management of the organisation. However, the presence of the equipment can intimidate the participants. The purpose of the recording should be made clear at the start of the interview.

The selection of interviews in the organisation and the order of the interviews are crucial to the success of the case study. Lubbe (2003:20) gives the following practical advice in terms of field procedure:

"1. Find at least three informants for each case study. This is for the purpose of validation.
2. At least two informants should be senior managers, i.e. individuals who are either a member, or reporting directly to, the board of directors or similar.
3. Obtain access to informants through a trusted intermediary wherever possible.
4. Make initial contact with the subject organisation at the highest level possible.
5. Find a friendly gatekeeper or guide as soon as possible.
6. Tape-record all interviews.
7. Support verbal information with documentary evidence where possible.
8. Attempt to secure multiple interviews per site to reduce travelling time.
9. Attempt to interview informants in their offices rather than interview rooms.
10. Engage as many members of the staff as possible, such as secretaries and support people, in general conversation about the organisation."

The next decision to be taken by the researcher is to decide what to report about each case study. Lubbe (2003:22) recommends the following:

"1. Introduction and general background of the organisation
2. The state of IT within the organisation
3. The reasons for the current decisions
4. The implementation of the IT decision"

Walsham (1995b:79) recommends the following to report on:

"1. Detail of the research sites chosen and reasons for this choice
2. The number of people that were interviewed
3. What hierarchical positions they occupied
4. What other data sources were used
5. How data was recorded
6. How the data was analysed
7. How the iterative process between data analysis and theory generation worked"

These recommendations of Walsham (1995b) are followed in the case study report presented in chapter 5.

Data analysis

After the collection of data during the case study, the researcher needs to analyse the data gathered. Yin (1994:102) argues that analysis of interpretive case study data depends on an investigator's own style of rigorous thinking, along with the sufficient presentation of evidence and careful consideration of alternative interpretations. He proposes the following techniques for the analysis of case study data:

1. Put information into different arrays.
2. Make a matrix of categories and placing the evidence within such categories.
3. Create data displays – flowcharts and other devices - for examining the data.
4. Tabulate the frequency of different events.
5. Examine the complexity of such tabulations and their relationships by calculating second-order numbers such as means and variances.
6. Put information in chronological order or using some other temporal scheme.

Yin (1994:103) advises the researcher to have a strategic plan for data analysis prior to the data collection phase. He advocates two broad strategies for the analysis of case study data. The first strategy is to rely on theoretical propositions. These propositions are the literature that motivated the researcher to investigate a specific problem environment. The propositions help to focus attention on certain data and to ignore other data. The second strategy is to develop a case description. A descriptive framework is developed to organise the case study data. Yin (1994:104) argues that the description might help to identify the causal relationships that need to be highlighted.

After selecting a strategy, one needs to select a practical method for analysing data. Such methods include pattern-matching, explanation building, time series analysis and program logic models. Only pattern-matching is described here, since the approach chosen by the researcher reflects this method.

Yin (1994:106) states: “For case study analysis, one of the most desirable strategies is to use a pattern-matching logic.” In pattern-matching, the observed data is compared with a predicted pattern (or several alternative predictions). If the patterns coincide, the results can help a case study strengthening its internal validity. Yin (1994:106) further explains pattern-matching in terms of dependent and independent variables, which are categorised as positivistic methods in this thesis. The second analysis method quoted above, namely “Making a matrix of categories and placing the evidence within such categories”, is viewed by the researcher as a method to achieve pattern-matching.

The researcher further investigated the suitability of ethnography as an alternative method of data collection in interpretive social research.

2.4.2.2 Ethnography

According to Agar (1980:79), the goal of ethnography is to reduce the gap between the researcher’s account of the situation and that of a participant in the situation. This implies that the researcher wants to understand and interpret the situation in the same way as the participant would. This can only be achieved through extended personal involvement.

The emphasis is on the role of the researcher. In traditional hypothesis-testing type research methods (called positivistic methods in this thesis), the researcher is seen as an objective observer. Most often there is very little personal contact between the researcher and the participants. This may be because the data is gathered by questionnaires, or because representatives of the researcher are conducting standard interviews. In hypothesis-testing interviews, it is important to use the same interview questions and the same interview environment for all the respondents to enable the researcher to compare the data collected. In this situation, the researcher is in a controlling relationship with the participant.

This control factor of the relationship changes dramatically in ethnographic studies, where the role of the researcher is that of a student or child. The researcher wants to learn from the participants about the situation by becoming a part of the community. Agar (1980:75) argues that the researcher aims to understand the situation as a whole. This holistic approach inspires the researcher to identify connections and relationships in the situation. The researcher is continuously improving his/her understanding of the situation by comparing events to his/her interpretation of the situation and making necessary adjustments. The relationship between the researcher and the participants grows into friendship as trust develops.

The researcher wants to understand a situation to such a degree that he/she is able to "behave appropriately in the community" or "inappropriately" if he/she chooses to do so (Agar, 1980:77). This understanding is achieved through paraphrasing the events in the situation. Agar (1980:79) expresses paraphrasing as, "We are talking about decode rather involved sequences of verbal and nonverbal behaviour, and then encode our understanding of the meanings of that sequence into some utterances to check whether we understood what just occurred. It is in this special sense that I speak of giving account."

Ethnography has been used in information systems research by Orlikowski (1991). Klein and Myers (1999:79) aimed their set of principles for conducting and evaluating interpretive field studies in information systems (IS) not only at case study research, but also at ethnography studies.

2.4.2.3 Grounded theory

The theory generation mechanism is the most important decision the interpretive researcher takes in the research design. The following three sections discuss possible methods to be used in the theory generation process.

Grounded theory is an attempt to develop a methodology (or set of methods) to organise data, gathered during an ethnographic study, into a theory.

Glaser and Strauss first described grounded theory (GT) in 1967. The aim of GT is to develop a theory from data rather than gathering data to test a theory or hypothesis. This means that qualitative methods are used to obtain data about a phenomenon and that a theory emerges from the data. Since this is qualitative research, the research problem is not stated precisely or in terms of dependent and independent variables. The first description of GT should be seen as a methodology for arriving at a grounded theory from data. The theory is grounded in the reality as represented in the data.

Since the first description of GT, Glaser and Strauss worked on separate implementations of their methodology. Strauss and Corbin (1990, 1998) developed a detailed description for the development of a grounded theory. Glaser (1992) criticises their approach as forcing a theory from the data and therefore preventing the natural emergence of the theory from the data. Strauss and Corbin (1990, 1998) give guidelines (techniques and procedures) for the inexperienced researcher to get the most from the data but stress that they are only tools and should never drive the analysis.

Every researcher who chooses to use GT as a research methodology, should investigate this divergence between the founders of GT critically (Smit, 1999:221; Goulding, 1998:56). It is the opinion of the researcher that the methods of Strauss and Corbin can be very helpful to organise one's data and to strengthen the scientific value of the emerging theory. However, coding procedures should not overshadow the influence of creativity of the original GT concept. It is clear that Strauss and Corbin (1998) took the critique of Glaser to heart in producing the second edition of their monograph on the procedures and techniques of GT in 1998. They warn their readers against the rigid application of their guidelines (for example see pp 129, 142 of Strauss & Corbin (1998)).

The procedures of Strauss and Corbin will be discussed to give the reader an understanding of the relevant issues when using GT as research method for the research of reflections on systems thinking in IS practices.

Procedures for creating a grounded theory

A theory is defined by Strauss and Corbin (1998:22) as "a set of well-developed categories (e.g. themes, concepts) that are systematically interrelated through statements of relationship to form a theoretical framework that explains some relevant social, psychological, educational, nursing or other phenomenon". Grounded Theory was also developed to aid qualitative researchers to perform "good science". Strauss and Corbin (1990:27) states that well performed GT meets all the requirements of "good science": significance, theory-observation, compatibility, generalisability, reproducibility, precision, rigor, and verification. Coding is the central method in the transformation of the data to a theory. Coding is defined as the analytic process through which data are fractured, conceptualised, and integrated to form theory (Strauss & Corbin, 1998:3). Its aim is to identify, develop and relate the concepts that are the building blocks of theory. Strauss and Corbin (1990) identify three different types of coding to transform data into a theory that is grounded in reality, i.e. open coding, axial coding, and selective coding, all of which will be discussed in the following paragraphs. The different types of coding are done simultaneously and the division between them is an artificial way of explaining the process.

Open coding

Open Coding is the analytic process through which concepts are identified and their properties and dimensions are discovered in data. To be able to identify the concepts (labelled phenomena), we have to open up the text and expose the thoughts, ideas, and meanings contained therein (Strauss & Corbin, 1998:102). A concept should be viewed as an abstract representation of an event, object, or action/interaction that a researcher identifies as being significant in the data. Concepts are compared with each other.

Categories emerge from similar concepts that have similar properties. Properties are characteristics that are common to all the concepts in the category. The properties of

the concept “flower” can be size, duration, colour, shape, etc. The categorisation of concepts into categories is an abstraction process. The researcher can give names for categories, but it can also come from the words of the respondents. However, it should be a logical descriptor of the reality (Strauss & Corbin, 1998:114). The following quote from Strauss and Corbin (1998:105) on the identification of categories is vital to later arguments presented in this chapter: “We want to see new possibilities in phenomena and classify them in ways that others might not have thought of before (or, if considered previously, were not systematically developed in terms of their properties and dimensions).”

The categories should be grounded. This implies that they are formed from evidence in the research situation. Literature may be used to add new categories, but such categories will be labelled as preliminary until they can be verified by the data and thus be grounded in reality. The interpretation of events by the researcher influences the naming of categories (Strauss & Corbin, 1998:127).

Dimensions represent the location of a property along a continuum or range. The dimensions of the size property of the flower category can be from small to large and of the colour property can be different shades or intensities. Categories give us a method for comparing different incidents. Incidents are compared in terms of properties and dimensions. Categories can be divided into subcategories that answer questions about categories like what, when, where, who, how, and with what consequences. The relationships between categories will be studied to form theories.

Axial coding

Axial coding is defined by Strauss and Corbin (1998:124) as “the process of relating categories to their subcategories, termed “axial” because coding occurs around the axis of a category, linking categories at the level of properties and dimensions”. The purpose of axial coding is to reassemble data that were fractured during open coding (Strauss & Corbin, 1998:124). This is achieved by refining information about each category and its subcategories. The conditions, actions/interactions, and consequences associated with the phenomenon (or category) are identified to describe the context (structure) and the process of a phenomenon. Since a category is a coded form of a phenomenon, it can be seen as a representation of a pattern of happenings, events, or actions/interactions which can be described by conditions, actions/interactions and consequences.

Conditions explain the situation or context in which a phenomenon occurs. Conditions can be causal, intervening, and contextual. Contextual conditions are the specific sets of conditions (causal and intervening) that intersect dimensionally at this time and place, to create the set of circumstances or problems to which a person responds through actions/interactions.

Actions/interactions are the answers to the question of how people handle the conditions. Strategic actions are actions that are purposeful in solving a problem and thereby shape the phenomenon. Routine actions represent every day responses to situations. Both these types of actions need to be investigated to gain full understanding of how people maintain the social order (Strauss & Corbin, 1998:133).

Irrespective of whether action is taken in response to a problem situation or not, there are always consequences. Some of these consequences are intended and others not. The consequences and their changing of the phenomenon need to be described in order to understand a phenomenon completely. Consequences have properties such as duration, visibility, impact, predictability, and scope.

Axial coding is about finding relationships between categories and subcategories. These represent links between concepts in the research situations. Hunches or "hypotheses" of the researchers about how concepts are linked, are stated. These relations should now be validated against the data from the actual incidents to determine if they can be grounded in reality. Contradictions between reality and the hypothesis help us to refine our description of the category by refining the conditions, actions/interactions, and consequences of phenomena.

Selective coding

Selective coding is the process of intergrating and refining the theory (Strauss & Corbin, 1998:145). Categories are only descriptions of data and are not yet a theory. Various categories need to be integrated to form a theory. The first step is to decide on a central category that represents the main theme of the research. One needs to find an intersection between all the important categories in the research. Strauss and Corbin (1998:147) give the following criteria for choosing a central category:

"1. It must be central; that is, all other major categories can be related to it.
2. It must appear frequently in the data. This means that within all or almost all cases, there are indicators pointing to that concept.
3. The explanation that evolves by relating the categories is logical and consistent. There is no forcing of data.
4. The name or phrase used to describe the central category should be sufficiently abstract that it can be used to do research in other substantive areas, leading to the development of a more general theory.
5. As the concept is refined analytically through the integration with other concepts, the theory grows in depth and explanatory power.
6. The concept is able to explain variation as well as the main point made by the data; that is, when conditions vary, the explanation still holds, although the way in which a phenomenon is expressed might look somewhat different. One also should be able to explain contradictory or alternative cases in terms of that central idea."

There are several techniques to determine the central category. These include writing the storyline, making use of diagrams, and reviewing and sorting memos, either by hand, or by computer program. When the central category is described, for example by writing a storyline, the gaps in the theory are exposed. Refining the coding of major categories should fill these gaps. The aim is to write a story to which incidents in the data can be fitted. The story can only become a grounded theory when data representing incidents in reality, can be fitted to the story. Cases that do not fit the storyline should be explained in terms of intervening conditions. Discovering outlying cases and building explanations for them into the theory, increase its generalisability and explanatory power.

Sampling

The discussion on grounded theory is closed with a short discussion on sampling procedures. Theoretical sampling is defined by Strauss and Corbin (1998:210) as "data gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons,' whose purpose is to go to places, people, or events that will maximise opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions".

During open coding, sampling should be done as wide as possible to enable researchers to be open to discover concepts in the situation. Although sampling should be done systematically, the researcher must be flexible enough to code any event that he/she finds relevant to the study. During the study, the researcher should question and compare the data continuously. The answers to the researcher's questions will lead to further sampling and the coding of more incidents. During axial coding, sampling is done to define the dimensions and properties of the categories, as well as to define the subcategories and their relationships to the categories. During selective coding, sampling is used to strengthen the theory. Incidents are tested to fit the theory, and the theory is refined until the categories are saturated. This means that more coding does not alter the description of the categories.

It should be noted that sampling could not be planned in detail before the start of the field study. It is central to GT to discover a theory in the data and not to test a prewritten hypothesis by gathering appropriate data. It is not persons or organisations that are sampled but incidents and events. Although sampling during the beginning of the project is rather unfocussed, it will become more focussed as the project progresses. Sampling will only end when all the categories are saturated.

2.4.2.4 Giddens' structuration Theory

For purposes of generalisation, Orlikowski (1992:398) describes Giddens' (1984) theory of structuration, which questions the objective-subjective dimension in social and organisational investigation. Giddens proposes a dualism between objectivism and subjectivism. The theory of structuration recognises that human actions are enabled and constrained by structures, yet that these structures are the result of previous actions. Actors are seen as knowledgeable and reflexive (observe and understand what they are doing and why they do it) but also restricted by their situation.

The actions of human actors become practices over time and are institutionalised as structures. When institutionalisation occurs, problems or difficulties with these structures are identified, perhaps by other actors in the organisation's specific situation, which will lead to alternative practices forming new structures. This creates a dualism between objective structural features of organisations and subjective knowledgeable actions of human agents.

Orlikowski (1992:412) studied a software development organisation that employed external consultants to apply Giddens' theory to software development and evaluate the results. The organisation decided to design tools according to current practices in the firm to increase productivity and quality control. These tools were not well accepted by all consultants and some of them bypassed the tools because of their so-called restrictiveness. New employees saw the tools as the way the task had to be performed, in fact as the only way to do their jobs. Eventually some of the longer serving employees rebelled against the use of the tools, and consequently the tools were changed to represent the practices of the consultant more closely. These, in time, became the structure or method to be followed in the organisation.

The applicability of these generalisation strategies to the research problem under investigation, will be discussed in section 2.5.

2.4.3 Critical social research practice

As stated earlier, different methods can be applied from different philosophical perspectives. Action research can be applied from a positivistic, interpretive or social philosophical perspective. In this section it is viewed from a critical perspective.

2.4.3.1 Action research

The historical development of action research

Kurt Lewin first developed action research in the late 1940's. He focussed his research on the natural setting of the problem situation. Lewin conceptualised social change as a three-stage method: dismantling former structures (unfreezing) changing the structures (changing) and locking them back to the permanent structure (freezing). This implies a stable state prior and after the intervention or change phase (Greenwood & Levin, 1998:17). Lewin (1948) argued that one could only understand the inner structure of a social system by trying to change it. Lewin's work assisted the Norwegian efforts to improve working conditions.

During the same time, similar work was done in the Tavistock Institute of Human Relations in London. Trist and Bamforth did a study in 1951 on the relationship between technology and productivity at British coal mines. Lewin joined the

Tavistock group and inspired many research projects aimed at social change in the workplace.

What is action research?

Blum (1955:1) identified two stages in action research. During the diagnostic stage, the researcher and the subjects of the research study the social situation together. The diagnostic phase is followed by the therapeutic phase that involves collaborative change experiments. Changes are designed and introduced, and the results are studied to introduce more changes to improve the situation.

Baskerville (1999:6) describes four major characteristics of IS action research:

"1. Action research aims at an increased understanding of an immediate social situation, with emphasis on the complex and multivariate nature of the social setting in the IS domain.
2. Action research simultaneously assists in practical problem solving and expands scientific knowledge. This goal extends into two important process characteristics: First, there are highly interpretive assumptions being made about observation; second, the researcher intervenes in the problem setting.
3. Action research is performed collaboratively and enhances the competencies of the respective actors. A process of participatory observation is implied by this goal. Enhanced competencies (an inevitable result of collaboration) are relative to the previous competencies of the researchers and subjects, and the degree to which this is a goal, and its balance between the actors, will depend upon the setting.
4. Action research is primarily applicable for the understanding of change processes in social systems."

Baskerville and Pries-Heje (1999:3) identified five stages in the cyclic IS action research process: (1) diagnosing, (2) action planning, (3) action taking, (4) evaluating, and (5) specifying learning, as depicted in figure 2.2.

Baskerville (1999:14) gives as explanation of these components. The client structure, also known as the client-system infrastructure, is the specification and agreement that constitutes the research environment. It provides the conditions under which change may be specified. It also defines the responsibilities of the client and the researcher and is by nature a collaborative undertaking.

Diagnosing refers to a collaborative effort by the researcher and the client to analyse the primary problems of the current situation that form the underlying causes of the desire for change in the organisation.

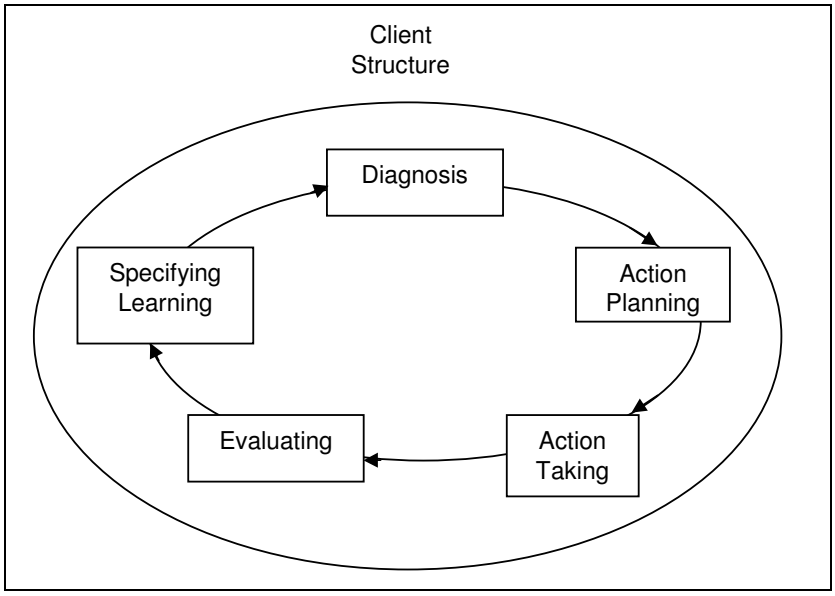


Figure 2.2 The action research cycle (Baskerville & Pries-Heje, 1999:4)

Action planning is a collaborative effort to specify actions to relief or to improve the specified problems. The plan should also include a description of the target state or desired future state of the organisation.

Action taking refers to the collaborate effort of intervention in the organisation. Changes can be made directly or indirectly. Lewin's (1948) model of unfreezing, changing and freezing can be followed.

A collaborative evaluation of the resulted state of the organisation is done to determine if the changes had the desired affect. This implies that the current state is compared with the desired future state described during action planning. Where the action was successful, the evaluation should determine whether the success could be attributed solely to the planned action. Where the action was unsuccessful, the reasons should be analysed, and the action plan for the next iteration needs to be designed.

The research team needs to specify and document the learning that took place during the specific iteration of the action research cycle. The organisational norms should be changed to reflect the new knowledge gained. Where the change was unsuccessful, the additional knowledge should be added to the original research design, altering the research plan as required. Where the change was positive, the specific situation and the successful action need to be carefully documented to aid future research, not only in the specific situation, but also in similar situations.

The diagnosis leads to a hypothesis, and the specifying learning phase leads to theory generation on the resulting change.

Theory generation and grounded action research

Checkland (1981) used action research in the research that led to the development of the soft systems methodology (discussed in chapter 3). He points out that the action researcher does not control the direction of the research; he has to follow wherever the situation leads him, or he needs to stop his research. Action research is suitable for ill-defined social problems and according to Checkland (1981:153), cannot be used to study physical phenomena such as magnetism.

Baskerville and Pries-Heje (1999:4) highlight the theory generation process of action research, as well of the shortcomings thereof. They argue that at the beginning of the research, researchers draw upon existing theory as foundations upon which to plan and take action. This theoretical framework is reinforced, withdrawn or modified to reflect the realities of action-taking according to the outcomes of each cycle. It is this evolution of theory that constitutes the scientific contribution of action research. Baskerville and Pries-Heje (1999:4) states that little attention is given to the exact processes by which such theories are cyclically developed during the course of action research.

Baskerville and Pries-Heje (1999) propose the use of grounded theory techniques to strengthen the scientific nature of the theory generation process. However, they do mention a major philosophical contradiction in this approach: “This may mean that every action research project begins, from a grounded theory perspective, with certain predefined categories and perhaps even a predefined core category. Since this contradicts a grounded theory tenet that a theory must be allowed to wholly emerge from the open coding, this “grounded action research” method does not

purely retain the "grounding" for its theory. This contradiction suggests that, since grounded theory is a complete research method in its own right, action research must use grounded theory components selectively. The resulting hybrid is action research, but does not constitute a canonical grounded theory." (Baskerville & Pries-Heje, 1999:17).

This argument represents one of the difficulties presented in the following section on the applicability of grounded theory for the proposed study. Baskerville and Pries-Heje (1999) do not relate this issue back to the philosophical and methodological foundations of grounded theory and action research respectively. In the discussion of abstraction according to Harvey's (1990) elements of critical social research methodology, it is clear that critical social research begins with a theory for which evidence is sought in the problem situation, as is the case in action research. Similarly, in the generalisation principle of Klein and Myers (1999) for interpretive field studies, it is argued that theory is generated as a result of observation, as is the case in grounded theory.

The difference in abstraction, from theory to evidence (in the case of action research) and from observation to theory (in the case of grounded theory), is a methodological difference, and it is the main motivation behind the philosophy, methodology and practice organisation of this chapter. When one attempts to merge these practical methods, it is necessary to take the methodological and therefore the philosophical foundations of these methods into account.

2.5 Research considerations with regard to this study

After the detailed discussion of the philosophy, methodology and practice of social research, it needs to be applied to the specific research question of this thesis. The research question as stated in chapter 1 evolves around the use of systems thinking techniques by data warehousing practitioners. The study first aims to explore the manner in which data warehousing practitioners use systems thinking techniques intuitively (unknowingly) and secondly, if that is the case, to set up a framework for the explicit use of systems thinking techniques in data warehouse design methodology. The assumption is made that the data warehousing practitioners under study are not aware or trained in the detail of systems thinking methodologies.

The case study data (reported in chapter 5) indicates that this assumption is reasonable in the South African context.

Considerations of philosophy, methodology and research practice are given in the next paragraphs and form a research plan for the proposed study:

2.5.1 Philosophical considerations with regard to this study

When this research problem is viewed from the philosophical foundation, the following observations can be made:

1. The first part of the research to understand the motivation behind current data warehousing practices has a strong interpretive nature.
2. The focus on the strategies or thoughts of the practitioners rules out the use of positivistic methods.
3. The researcher conducting this research does not have an emancipatory motivation for the first part of the research, therefore the research does not fit into critical social theory.

The aim of the first phase of the research is to understand the motivation behind the practices of the data warehouse developers. One does feel intuitively that the use of hermeneutics can be very fruitful in this process. The actions of individuals need to be understood in order to understand the practices of the data warehousing team and vice versa. The individual phases of the data warehouse development lifecycle aid in the understanding of the data warehouse as a whole and visa versa. One can therefore argue that this part of the research process has a strong interpretive nature.

The aim of the second part of the research is to develop a framework for the explicit use of systems thinking techniques in data warehouse design methodology. This part, which provides more of a philosophical challenge, can be seen as a second phase of the research process after the data collection has been completed and therefore represents the theory generation part of the study. Positivistic methods rely heavily on statistical tools in the analysis of data, and one senses that they are not applicable to this study. Analysis and generalisation in interpretive and critical social theory are methodological issues which will be debated further from a methodological level.

Finally, the purpose of the research from a philosophical view begs discussion. Why do we need a framework for the explicit use of systems thinking techniques in data warehousing practices? The researcher believes that the answer is ultimately to improve quality of data warehouse design. This implies that the researcher wants to change the practices of the data warehousing practitioners in the long run, except in those cases where practitioners are already using appropriate systems thinking techniques in all of their data warehousing practices. However, this is most unlikely, since data warehousing practitioners are not familiar with systems thinking ideas. One might argue that this part of the research is critical in nature, since intervention is implied. The intervention is however not part of the research process but rather a result of the completed study.

As a result of the arguments presented in this section, one may argue that the research problem has a strong interpretive nature, but intervention and therefore critical social theory is implied.

2.5.2 Methodological considerations with regard to this study

Since positivistic methodology is not applicable to this study, the debate should focus on interpretive and critical social theory methodology. At first glance, it seems that the proposed case study based research on data warehousing practices is a typical example of interpretive field studies in IS, and that the methodological principles of Klein and Myers (1999) are most suitable for this research problem. If this is true, a decision on the generalisation method is the most difficult decision to be made, and grounded theory seems to be applicable for this purpose.

Closer inspection of the methodology and the specific nature of this problem highlight the problems of a purely interpretive approach to this study. The theory generation process in interpretive methodology is based on the fact that theory is generated from the observational data. The theory is not stated at the beginning of the research and data is not collected to support the theory. The idea is that the theory will emerge from the data.

The assumption made in this study about the knowledge of the data warehousing practitioners of systems thinking techniques, complicates the generalisation process.

The detail of this argument is presented in the section on practical considerations but can be summarised as follows: Since the data warehousing practitioners do not know the terminology or principles of systems thinking techniques, it is the responsibility of the researcher to map their actions towards systems thinking techniques. In order to do this, the researcher needs to start off with some kind of mapping, linking the data on warehousing practices to systems thinking methodologies. This is in conflict with interpretive methodology.

Critical social theory methodology on the other hand seems to be more suited, since the element of abstraction presented by Harvey (1990) enables the researcher to start with a concept theory and to use the case study to seek evidence to prove or disprove the theory. In this case, the researcher can start by creating a preliminary framework for the use of systems thinking and use the data collected during the case study to find evidence in support or in opposition to the framework.

Critical social methodology focusses on the structures in the organisation. This focus is not present in interpretive methodology. Critical social methodology ultimately aims to change oppressing structures in the problem environment. The researcher should decide whether this research problem fits this situation. To make an informed decision, one needs to understand the use of the term “structure”. The philosophers in the critical social tradition view structure from different perspectives. Habermas viewed the use of language as communication medium as structural and argued that communication can be restricted by certain structures in language. Marx viewed economic hierarchies as structures oppressing the workers class.

The decision to be made here is whether practices of data warehousing professionals are structures, whether these structures are oppressive and therefore need to be changed and finally, whether it is the aim of the researcher to change these structures. First then, the question whether common practices can be viewed as structures. From Orlikowski’s (1992) work on Giddens’ structuration theory, it is clear that methodological practices of IS professionals can be viewed as structures. Furthermore, one needs to make a decision on the oppressive nature of these structures. The oppressive nature of data warehousing practices was not the initial motivation for the study. The original motivation was the mapping of data warehousing practices on systems thinking techniques. However, it can be argued that certain data warehousing practices (structures) lead to poor quality projects, and that they are oppressing high quality projects. If the researcher in the study reported

in this thesis, confronts herself with the question whether she wants to improve data warehouse quality, the answer is in the affirmative. One can therefore argue that this study aims to improve data warehouse quality through the altering of data warehousing practices (structures). A major difference between this study and typical critical social theory studies lies in the element of praxis. The researcher will not attempt to change the practices of the data warehousing professionals during the data gathering or analysis phase of the research. The research strategy is not comparable with the change cycle of action research but rather with the diagnostic phase. This is mainly due to the high costs involved in data warehousing projects. However, the research will lead to a framework for the improvement of data warehousing practices through the explicit use of systems thinking techniques.

The above argument shows that the focus on structural change of critical social theory methodology is not inappropriate for this study. The practical research design presented in the following section, will take both interpretive and critical social methodology into account.

2.5.2.1 Linking methodological aspects of this study to interpretive and critical social methodology

As a summary to this section on methodological considerations of this study, two tables are given to link the chosen methodology to the methodological principles discussed in section 2.3. Table 2.2 gives perspectives on the problem situation from an interpretive methodological perspective according to the principles of Klein and Myers (1999). Table 2.3 describes the link between the critical social theory principles described by Harvey (1990) and the methodological considerations of this study. A short description of each principle is repeated in these tables to aid the reader.

1	**The fundamental principle of the hermeneutic circle** suggests that all human understanding is achieved by iteration between the interdependent meaning of parts and the whole they form. This principle of human understanding is fundamental to all the other principles. *The researcher aims to understand data warehousing practices by understanding the practices of the data warehousing team and that of the individual team members in a hermeneutic context. A hermeneutic approach is also followed to understand the individual phases of a data warehousing project in the context of the project as a whole.*

2	**The principle of contextualisation** requires critical reflection on the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged. *The historical contexts of the different organisations used in the case studies need to be investigated. Economic constraints and social and political contexts in each organisation are viewed as enriching the understanding of data warehousing practices.*
3	**The principle of interaction between the researchers and the subjects** requires a critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and the participants. *It is accepted that research material is influenced by the interaction between the researcher and the participants. The researcher will be careful not to influence the respondent by her reactions to responses given. It is also important not to take on a consulting role. To manage this, the researcher aims to revisit the organisations after the completion of the research study to answer questions put to the researcher during the data collection phase.*
4	**The principle of abstraction and generalisation** requires relating the idiographic detail revealed by the data interpretation through the application of principles one and two to the theoretical general concepts that describe the nature of human understanding and social action. *A method based on pattern matching is used in chapter 5 to analyse the responses of the data warehousing professionals in terms of system thinking concepts. Questions covering data warehousing concepts are explored from different systems thinking methodological approaches to guide the researcher in understanding the given responses from a specific systems thinking methodology's point of view. However it should be noted that the developed framework (given in chapter 6) do not represent current data warehousing practices, but rather suggested practices in terms of systems thinking concepts. This aspect is atypical of interpretive research.*
5	**The principle of dialogical reasoning** requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tells") with subsequent cycles of revision. *The researcher conducted follow-up interviews with role players in the organisations to explore the relationship between the interpreted data, the resulting framework and reality.*

6	**The principle of multiple interpretations** requires sensitivity to possible differences in interpretations among the participants as typically expressed in multiple narratives or stories of the sequence of events under study. They are similar to multiple witness accounts, even if all participants tell it as they saw it. *The interpretive data given in chapter 5 represent the responses of individuals. It is very interesting to study the different interpretations of factual events from a systems thinking point of view. The researcher hopes to expose these differences in order to achieve a better understanding of the problem situation, but also to benefit the role players in the organisation.*
7	**The principle of suspicion** requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants. *The number of respondents to be interviewed in each organisation is not determined prior to the case study. More respondents will be interviewed when signs of such distortions are detected to clarify the understanding of the distortions and the organisation of the researcher.*

Table 2-2 Interpretive methodological considerations of this study

1	Through **abstraction**, critical social research aims to reveal underlying structures that are otherwise taken for granted. These structures specify the nature of the abstract concepts which have themselves been assimilated uncritically onto the prevailing conceptualisation. *This research study explores the underlying structures of data warehousing practices and success. These structures are explored from a philosophical and methodological point of view in terms of systems thinking. Systems thinking principles such as boundary judgement and ownership are examples of abstract concepts that are yet to be critically explored by data warehousing professionals.*
2	**Totality** refers to the view that social phenomena are interrelated to form a total whole. Social phenomena should not be investigated in isolation but always as part of a larger context. *This research study focusses on the role of data warehousing in the total organisation. It explores different motivations for the initiation of the data warehousing project. The resulting framework aims to give a broadened view of data warehousing in the context of the organisation as a whole.*

3	**Essence** refers to the fundamental element of the analytical process. Critical social researchers view essence as a fundamental concept that can be used as the key to unlocking the deconstructive process. *Systems thinking concepts, as described in chapter 3, are used as the key to unlocking the deconstructive process. Data warehousing practices are deconstructed by means of analytical questions (given in chapter 5) formulated to explore the underlying structure of data warehousing practices.*
4	According to Harvey (1990:22), **praxis** means practical reflective activity. It is activity that changes the world. The critical social researcher is not only interested in understanding the world; he/she aims to change the world. It is not the actions of an individual that is of interest but rather the actions that change the social formations. *From a critical perspective, the aim of this research is to improve data warehousing practice by understanding the underlying structures of current practices before proposing a framework for change in current data warehousing practices. The framework for improved data warehousing practices is given in chapter 6.*
5	The positive view of **ideology** sees it as false consciousness which hides the interests of dominant groups from themselves. According to the negative view of ideology, it cannot be detached from the material conditions of their production; it is constantly reaffirmed through everyday practice. The nature of the ideology needs to be revealed by the researcher through the identification of the essence of social relations and the separation of this essence from structural forms through a process of dialectical deconstruction and reconstruction. *Pattern matching is used in chapter 5 to map current practices and ideas of data warehousing professionals to systems thinking methodologies. The ontological and epistemological foundations of these systems thinking methodologies are explored in chapter 3 to identify their ideological nature.*
6	**Structure** is seen by the critical social researcher as more than the sum of the elements. It is viewed holistically as a complex set of interrelated elements which are interdependent and which can be conceived adequately only in terms of the complete structure. *The aim is not only to break data warehousing practices down to specific development lifecycle phases, but rather to understand the underlying boundary judgements (and other systems thinking concepts) made by data warehousing professionals in their everyday activities.*

7	Critical research **history** is not so much interested in the historical facts as in the circumstances within which it occurred. It investigates the social and political contexts, addresses the economic constraints and engages the taken-for-granted ideological factors. It also takes the situation of the researcher into account. *The historical contexts of the different organisations used in the case studies need to be investigated. Previous attempts to change current practices and the reasons for such changes need to be explored. Economic constraints and social and political contexts in each organisation are viewed as enriching the understanding of data warehousing practices.*
8	The critical researcher aims to **deconstruct** the situation into abstract concepts in order to study the interrelations between the concepts with the purpose of discovering the key to the structure of the situation. The core concept is used to **reconstruct** the situation. This is an ongoing process to expose the ideology underpinning the situation in order to identify the oppressive mechanism, which requires change. *Data warehousing practices are deconstructed through asking specific analytical questions. These questions (given in chapter 5) are formulated to identify different systems thinking perspectives of respondents. Individual responses to these questions (that represents the deconstruction) are also given in chapter 5. Reconstruction of the data warehousing practices is done according to systems thinking concepts and presented as a framework in chapter 6. Chapter 6 is specifically organised to illustrate the reconstruction of practices according to systems thinking concepts. The researcher conducted follow-up interviews with role players in the organisations to explore the relationship between the framework and reality. However the framework has not been used explicitly to guide data warehousing practices in any organisation. This aspect is atypical of critical research.*

Table 2-3 Critical social methodological considerations of this study

The methodological considerations with regard to this study identify differences between this study and typical interpretive as well as critical social research methodology. This underlines the pluralistic nature of the research activity reported in this thesis.

2.5.3 Practical considerations with regard to this study

This section presents the practical research plan for the study. A combination of interpretive and critical social methodologies is applied in this research. Case studies will be used as data collection method. The aim of this research is to explore

current data warehousing practices from a systems thinking perspective, in order to design a framework for the explicit use of system thinking techniques in data warehousing activities. The researcher believes that the framework would be more acceptable to the practitioners if it relates to current data warehousing practices.

The first part of the practical research plan describes how the case studies will be conducted. This discussion is followed by a discussion on the applicability of grounded theory for the development of a theory. This section concludes with a discussion on the theory generation process that will be followed to create a framework for the explicit use of systems thinking techniques in data warehousing practices.

2.5.3.1 Data collection

The researcher in this study had to choose between interpretive case studies and ethnography as data source. The use of ethnography has advantages in this situation, in that the researcher has enough time in the research environment to develop a true understanding of the motivation behind the research practices of the data warehousing practitioners. However, two problems with ethnography as data collection method for this study surfaced. Firstly, the researcher believes that from a systems thinking methodology perspective (discussed in chapter 3), data warehousing practices are dependent on the orientation of management and structures (procedures) in a specific organisation. This implies that the researcher would have to study more than one, perhaps as many as four organisations to gain understanding of the underlying systems thinking ideas in data warehousing practices. Although this is possible in ethnography, it would be very time consuming. A second concern with the use of ethnography for data collection is the role of the researcher in the organisation during the data collection period. The researcher believes that an organisation would expect financial gain from the presence of the researcher. This implies that the researcher should add some value to the development of the data warehouse. Since the researcher is trained in data warehouse development practices, the researcher might turn into a consultant, thereby influencing the very aspect that needs to be researched. It would be difficult to gain the trust and respect of the development team if the researcher constantly tries to conceal or withhold knowledge.

At least three interpretive case studies will be conducted to collect data for the research. The data collected, will be used to explore current data warehousing practices from a systems thinking point of view. Since chapter 5 covers the detail of each case study, this section will deal with the research design that was done prior to conducting the case studies.

The first question was to determine where the case studies should be done. What should be the similarities between the different organisations, if any? Should all the organisations be in the same economic sector, or should an effort be made to represent more that one economic sector? The researcher decided that data size determines the design practices in data warehouse development. Sound design practices are more important when large data warehouses are being designed, therefore the researcher decided to focus on organisations with large data warehouses. A large data warehouse is one with a large number of records in the base fact tables of the data marts. (Data warehousing terminology is discussed in chapter 4.)

Since the researcher needed to bridge a gap between studying the current practices of data warehousing practitioners and proposing methods to be used by data warehousing practitioners from a systems thinking point of view, a data warehousing consulting organisation was chosen for one of the case studies. The respondents of a consultation organisation would be more likely to report on ideal practices, since they have experience in both successful and unsuccessful projects in a variety of organisations.

The second question was to determine whom to interview in the organisation. Since different phases of the development lifecycle of a data warehouse will be researched, it is important to interview employees responsible for each of the stages in the data warehouse development lifecycle (this lifecycle is discussed in chapter 4). It will also be necessary to interview employees in the lower levels of the organisational hierarchy, since systems thinking ideas require, among other things, that all employees involved in the development lifecycle should keep the organisation's objectives in mind. Interviews with top management will serve to interpret conflicting responses from section heads in lower levels of management.

The order, in which the interviews are conducted, is of significance. It will be important not to waste the time of top management with questions that could have

been answered to the researcher's satisfaction by lower level employees. Top management on the other hand, might want to be interviewed first to set certain ground rules in terms of confidentiality and so forth. Consequently, the case study will start with a short interview with the manager and end with an extensive interview with the same manager. The researcher is of the opinion that starting the case study with a short interview with the manager has the distinct advantage of providing the researcher with an overview of the business. Detailed interviews with section heads will then follow, succeeded by interviews with employees responsible for the physical implementation of each of the data warehouse life cycle phases. The case study will be concluded with an extensive interview with top management.

The researcher foresees that the organisations involved in the case studies reported in this thesis, will require the signing of confidentiality agreements. It will be made abundantly clear to all respondents that information obtained from them will not be discussed explicitly with their colleagues or superiors. The organisations will be requested to make documentation about their practices available in terms of the confidentiality agreement.

Semi-structured interviews will be conducted. It is important to keep a conversational mood during the interview, since the researcher accepts that useful information is gathered from informal remarks rather than answers to specific questions. The structured questions are intended to keep the interview moving forward. The questions will not necessarily be asked in the planned order, but may be rearranged to aid the natural flow of the conversation. These questions are presented in the first part of chapter 5, as a mapping that was used in a pattern-matching analysis approach. These questions were carefully designed to be open–ended questions that aid the natural flow of the conversation. The researcher will ensure that, at the end of each interview, all questions were asked and answered.

Each interview will start with an introduction explaining the background of the researcher, the purpose of the case study and a short explanation of how the specific interview fits into the case study. The researcher will also give an explanation of the extent of the confidentiality agreement. Having explained the purpose of recording the interview, permission will be asked to do so. The researcher will also ask permission to attend routine project meetings. The attendance of these meetings will give insight into the internal social structure and the group dynamics of the organisation in question.

The interviews and the meetings are to be recorded with a notebook computer and a small microphone, which might prove to be less intrusive than traditional tape recordings since the respondents are used to having computers in their environment. Recording on a computer has the added advantage of simple backup operations.

2.5.3.2 Applicability of grounded theory (GT) for this study

This section investigates the applicability of GT as theory generation methodology for this study. The aim is to explore whether GT can be used to achieve the initial goal of the study, namely to understand the practices of data warehousing practitioners from a systems thinking methodology point of view. In the view of the researcher in this study, certain aspects of GT methodology as described in section 2.4.2.3, complicates its usage for the stated purpose. The point to be considered is that the data warehousing practitioners generally do not know the detail of systems thinking methodologies. The research is specifically done to explore their practices according to systems thinking methodologies, or stated differently, to ascertain whether they use systems methodologies unknowingly?

The emergence of concepts and categories

In GT the concepts that result in categories emerge from the data. It is abstractions of patterns of events or incidents in the problem situation. Although it is conceptualised by a researcher, there is a strong relationship between the names of the categories and behaviour in the research situation.

In the proposed study, GT should link the practices of data warehousing practitioners to concepts of systems thinking methodologies. This means that the categories resulting from open and axial coding, should reflect both systems thinking methodologies and data warehousing practices. This would require co-operation between inductive and deductive methods to determine categories. On the one hand, categories representing data warehousing practices would emerge from the data inductively, while on the other hand, the researcher would introduce preliminary categories representing system thinking deductively. The second group of categories would only be grounded, once incidents in the data can relate to them. The central category determined in selective coding will relate the two groups of categories.

Strauss and Corbin (1998:161) state that "finally, the theory is validated by comparing it to raw data or by presenting it to respondents for their reactions. A theory that is grounded in data should be recognisable to participants, and although it might not fit every aspect of their cases the larger concepts should apply." This implies that either the IS practitioners will not be able to verify the theory, or that they would have to be informed about the detail of systems thinking methodologies after the coding is finished.

The sampling process

In true GT tradition, the researcher looked at a similar research problem in a totally different environment to assist in identifying the pitfalls of sampling. Consider a study about adjustment problems pre-school children are experiencing. The study is similar in that the children do not know the terminology concerning adjustment problems. The problems of the children should at some point be compared with what is known from literature as adjustment problems, just as the practices of data warehousing professionals should be compared with different systems thinking methodologies. Now consider the children's actions.

When sampling is done, the researcher will focus on events that he/she thinks represent either adjustment problems, or specifically no such problems. The children will be observed for any action that may or may specifically not reflect adjustment problems. One problematic example comes to mind. A child falls over while playing and starts to cry. The crying child immediately draws the attention of the researcher. Is this an incident indicating adjustment problems? Certainly the fact that the child was playing, indicates the opposite. However, the intensity of the crying might just as well indicate adjustment problems. Was the fall only a spark for an emotional outburst? It seems that the researcher should evaluate the intensity of the emotions to link the incident to adjustment problems, or to conclude that the child got a fright from the fall or was perhaps just overly tired. The point made is that the researcher wears adjustment problem spectacles while observing the children. The researcher should wear these spectacles with great responsibility and consistency.

Another problem situation can illustrate similar difficulties. A researcher may want to investigate the degree to which parents utilise pedagogical theories in the upbringing of their children without knowledge of pedagogical principles. The parents would not

be able to articulate their actions in terms of pedagogical terminology, and the researcher would need to do a mapping between the actions of parents and pedagogical terminology. The researcher has to decide to which degree a specific action corresponds to a specific pedagogical principle.

Clearly, the researcher looking for indications of systems thinking in IS practices has a similar problem. Which practices should be investigated? Only those that clearly reflect systems thinking? In that case, can it still be called OPEN coding? Rather, how can one still achieve open coding? Is it feasible to code all the practices (a tiresome process)? How do we determine whether a certain action represents a specific type of systems thinking methodology, or not? Once again, one is concerned that too much of the theory generation process is dependent on the perceptions of the researcher.

A solution to the problem for the researcher is to be aware of his/her perceptions. These perceptions need to be stipulated and the categorisation of data should not be done intuitively but systematically against the stated perceptions or qualifications of each category.

Possibilities for the use of GT in the proposed study

In order to make a decision regarding the applicability of GT to the proposed study, five possible perspectives of the problem situation have been identified. Each perspective will be discussed and evaluated critically.

Perspective 1: A three-phase method of comparison using GT

It is possible to divide the problem into three different phases. During the first phase, the data warehousing professionals will be studied and a grounded theory will be developed to describe their actions. Their actions are not studied through the spectacles of systems thinking. The aim is to discover how data warehousing professionals do their work. The result of this study will be a grounded theory (or network of ideas) describing the practices of data warehousing professionals. The second phase is to develop a similar network of ideas for systems thinking. This network of ideas will be set up mainly from literature. The result of this phase will be a set of principles that constitutes the use of systems thinking ideas in general. The third phase is to compare the two frameworks developed in the first two phases. The

aim is then to explore in what way the actions of the data warehousing professionals represent systems thinking.

The advantage of this approach is that GT is used in the way it was designed for, namely to let a theory emerge from observational data. The bias of the researcher towards systems thinking ideas is eliminated. The complexity of this perspective lies in developing two comparable frameworks or networks of ideas and to determine a method of comparing these frameworks. One possibility is to do a GT study on systems thinking literature and compare the different categories of the two phases. However, the different sets of categories will differ considerably, and this does not mean that there is no relation between the practices of the IS professionals and system thinking ideas. Other methods to set up a comparable framework for systems thinking need to be investigated before this approach will be successful.

Perspective 2: Two phases: From literature to practice

Another idea is to develop categories from systems thinking literature and attempt to ground them in data warehousing reality. During the first phase, the researcher studies systems thinking from a data warehousing perspective and develop categories (following GT coding techniques) that represent typical systems thinking ideas in data warehousing practices. These categories are not yet grounded in reality but represent actions of data warehousing professionals that would indicate the use of systems thinking ideas. During the second phase, the researcher will attempt to ground these categories in reality by testing the observational data against these categories. Observations that fit the theory will indicate practices that reflect systems thinking ideas and vice versa.

Although this approach seems practically possible, it is against the very spirit of grounded theory. GT was designed to allow a theory to emerge from the data without the detailed formulation of a hypothesis. The first phase can be seen as a hypothesis and the second phase as a test for the hypothesis. If this approach is followed, one cannot claim a true grounded theory describing the influence of systems thinking on data warehousing practices.

Perspective 3: Narrow the scope of the study

One might limit the scope of the study to only phase one of perspective 1 above. This would change the research question to: "Can the practices of IS professionals (in this case data-driven DSS designers) be generalised into a descriptive narrative using GT?" Although this is a workable solution, it does not mean that the study will improve the quality of the work done by data warehousing professionals. One is tempted to question the overall value of such a study.

Perspective 4: Do we need a theory to describe our observations?

From this perspective one might query the argument that led to the consideration of grounded theory in the first place. The stated research question was of an interpretive nature, and the fourth principle for interpretive case studies advocates generalisation. The researcher chose to explore GT as the most appropriate method to satisfy this requirement. The question may be asked whether a theory to describe the researcher's observations is really needed. Is this not complicating the issue? Can one simply make observations of the practices of data warehousing professionals and give a valued judgement on whether these actions reflect systems thinking ideas? The generalisation then comes from repeating the process in different data warehousing environments through multiple case studies.

The above approach simplifies the proposed research, but one has to investigate the scientific value of the method followed. One way of improving the scientific value, is to divide the process into two stages; first identify data warehousing practices that reflect systems thinking before the first case study is conducted, and then follow a strict coding process to prove that the observations fit the typical systems thinking behaviour described in stage one.

This option does not use GT directly as a research methodology, but the coding processes described in the discussion of GT may be used to organise the field observations.

Perspective 5: What about action research?

One may question another assumption that led to the consideration of GT for this study, namely that of interpretive research. It was argued that the researcher does

not want to change the practices of data warehousing professionals and therefore research methods proposing that intervention is not applicable to this study. Perhaps there is a different way of viewing the situation. One might argue that the main purpose of the study should be to develop a framework for the use of system thinking in data warehousing practices. The first stage involves investigating whether the practices reflect systems thinking ideas, thus constituting the diagnostic phase of an action research project. The next stage is to set up a framework for the use of systems thinking ideas in data warehousing practices. The acceptance of this framework in industry needs to be tested. If the practitioners accept the framework, it does represent an intervention in the practices of data warehousing professionals. This approach differs from the typical action research project, where the researcher advocates a course of action and then tests the success of that action. Grounded theory coding methods may be used to organise the data, an option that certainly has a lot of merit. It should not be seen as a way to avoid generalisation, since the generalisation will come from the acceptance of the framework by the data warehousing industry.

Conclusion regarding the applicability of GT for this study

The first three perspectives directly use GT as research methodology for the proposed study. The last two perspectives explore different ways of achieving generalisation in the study. GT can be used as a method of data organisation in the last two options. After examination of these perspectives, it is clear that the nature of this research problem complicates the use of GT.

The researcher of this study gained valuable insights after identifying these perspectives of the problem situation. It became clear that a pure grounded theory is very difficult to achieve, if not unsuitable, in this situation. This is mainly due to two aspects:

1. The practitioners are not knowledgeable on system thinking methodologies, which would result in concepts and categories that will not reflect systems thinking methodologies.
2. The aim of the researcher is not only to describe current data warehousing practices from a systems thinking methodology point of view, but more importantly to design a framework for the explicit use of systems thinking methodologies in data warehousing practices. The case study part of the

study is to ensure that the resulting framework relates to current data warehousing practices.

After evaluating the problem from the different perspectives mentioned above, the researcher decided not to use grounded theory in this problem situation. This evaluation also led to an understanding of the pluralistic nature of the chosen methodology.

2.5.3.3 Theory generation and generalisation

It proved to be impossible to design questions to be asked during the interviews without an in-depth knowledge of systems thinking and an initial idea of the mapping of systems thinking techniques and data warehousing practices. The researcher therefore decided to follow the abstraction methodology of critical social research. This means that a literature study on systems thinking was followed by a literature study on data warehousing. A mapping between systems thinking ideas and data warehousing was developed from literature and is presented in chapter 5. This mapping is presented in table format, which forms the basis of a pattern-matching method used for case study data analysis. From the analysis of the case study data, a framework will be developed to make the mapping between systems thinking ideas and data warehousing practices explicit. The framework is presented in chapter 6 as a conclusion to this study.

This method of abstraction is contrary to the typical theory building methods used in interpretive research and represents the critical component of the study. The following argument explains this contrast. It is important to divide the study into two parts. The first part is to understand, by doing case study research, to which degree practices of data warehousing practitioners represent systems thinking ideas, and the second part is to set up a framework for the explicit use of systems thinking ideas to improve quality in data warehousing practices. If this was an interpretive field study, the resulting theory would have described current data warehousing practices in terms of systems thinking ideas. In grounded theory terms, the theory would be a narrative describing the relationship between current data warehousing practices and systems thinking ideas. In this study however, the final framework (part 2 of the study) for the use of systems thinking ideas in data warehousing practices, should be viewed as the theory component of the study. The initial study to explore current data warehousing practices from a systems thinking perspective (part 1 of the study),

is done to assure that the resulting framework relates to current data warehousing practices in order to foster the acceptance of the framework (part 2) by data warehousing professionals.

One might argue that the first phase of this study is similar to the diagnostic phase of action research, but the difference lies in the fact that the researcher does not use an organisational setting to test and improve the framework, because of the cost and duration of a typical data warehousing project. Data warehousing projects are developed in large companies over long periods of time and at very high costs. It is therefore impossible to implement a typical action research cycle for implementing and improving the framework.

2.6 Summary

The aim of this chapter is to give a philosophical and methodological foundation for a pluralistic research plan. This was done by describing positivistic, interpretive and critical social research philosophies. It was shown that in positivistic methods, the researcher is objective, while subjectively engaged in the research environment of interpretive and critical methods. Unlike the critical social researcher, the interpretive researcher does not seek to emancipate oppressed parties in the research situation. These different models were applied to IS research.

Research methodology was also discussed from a positivistic, interpretive and critical social viewpoint. It was shown that, apart from the emancipatory nature of critical social theory, it also differs from interpretive methodology with regard to abstraction or theory generation. In interpretive methods, theory is generated from data gathered through observation, while critical social theory starts off with a preliminary theory and uses observation to either prove, or disprove, or refine the theory.

Research practice was discussed from a positivistic, interpretive and critical social viewpoint, followed by case study data collection and generalisation through the use of pattern-matching, grounded theory and Giddens' structuration theory. Action research was discussed from a critical social theory point of view.

This discussion on philosophy, methodology and practice of social research was followed by research considerations of this study on a philosophical, methodological

and practical level. It is concluded that, although the proposed study has many interpretive qualities, the required research methodology resembles critical social theory methodology with one major difference, namely that the problem situation is changed through the resulting theory (in this case a framework), rather than through the research process.

The proposed research methodology requires that literature studies are done on systems thinking, as well as on data warehouse development practices. The researcher needs to develop a mapping between systems thinking ideas and data warehousing practices. The case study data, analysed with pattern-matching, will be used to understand which systems thinking ideas are already used by data warehousing professionals unknowingly. This knowledge, presented in chapter 5, will enable the researcher to develop a framework, which enhances current data warehousing literature relating to success factors. The resulting framework gives an explicit mapping between data warehousing practices and systems thinking ideas. The framework, presented in chapter 6, will be distributed to data warehousing practitioners. This represents intervention in data warehousing practices.

CHAPTER 3 SYSTEMS THINKING

3.1 Introduction

This chapter introduces systems and systems thinking to the reader. A system can be defined as a set of interrelated elements (Ackoff, 1971:661). According to Checkland (1981:5), a systems approach represents a broad view, taking all aspects into account and concentrating on interactions between different parts of the problem. Section 3.2 provides a basic description of systems in terms of background, definition of terminology and the systems approach.

The main objective of this chapter is to discuss systems in terms of the relationships between philosophy, methodology and practice. Section 3.3 focusses on philosophy, section 3.4 on methodology, section 3.5 on practice in general and section 3.6 on practice in information systems. In order to apply systems thinking concepts to data warehousing practices, as is done in this thesis, one needs to understand the underlying philosophies of these systems thinking concepts.

It is important to clarify any misinterpretations of the terms “methodology” and “method.” In this thesis, the term “methodology” takes on two different meanings (congruent with Jackson (1991:3)), which must be differentiated from the term “method”. These meanings are:

1. “Methodology” refers to procedures used by a theorist to find out about social reality. In the context of systems thinking, it refers to methods for exploring and gaining knowledge about systems. Methodology focusses on the ontological and epistemological assumptions when gaining knowledge (Jackson 1991:3). When soft, hard, critical and disclosive systems thinking are referred to as methodologies in section 3.4, this definition of “methodology” applies.
2. “Methodology” can also be defined as the organised set of methods or techniques an analyst employs to intervene in and change real-world problem situations. Midgley (2000:105) uses the term “method” to describe this type of methodology. Very little attention is given to the theoretical underpinnings of the set of techniques. The discussion on systems practice methodologies

given in section 3.5, uses this definition of "methodology". In this thesis, this type of methodology is seen as "practice".

3. "Method" can be defined as a generalisation of a specific technique. It is more subject-related than the second meaning of methodology given above. Section 3.6 describes methods used in information systems development.

A subscript, e.g. "methodology$_1$", will indicate which definition applies to the term used. In this example, it refers to the first definition given in the introduction.

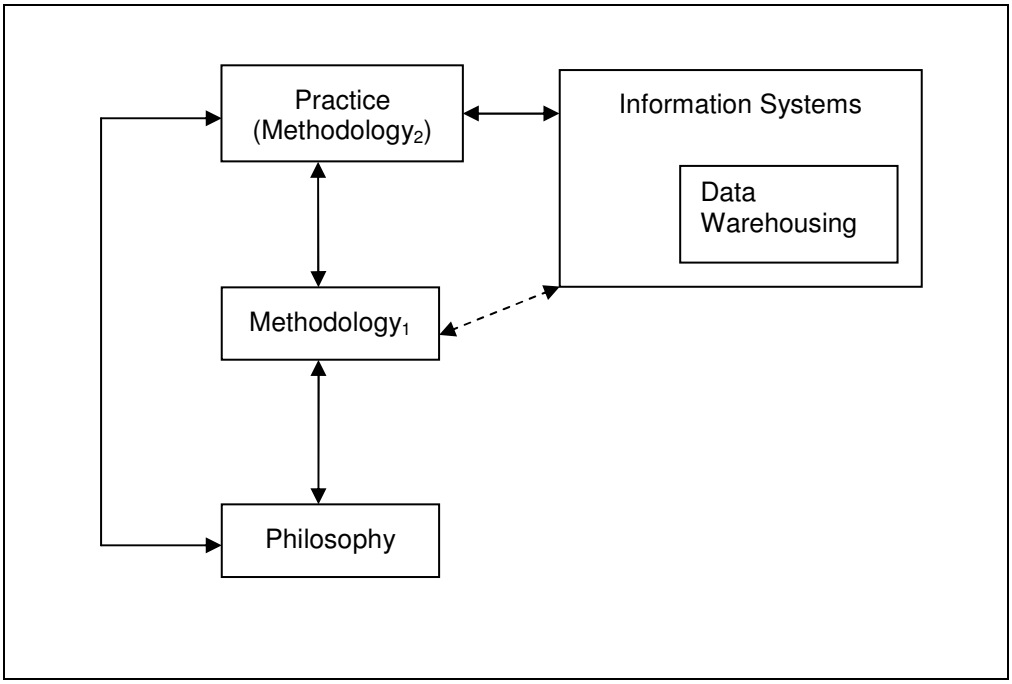


Figure 3.1 The relationship between philosophy, methodology$_1$, and practice

Figure 3.1 shows the relationship between philosophy, methodology$_1$ and practice. Philosophy is the foundation of methodology$_1$ and practice. Systems thinking is seen as a methodology$_1$ that links philosophy and practice. The practice layer represents methodologies$_2$ used to apply systems thinking methodologies$_1$ to everyday problem situations. The soft systems methodology (SSM) introduced by Checkland (1981) is such a methodology$_2$ for applying soft system thinking to everyday problems. Different attempts to develop such methodologies$_2$ for critical and disclosive systems thinking are currently under way and will be discussed in this chapter. In this thesis, systems thinking methodologies$_{1\&2}$ are applied to information systems development and specifically to data warehousing as a specialised application on the practice level. A mapping between the systems thinking methodologies$_{1\&2}$ discussed in this chapter and data warehousing practices is given in chapter 5. This chapter forms part

of the theoretical foundation of the framework for the use of specific systems thinking methodologies$_{1\&2}$ in data warehousing practices, discussed in chapter 6.

The chapter starts with a general discussion on systems and systems thinking. Different views on systems are rooted in different philosophical ideologies. Section 3.3 gives an overview of influential philosophies and dimensions of systems thinking. This leads to the discussion of different systems thinking methodologies$_1$ i.e. hard, soft, critical and disclosive systems as discussed in section 3.4. A discussion on the application of systems thinking methodologies$_1$ in practice in section 3.5, is followed by a literature study on current applications of systems methodologies$_{1\&2}$ in information systems development as presented in section 3.6.

3.2 Systems thinking and the systems approach

This section focusses on systems and systems thinking. The emergence of systems thinking as a reaction to reductionism, leads the reader to ask: "What is a system?" The definition of a system is followed by its five characteristics as identified by Churchman (1968). The input – output systems approach is then related to these five characteristics of a system. The objectives of general systems theory are stated to illustrate the interdisciplinary nature of systems thinking. Systems thinking provides a solution for multifaceted problems by crossing the traditional boundaries of different disciplines. The section concludes with practical notes on applying the systems approach.

3.2.1 The emergence of systems thinking

Since systems thinking is proposed as a method to overcome the shortcomings of the traditional scientific approach, it is necessary to briefly discuss the traditional scientific approach. Checkland (1981) gives a detailed description of the history of science and the emergence of systems thinking.

3.2.1.1 Reductionism as scientific method

The Greek philosophers, Plato and Aristotle, developed the art of rational thinking, which forms the basis of scientific knowledge. Science is a way of acquiring publicly

testable knowledge of the world. This knowledge is generally gained from rational thought combined with experience. The experience is gained from deliberately designed repeatable experiments. These experiments are designed to enable the scientist to formulate laws that govern the regularities in the universe. These laws are expressed mathematically. Three key aspects of the scientific method are reductionism, repeatability and refutation. An experiment can be seen as a reduction of the real world, a reduction for a specific purpose. Such an experiment is only seen as valid when it is repeatable. It should be noted that the experiment should be separated from the theories derived from it. Although the repeated experiment will yield the same results, it does not mean that everyone will form the same theory as a result of the experiment. Theories that stand the test of falsification over time are considered to be strong theories. Checkland (1981:51) argues that by means of the reduction of the real world into an experiment, the researcher aims to control the investigation completely, so that the changes that occur, are the result of his actions, rather than the result of complex interaction of which he is unaware.

Reductionism is the basis for removing complexity from problems. Descartes' second rule for "properly conducting one's reason", which is central to scientific problem solving, i.e. dividing up problems into separate parts, assumes that this division will not distort the phenomenon being studied (Checkland, 1981:59). This implies that components of the whole behave the same when studied separately as when they are part of the whole. Although this approach is reasonable for many physical phenomena in the world, it is very difficult to apply to problems in a more complex social environment.

Ackoff (1974:8) defines reductionism as a doctrine that maintains that all objects and events, as well as their properties, and our experience and knowledge of them, are made up of ultimate elements, indivisible parts. All positivistic scientists identify something to form the basis element of their subject. Physical scientists believe that everything is made up of atoms; biologists believe that cells are the basic elements of life. Even Freud reduced personality to basic elements, i.e. id, ego, and superego.

Machines used during the industrial revolution could be reduced to three basic elements: the wheel and axle, the lever, and the incline plane (Ackoff, 1974:11). Mechanisation led to reduction of everything, including man to machines.

3.2.1.2 Expansionism

During the mechanistic age of the 18th century, man felt like a machine and believed that the world was a machine created by God to serve his purposes, a machine for doing his work (Ackoff, 1974:11). The mechanical age was characterised by analytical thinking that broke anything that needed to be explained, down into its parts.

In reaction to reductionism, Ackoff (1974:12) defines expansionism as a doctrine that maintains that all objects, events, and experiences of them, are part of larger wholes. It does not deny that they have parts, but focusses on the wholes of which they are parts. During the 1940's the focus in philosophy shifted away from particles to symbols and later to languages. The context of the word in a whole sentence or phrase, is key to the understanding of that word. During 1949, the mathematicians Claude Shannon and Warren Weaver (1949) specified language as part of the larger whole of communication. Wiener (1949) did similar work in defining a larger concept, namely control, of which communication forms a part. It was the work of biologist Ludwig von Bertalanffy (1968) that caused the rest of the scientific world to take notice of the systems concept. He believed that science was broken up in too many specialisation fields, each with too narrow scope and therefore advocated interdisciplinary thought. Section 3.2.5.2 refers to Von Bertalanffy's (1968) work to find common factors in all systems.

Checkland (1981) discusses three problem areas of science: complexity, social science and management. Our knowledge is categorised into subject areas, to which we are so used to, that we have difficulty seeing the unity that underlines the diversity. This is done to help us simplify our world in order to make sense of reality, because of our limited ability to grasp the whole. Although most problems in physics can be explained with a manageable number of variables, which can be isolated in experimentation, it is very difficult for the biologist to do the same. When we examine social science in social reality, we find not only a large number of variables, but we are confronted with the question of value-free sociology. We are confronted with the question of whether the observer is able to stay objective, or whether he or she will participate subjectively in the organisation. It is very difficult to design repeatable experiments in the social environment, owing to the unpredictability of social happenings. Managers often see their work as practice rather than science. Operational research and management science developed certain strategies to

handle specific types of managerial problems (e.g. linear programming problems), by building models that represent reality. However, it is extremely difficult to estimate how accurately reality is represented by a specific model. There are countless situations in the everyday activities of a manager for which it is not possible to create models.

Checkland (1981:74) stresses that the aim of systems thinking is to tackle problems of irreducible complexity by thinking in wholes, rather than overthrowing the tradition of science.

3.2.2 Definition of a system

When Weinberg (1975:51) declares: "A system is a way of looking at the world", he attempts to open up people's minds. He wants us to realise that people view things differently according to each one's own experience and point of view. Weinberg (1975:57) further states that it is the purpose of the system that gives it its right of existence. For our purpose, it is interesting to note that, prior to the referred one, Weinberg published seven books in the field or computer programming, including reference manuals in specific computer languages.

The systems approach considers the system as a whole, consisting of interdependent elements (Kramer & De Smit, 1977:10). The specific arrangement of the parts of a system is significant. The environment and the interaction of the system with its environment cannot be ignored.

Ackoff (1974:13) defines a system as "a set of two interrelated elements of any kind; for example, concepts (as in the number system), objects (as in a telephone system or human body), or people (as in a social system)." The system is not indivisible but must be seen as a whole that can be divided into parts. Ackoff (1974:13) states that the elements of the set and the set of elements have the following three properties:

"1. The properties or behaviour of each element of the set has an effect on the properties or behaviour of the set taken as a whole. For example, every organ in an animal's body affects its overall performance.
2. The properties and behaviour of each element and the way they affect the whole, depend on the properties and behaviour of at least one other element in the set. Therefore, no part has an independent effect on the whole, and

each is affected by at least one other part. For example, the behaviour of the heart and the effect it has on the body depends on the lungs.

3. Every possible subgroup of elements in the set has the first two properties; each has a non-independent effect on the whole. Therefore, the whole cannot be decomposed into independent subsets. A system cannot be subdivided into independent subsystems. For example, all the subsystems in an animal's body, such as the nervous, respiratory, digestive, and motor subsystems interact, and each affects the performance of the whole."

A system is always more than the sum of its parts. A system's emergent properties are those properties that do not exist in the parts but are found in the whole (Weinberg, 1975:60). A system also forms part of a larger whole or system.

In order to describe a specific system, we need to define terminology. Kramer and De Smit (1977:13) discusses the following terms:

- *System:* "A set of interrelated entities, of which no subset is unrelated to any other subset" (refer to figure 3.2).
- *Aggregate:* "A set of entities which may perhaps be partly interrelated, but in which at least one entity or subset of entities is unrelated to the complementary set of entities" (refer to figure 3.3).
- *Entity:* "A part of a system: something that has objective or physical reality and distinction of being and character."
- *Relation:* "The way in which two or more entities are dependent on each other."
- *Structure*: "Set of relations between entities; the whole of the relations."
- *State:* "The state of a system, containing the information on the system's earlier history and its present condition, is necessary and sufficient for predicting the output or the probability of a certain output, given a certain input."
- *Subsystem:* "An element or a functional component of a larger system which fulfils the conditions of a system in itself, but which also plays a role in the operation of a larger system."

Checkland and Scholes (1999:19) add the idea of survival of a system. They state that a system should survive changes in the environment. Survival is only possible

where a system has processes of communication and control to adapt to changes in the environment.

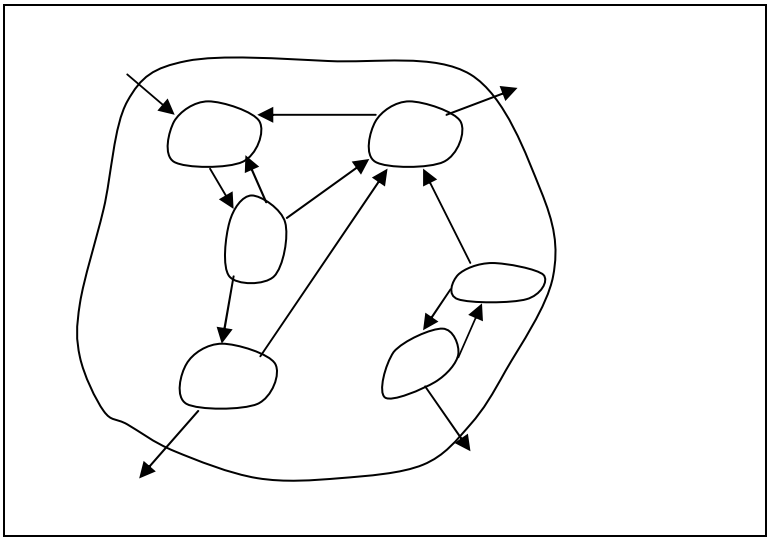


Figure 3.2 System (Kramer & De Smit, 1977:14)

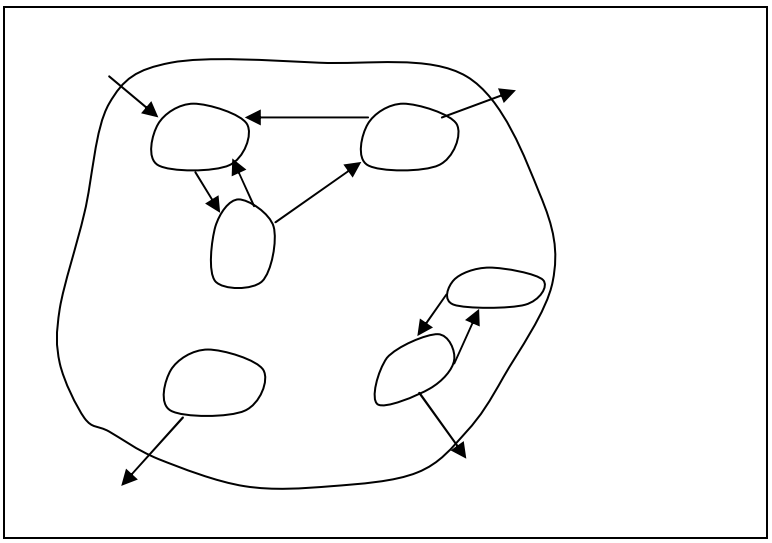


Figure 3.3 Aggregate (Kramer & De Smit, 1977:14)

3.2.3 Different classes of systems

Checkland (1981:110) specified different classes of systems: natural systems, human activity systems, designed physical systems, designed abstract systems and transcendental systems. The relationship between these classes of systems is depicted in figure 3.4.

Natural systems are systems whose origin is in the origin of the universe and which are as they are as a result of the forces and processes which characterise this universe (Checkland 1981:110). A designed physical system is a physical system designed with fitness for purpose in mind, for example, a hammer. Designed physical systems exist because a need for them in some human activity system has been identified (Checkland, 1981:119). Designed abstract systems, such as mathematics, poems, or philosophies, represent the ordered conscious product of the human mind. These abstract designed systems often lead to physical designed systems like books and films. Human activity systems describe the behaviour of people. They are less tangible than designed systems, but they are clearly observable. Transcendental systems are systems beyond knowledge.

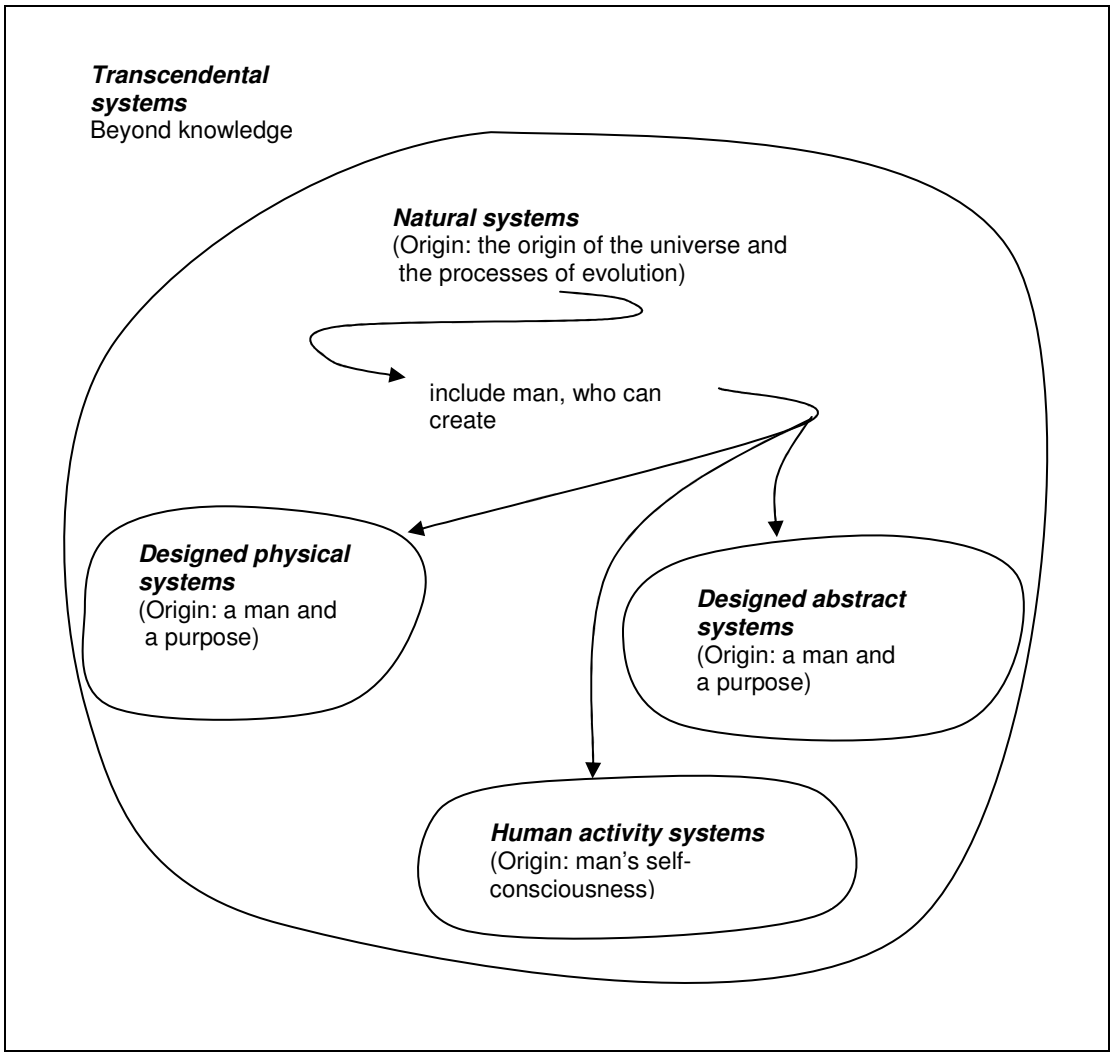


Figure 3.4 Five classes of systems (Checkland, 1981:112)

3.2.4 Systems as described by the systems approach of Churchman

Churchman (1968) developed a systems approach to address problem situations holistically. His work influenced many systems thinkers, such as Checkland and Jackson. It is presented here to serve as a methodology$_2$ for viewing a problem situation as a system. The work of Churchman (1968) is used as a structure for the discussion of the framework for the use of specific systems methodologies$_{1\&2}$ in data warehousing practices given in chapter 6.

Churchman (1968:11) declares that: "Systems are made up of sets of components that work together for the overall objective of the whole." He discusses five characteristics of a system, namely the total system objectives, the system's environment, the resources of the system, the components of the system, and the management of the system. If we analyse a situation using these characteristics, we follow what Churchman calls "the systems approach".

3.2.4.1 The total system objectives

When studying a problem situation in terms of a system, one needs to state a total objective of the system. This is much harder than it appears to be. The stated objective sometimes differs from the real objective. Churchman (1968:31) gives the example of a medical test laboratory that states their objective to perform as accurate tests as possible. Their real objective is not "accuracy" but what accuracy is good for, i.e. improving the doctor's diagnosis. If their objective is accuracy, they might sacrifice other objectives, for example spending funds wisely or containing costs. We sometimes hide our real objectives, because we believe they will not be acceptable from other's point of view. The difference between the stated objective and the real objective is that a person will not sacrifice his real objective to attain some other goal. The systems analyst should therefore identify the single goal of the system that will not be sacrificed in favour of any other goals.

The ability to measure performance goes hand in hand with stating clear objectives. We need a score to see how well the system is performing. Churchman (1968:31) uses the performance measure of a large organisation as example. Should the stated goal of increasing net profit be considered as a real goal? Should the real goal not be to increase the gross profit and the growth of personnel numbers? Will the managers be willing to sacrifice a little bit of the net profit to increase the size of

the organisation? The true measure of performance will help us to identify the true goal of a system. One should also refer to legitimate objectives as those that have to do with the morality of the systems objectives. An objective can only be a real objective if it is acceptable from a social point of view. One cannot state objectives without a very careful examination of the consequences of these objectives.

3.2.4.2 The system's environment

Churchman (1968:35) defines the environment of a system as that part that is outside the system. Ackoff (1971:662) defines the environment of a system as "a set of elements and their relevant properties, which elements are not part of the system but a change in any of which can produce a change in the state of the system. Thus a system's environment consists of all variables that can affect its state. External elements that affect irrelevant properties of a system are not part of its environment. The state of a system at a moment of time is the set of relevant properties which that system has at that time".

Are roads part of the system of the automobile? To answer this question, we should rather ask: "Can roads be controlled by the automobile?" If we say the automobile can influence the design of roads (e.g. the steepness of the inclines, etc.) then roads are part of the system of the automobile. Others may reason that roads can influence the design of the automobile but not the other way round. Roads then become a constraint in the design process of the automobile and therefore should be seen as the environment of the automobile. This type of situation motivates Ackoff (1971:663) to say that the elements that form the environment of a system and the environment itself, may be conceptualised as part of a system when they become the focus of attention. Every system can be conceptualised as part of a larger system.

The environment determines in part how a system performs (Churchman, 1968:36). The demand for an industrial firm's product determines partly how the firm performs. Demand for the product is an example of the requirement schedule of the environment of a system.

3.2.4.3 The resources of the system

Resources are the means that the system uses to reach its objective. The system has control over the resources. Resources can be influenced to increase their

advantage to the system. Churchman (1968:38) argues that, although a balance sheet is used to indicate a firm's resources, it does not show all the resources, for example peoples' potential. The same can be said about an income statement; it is supposed to show how the resources were used, but it does not show anything about lost opportunities. He argues that a firm needs an information system to keep track of its resources, as well as how they were used or not used in lost opportunities. Churchman (1968:39) states that "resources are the general reservoir out of which the specific actions of the system can be shaped."

3.2.4.4 The components of the system

Large systems need to be divided into components to aid the management scientist in determining the performance of the total system. If the performance of components can be identified, it is possible to improve the performance of the whole system. The parts or components of the system are the different activities or jobs the system has to perform. These may also be called "missions". This differs from traditionally dividing organisations into departments. Churchman (1968:40) argues that the traditional division of organisations is not a functional division of the objective of the organisation. Production and Sales should be one department, since it is the production department that produces the product with which the customer is satisfied or not. In the traditional departmental division of an organisation, each department forms part of several missions in the organisation; this makes it very difficult to measure the performance of the different missions of the organisation. The ultimate aim of component thinking is to discover those components (missions) whose measures of performances are truly related to the measure of performance of the overall system (Churchman, 1968:43).

3.2.4.5 The management of a system

The management of a system has to deal with the generation of plans for the system. This includes the setting of the overall goals for the system, defining environment, the utilisation of resources, and the division of the system into components (Churchman, 1968:44). It is not the role of the systems analyst, (Churchman (1968) calls him the management scientist), to manage the system; he or she can aid the management team in reviewing the control procedures. These controls include checking the performance of the system against the set objectives, as well as adapting the system to changes in its environment (Churchman, 1968:45).

Checkland and Scholes (1999:22) indicate a shift in the understanding of the term system. They see a system as an abstraction of the notion of a whole, not as a physical description of a part of the world. To perceive something as if it was a system, differs from declaring it a system. The word 'holon' is used to emphasize this distinction. This term is discussed in section 3.5.2.1 as part of the soft systems methodology$_2$.

3.2.5 Systems thinking and the systems approach

Systems thinking is the study of objects as wholes and synthesising all the relevant information regarding an object, in order to have a sense of it as a whole (Kay & Foster, 1999:165). An object (system) is seen as part of a larger system or whole but also made up of smaller systems. This leads to a hierarchy of systems.

The whole (sum of the parts) has emergent properties that cannot be found in any of the parts. The specific structures and processes that glue the whole together are responsible for these properties and need to be analysed. These processes and structures are studied in terms of inputs, outputs, transformations, and interconnections between the components that make up the system.

3.2.5.1 The input-output systems approach

When applying the systems approach as described in Churchman (1968:61), a model is used to aid the analyst's understanding of the situation. This model is tested frequently against the environment to determine the approximation of reality. In doing so, data from current, as well as past events, is used. The input-output systems approach is such a model. The system receives inputs, which are transformed to yield outputs. The system becomes the black box that transforms the inputs into the desired output. It is this black box that interests the systems analyst.

Churchman's five characteristics of the systems approach can be related to the input-output systems approach. The environmental constraints, as well as the resources of the system, can be seen as the inputs to the system. When determining the performance measure, Churchman (1968:63) warns that the total output amount is not likely to be the performance measure of the system. The cost of transformation,

measurable in terms of input, should be taken into account. The performance measure of the system will be determined by the weighted output minus the input costs, where output is weighted by a quality assurance measure. The components of the systems can be related to the activities that are performed inside the system.

3.2.5.2 Objectives of systems thinking

Kramer and De Smit (1977:7) argue that systems thinking will aid the formulisation of theories where the organisation is the central point of study. Organisations should be approached as integrally as possible while different aspects are being investigated, thus constituting a multidisciplinary approach.

The interdisciplinary nature of problems is the motivation for a systems approach, according to Ackoff (1974:14). He argues that, although in the past, complex problems could be broken up into parts suitable for different disciplines, this is no longer possible. Solutions for these subproblems do not provide a solution for the original problem as a whole, since a variety of disciplines work together on the problem as a whole. This is clear in the academic movement away from the definition of new disciplines towards combining different disciplines to enlarge the class of phenomena with which they are concerned (Ackoff, 1974:15).

Interdisciplinary thinking is one of the main objectives of systems thinking. Von Bertalanffy (1968:38) summarises the objectives of general systems theory in five points:

"1. There is a general tendency towards integration in the various sciences, natural and social.
2. Such integration seems to be centred in a general theory of systems.
3. Such theory may be an important means of aiming at exact theory in the non-physical fields of science.
4. Developing unifying principles which run 'vertically' through the universe of the individual sciences, this theory brings us near to the goal of the unity of science.
5. This can lead to a much-needed integration of scientific education."

The term "systems approach" refers to methodologies$_2$ for problem solving and design (Kay & Foster, 1999:170). The soft systems methodology$_2$ is discussed in section 3.5.2 as an example of a systems approach. The input-output systems

approach, as well as Churchman's (1968) approach to problem solving through analysing the problem situation in terms of objectives, environment, resources, components and management, can be seen as examples of systems approaches.

3.2.5.3 Developments in systems thinking

Midgley (2000:191) refers to a first and a second wave in systems thinking. The first wave of systems thinking is criticised for regarding models as representations of reality, rather than aids for the development of inter-subjective understanding (Midgley, 2000:191). The first system approaches are also criticised for viewing human beings as objects that could be manipulated as parts of larger systems, instead of individuals with their own goals, which may or may not harmonise with wider organisational priorities.

The first wave of systems approaches can be viewed as quantitative applied science, which failed to see the value of bringing the subjective insights of stakeholders into activities of planning and decision making (Midgley, 2000:192).

In second wave systems thinking, systems are no longer viewed as real life entities, but rather as constructs to aid understanding, with the emphasis on dialogue, mutual appreciation and the inter-subjective construction of realities. Midgley (2000:193) credits the work of Churchman (1979), Ackoff (1981) and Checkland (1981) for this paradigm shift in systems thinking. These developments in the understanding of systems, coincide with different systems methodologies$_1$ described in section 3.4.

3.2.6 Application of the systems approach

Churchman (1968) and Ackoff (1974) describe the application of a systems approach in a variety of situations, including social problems. This section contains general advice on the application of a systems approach resulting from the illustrations of Churchman and Ackoff.

A decision maker needs to be identified before the systems analyst is able to describe the situation as a system. The system's decision maker is often a different party from the one initialising the investigation (Churchman, 1968:50). Only the decision maker will be able to state the real objective of the system, which is often

very difficult to determine. The reader is reminded that every component's objective should be in harmony with the system's objective. Objectives are often a quality-weighted difference between income generated by the output of the system and the cost of its resources. In an information system environment, the objective may be to provide information. In this regard, Churchman (1968) describes a library, where the objective may be to provide information or knowledge to the client. He highlights the problem of too much information, where information creates information, and the dilemma arises to determine what information is worth storing. The quality of service to the client is not only dependent on the volume of information, but also on the provision of useful information within a specific timeframe.

In a practical problem environment, one is quickly reminded of the interdisciplinary holistic nature of the systems approach, when the number of interested parties grows very quickly. The stated objective of the system should be to benefit all the interested parties. However, one should analyse the role players carefully to determine who form part of the environment and who form part of the system's resources. Once again, the key is to decide whether the decision maker can determine the conduct of the specific party. If the conduct of the party cannot be determined by the decision maker, the party should be viewed as part of the system's environment. If the decision maker can determine the conduct, the party is part of the resources of the system and should be used to optimise the goal of the system.

Factors belonging to the environment of a system can be studied with statistical methods, enabling the systems analyst to predict the occurrences of these events. Churchman (1968:56) uses simulations of past data, as well as mathematical formulas to simulate the environment of a system. If the systems analyst is able to predict the events in the environment of the system, his chance of reaching the system's objectives increases dramatically. Linear programming models are often used to describe the environmental constraints of the system. Although this method is useful in some cases, it restricts the model to linear equations, and it is difficult, if not impossible, to include value constraints. Different methods for studying the systems' environment are proposed by specific systems thinking methodologies$_2$.

It is the aim of system thinkers to describe social systems where people and their values form part of the system. Since mathematical models are not capable of representing values in the system, the systems analyst should be open to using other methods for describing values in the system. The analyst should make an early

decision on the influence of politics in his/her working environment. Although many people prefer to ignore the politics of the situation, it may lead to the failure of the project. It is important to be aware of the internal opposition towards the project, as this will assist in managing the consequences of future objections.

One of the key principles of systems approach is the hierarchical nature of the system. This implies that a system is always part of a larger system. Churchman (1968:137) states that the larger system may be the future world. The larger system is then infinite, stretching endlessly into future generations. The future can be described through stages of the system. The duration of each stage and the time between stages is relative to the system. Network models and PERT diagrams are very helpful in describing multistage systems. Planning is the best way of handling the future. Planning from a systems thinking perspective, should be divided into parts; a decision maker may choose from alternative courses of action in order to reach certain first-stage goals, which in turn lead to other stage objectives (Churchman, 1968:150). The effectiveness in terms of the stage's goal and the overall objectives of each alternative should be measured before the decision maker selects one of the possible alternatives. The effectiveness of an alternative is dependent on current, as well as future events, while possible future consequences of the current decisions should be investigated before an alternative is chosen. Once a plan is in action, new information needs to be fed back to aid the decision maker in altering the plan. Many systems thinkers compare this feedback to the feedback loop in cybernetics.

The last part of this section deals with the ability of the systems approach to incorporate human values in the system. The first question the systems analyst should ask himself, is whether it is his responsibility to determine the real objectives of the system. The determination of the real objectives is an extremely difficult process, mainly because the role players are not able to articulate their real objectives. Since the determination of the systems objectives are crucial to the success of the systems approach, the systems analyst cannot escape the responsibility of determining the systems objectives, or at least be part of the process.

Human values should enter the systems analyst's framework right at the beginning of the process. The real objectives of the system should include the values of the customers. The customers can be different parties and the system can be multi-

staged. This leads to increased complexities when determining the objectives. One method of dealing with human values is to quantify them. The analyst should strive to assign a monetary value to a stated value-based objective of the customer. The severity of illness for example, can be measured in days absent from work. The degree of complexity increases when there is more than one customer. The analyst will not always be able to find a representative customer and although it is sometimes possible to create a fictitious representative customer, most often weights need to be assigned to the objectives of the various customers. Because this is such a complex problem, an iterative process is advised.

This discussion of practical implementation of the systems approach was done independently of different systems methologies$_{1\&2}$ in order to introduce the reader to the general ideas of systems thinking and a systems approach to problem solving.

The main argument in this chapter is to study the philosophical background of systems thinking methodologies$_1$ and systems practice, before applying a systems methodology$_2$ to a specific problem situation.

3.3 Philosophical foundations of systems thinking in organisations

Different views of systems have different philosophical foundations. Hard systems thinking for example, can be connected, amongst others, to the work of the Austrian philosopher Karl Popper and critical systems thinking to that of Jürgen Habermas. The discussion given in section 3.4.1 on systems methodology$_1$ refers to the work of these philosophers. This section firstly introduces the work and ideologies of influential philosophers and secondly, explores the two dimensions of subjectivity versus objectivity and order versus conflict.

3.3.1 Philosophers that influenced systems thinking

The work of three philosophers, who had a forming influence on systems methodologies$_1$, is discussed in this section.

3.3.1.1 Karl Popper (1902-1994)

Karl Raimund Popper was born on 28 July 1902 in Vienna. Although he was a Marxist in his teens, he later became a Social Democrat. He did a lot of work in the community and became a Mathematics and Physics teacher, but philosophy occupied most of his time. Popper is best known for his falsification theory and his critique on logical positivism and Marxism.

For our purposes, Popper can be seen as a realist. He assumes that the material world exists independently of experience (Magee, 1973:46). Popper was opposed to Wittgenstein's obsession with the meaning of language. He agreed with Russell's view that language is transparent, in other words that language is a medium which could be employed without paying attention to it. Midgley (2000:23) states that Popper starts from the premise that knowledge, and the language that frames this knowledge, reflect the real world.

Popper (1982:114) described his world view in terms of three worlds: "By 'World 1' I mean what is usually called the world of physics: of rocks, and trees and physical fields of forces. I also mean to include here the worlds of chemistry and biology. By 'World 2' I mean the psychological world. It is studied by students of the human mind, but also of the minds of animals. It is the world of feelings of fear and of hope, of dispositions to act, and all kinds of subjective experiences, including subconscious and unconscious experiences. By 'World 3' I mean the world of the products of the human mind. Although I include art in World 3 and also ethical values and social institutions (and thus, one might say, societies), I shall confine myself largely to the world of scientific libraries, to books, to scientific problems, and to theories including mistaken theories."

Magee (1973:54) describes the independence of Popper's World 3 when he states: "Popper makes use of the notion not only of objective world of material things (which he calls World I) and a subjective world of minds (World 2) but of a third world of objective structures which are the products, not necessarily intentional, of minds or living creatures; but which, once produced, exist independently of them….and man's abstract structures have at all times equalled in scale and degree of elaboration his transformation of the physical environment: language, ethics, law, religion, philosophy, the sciences, the arts and institutions…..Their objective existence in relation to him meant that he could examine them, evaluate and criticise them,

explore, extend, revise, or revolutionise them, and indeed make wholly unexpected discoveries within them. And this is true of his most abstract creation of all, for example mathematics."

Popper's view that the third world is independent of the people in the situation, leads us to describe him as a hard systems thinker.

Flood and Jackson (1991a:83) distinguish hard and soft system thinking by identifying hard systems thinking with the falsification of theories (Popper's work) and soft systems thinking with the exposition of ideas.

3.3.1.2 Jürgen Habermas (1929-)

Jürgen Habermas was born in 1929 and brought up in Nazi Germany. After teaching at Heidelberg, he moved to the University of Frankfurt in 1964 and thereafter to the Max Planck Institute, Starnberg, in 1971. Habermas attempts to develop a theory of society with a practical intention, namely the self-emancipation of people from domination. His critical theory aims to further the self-understanding of social groups capable of transforming society (Held, 1980:250). This is also an attempt to disclose the fundamental interests of mankind as such, extending beyond technical issues. Habermas (1974:32) writes: "The theory serves primarily to enlighten those to whom it is addressed about the position they occupy in an antagonistic social system, and about the interests of which they must become conscious in this situation as being objectively theirs."

Habermas (1984:69) describes three "worlds", i.e. the external natural world, our social world and my internal world. These "worlds" are tightly interconnected, and it is our use of language that allows us to differentiate between them. These three worlds are present in everything we say and it is part of the art of reasoning to identify the speaker's inherent assumptions about the three worlds. This implies that the speaker says something about all three worlds, without even realising it himself (Midgley, 2000:27).

Habermas' interest constitution theory, in terms of which the interest of social theories reflects either a technical interest for prediction and control, or a practical interest for understanding human communicative interaction, or an emancipatory interest in social relations of power, domination, and alienation, can be seen as a

reaction against the "scientisation of politics", in which the laws of science are applied to politics. McCarthy (1978:1) (a leading commentator and translator of Habermas' work) states that Habermas' "theory of society conceived with practical intent" emerges from "extended reflections on the nature of cognition, the structure of social inquiry, the normative basis of social interaction, and the political, economic, and socio-cultural tendencies of the age." This is done in opposition to positivistic methods that according to Habermas, conceals the scientist's commitment to technological rationality behind the façade of value-freedom. Habermas strives to relate theory to practice different from the scientism approach, where the scientist criticises all non-scientific forms of theory and all non-technological conceptions of the relation of theory to practice, as a means of removing all barriers to the dominance of scientific thought and its technical utilisation (McCarthy, 1978:8). Habermas proposes the use of different methodological$_2$ rules and practices for the study of technical, practical, and emancipatory knowledge (Flood and Jackson, 1991a:6)

The work of Habermas is important for our purpose as a basis for critical systems thinking and the development of a critical systems methodology$_2$, based on a pluralistic use of different methodologies$_2$ and suitable for different aspects of a specific problem situation.

3.3.1.3 Herman Dooyeweerd (1894-1977)

Herman Dooyeweerd was born in Amsterdam on 7 October 1894. He grew up in a Calvinistic home and was influenced by the reformed protestant Abraham Kuyper. He studied law and later worked for the Department of Labour in the national government in The Hague, drafting labour relations law. From 1921 to 1926 he served as assistant director of the Abraham Kuyper Foundation, a research and policy organ of the Anti-Revolutionary Party of The Netherlands. In 1926 he became professor in legal philosophy at the Free University of Amsterdam. He retired in 1963 and passed away in 1977.

Dooyeweerd proposed a new framework for theoretical thinking in which he discussed fifteen aspects of reality. Dooyeweerd (1969:4) argues that it is possible to describe all aspects of reality in terms of his fifteen aspects. Kalsbeek (1975:40) summarises these aspects (from Dooyeweerd (1969)) by means of an example

presented in table 3.1. He discusses the fifteen aspects in terms of the launching of a manned space vehicle:

Aspect	Meaning	Typical Activities
Arithmetic	discrete quantity	Calculations of all kinds from the number of food packages to the precise number of minutes until splashdown.
Spatial	continuous extension	The amount of space required for the crew, their instruments, equipment, and waste materials.
Kinematic	motion	The predictable movements caused by the moon's gravitational pull; the kinds of movements expected at each stage of a normal lift-off.
Physical	energy	The peculiar properties of the fuels that make them ignite.
Biotic	vitality (life)	The precise test on the affects on the crew's breathing, circulation, digestion, etc.
Sensitive	feeling	Tests to determine how the men will react emotionally to weightlessness or cramped quarters.
Analytic / logical	distinction	The detailed planning of every distinct part of the project long before it was put on paper.
Historical	formative power	The development of a culture capable of such a project; a stage of technique capable of accomplishing it.
Lingual	symbolic meaning	Development of new sets of symbols to describe new activities.
Social	social intercourse	The social cohesion developed among the crewmembers; their relationship with the people on the ground.
Economic	frugality in managing scarce goods	Careful budgeting to finance each item.
Aesthetic	Harmony	The beauty of the lift-off that inspires all sorts of new works of art.
Juridical	Retribution	The question of "free space"; negotiations to determine whose laws and courts will control the activities carried on in space.
Ethical / moral	love in temporal relationships	The efforts to justify spending enormous sums of money on space flights in the face of widespread starvation over much of the earth.

Pistic	faith, firm assurance	Man's opinion of himself and his work revealed in the vision of space travel: Wanton arrogance (the Greek *hubris*)? The pioneering spirit? The urge to control the universe through the sovereign power of technology? An effort to obey the cultural mandate? Both the questions and the answers given relate to the faith aspect of the whole project.

Table 3-1 Meaning and application of Dooyeweerd's aspects (Kalsbeek, 1975:41,100).

Dooyeweerd (1969:4) describes the relationship between the aspects: "The relation between the specific sovereignty of each separate modal law-sphere and the temporal coherence of meaning of all the model spheres is not intrinsically contradictory."

According to Dooyeweerd, these aspects can be observed in everything that exists in temporal reality. Kalsbeek (1975:38) tests this by applying the aspects to different things, for example looking at a tulip and describing an arson act on a farm.

Dooyeweerd's thinking is important to us because it forms the basis of disclosive systems thinking, and it can be seen as a complement to soft systems thinking. Basden (2002:11) proposes that Dooyeweerd's aspects be used to improve our understanding of information systems.

3.3.2 Two dimensions of thought in philosophy of system design

Burrell and Morgan's method (1979:2) for social sciences concentrates on assumptions related to ontology, epistemology, human nature and methodology$_2$. Jackson (2001:241) acknowledges the influence of this work on the development of critical systems thinking. Hirschheim and Klein (1989:1201) follow the same ideas when they define four paradigms of information system development. Their paradigms concur with those of Burrell and Morgan (1979:22). It is important to understand the above assumption fields first.

- *Epistemological:* The foundations or sources of knowledge.
- *Ontological*: Assumptions concerned with the very essence of the phenomena under investigation; it concerns the worldview of the investigator.

- *Human Environment:* Relationship with the environment and specifically the degree to which an individual is able to influence this environment.
- *Methodologies*$_2$*:* As described by Burrell and Morgan (1979:2), this deals with the involvement of the investigator and the methods of investigation with regard to the situation and the concepts.

There are two dimensions in which these assumptions can be described, namely the objectivism - subjectivism and the order - conflict dimensions. Burrell and Morgan (1979:16) argue that the latter should rather be described as the regulation-radical change dimension. Figure 3.5 depicts these dimensions.

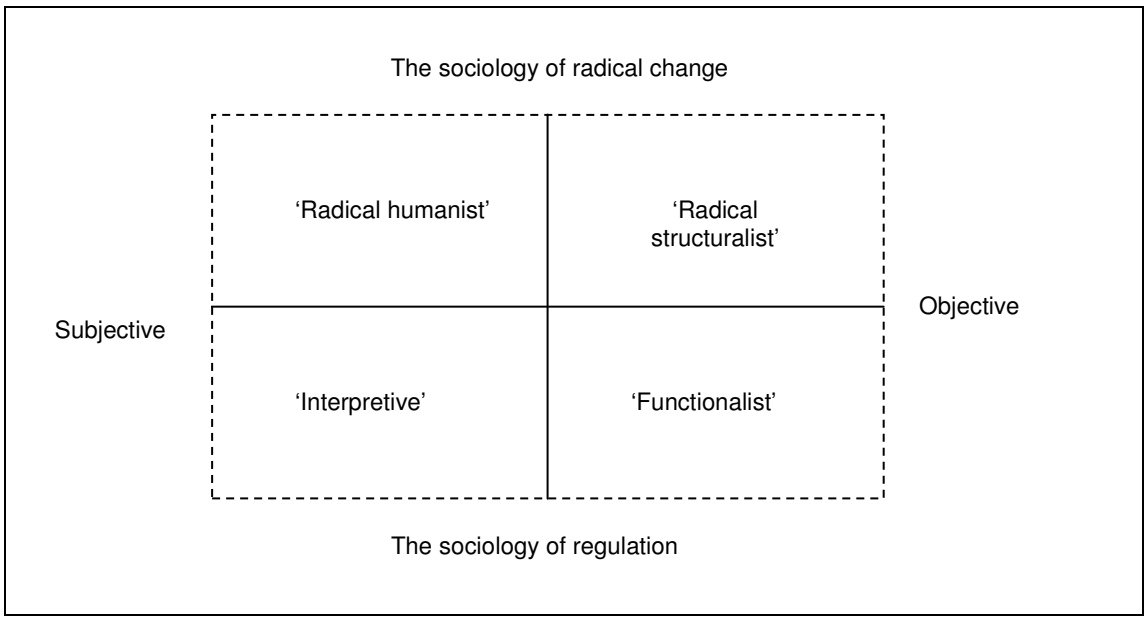


Figure 3.5 Four paradigms for the analysis of social theory (Burrell & Morgan, 1979:22)

It should be noted that intellectual traditions mix these assumptions in terms of objectivity and subjectivity. It is therefore important to distinguish between the four fields of assumptions. Let us first examine the subjectivism versus objectivism dimension according to the above-mentioned assumptions.

3.3.2.1 The subjective – objective dimension

Ontological assumptions

Perceived subjectively, the social world, external to individual cognition, is made up of nothing more than names, concepts and labels that are used to structure reality.

There is no real structure in the world and structure exists only in the mind of the observer, leading to different perceptions of reality. This is called nominalism.

Perceived objectively, the social world, external to individual cognition, is a real world made up of hard, tangible and relatively immutable structures. Even if we do not label all structures, they still exist. This is called realism.

Epistemological assumptions

Burrell and Morgan (1979:5) argue that one can only understand a situation by being part of that situation. One has to understand it from the inside, rather than from the outside, and it is not possible for science to generate objective knowledge of any kind. This is called anti-positivism, which is subjective in nature.

Burrell and Morgan (1979:5) use positivism to characterise "the epistemologies that seek to explain what happens in the social world by searching for regularities and causal relationships between its constituent elements." The observer is objective towards the situation and should not influence the situation.

Assumptions about human nature

Subjectively speaking, man is completely autonomous and free-willed, which leads to voluntarism. Objectively speaking, man and his activities are viewed as being completely determined by the environment or situation in which he is located, which leads to determinism.

Methodological$_2$ debate

In terms of ideographic methodology$_2$, one can only understand the social world by acquiring first hand knowledge. One needs to search inside situations by exploring history and background and allowing the subject to reveal its nature and characteristics during the process of investigation. This is a subjective approach.

In terms of nomothetic methodology$_2$, research is done according to systematic protocol and technique. The systems analyst is pre-occupied with the construction of scientific tests and the use of quantitative techniques for data analysis.

3.3.2.2 The order – conflict dimension

The second dimension in which approaches to sociology can be classified is the order-conflict dimension. At the one end of the spectrum are the approaches that concentrate on the stability, integration, functional co-ordination and the consensus in society, focussing on the status quo.

At the other end are approaches which are concerned with the problems of change, conflict, coercion, modes of domination and emancipation of society. Jackson, (1991:19) describes the conflict or "radical change" end of the dimension as: "Society is seen as being driven by contradictions and by structural conflict. Some groups of society benefit at the expenses of others; any cohesion that exists is achieved by the domination of some groups over others. The sociology of radical change looks beyond the status quo." A summary given by Burrell and Morgan (1979:18) of the radical change dimension is given in table 3.2.

The sociology of **regulation** is concerned with:	The sociology of **radical change** is concerned with:
The status quo	Radical change
Social order	Structural conflict
Consensus	Modes of domination
Social integration and cohesion	Contradiction
Solidarity	Emancipation
Needs satisfaction	Deprivation
Actuality	Potentiality

Table 3-2 The regulation-change dimension (Burrell & Morgan, 1979:18)

3.3.3 Four paradigms of thought in philosophy of system design

When the two dimensions discussed above are presented graphically, the four quadrants represent four paradigms. A paradigm is the most fundamental set of assumptions adopted by a professional community, allowing its members to share similar perceptions and engage in commonly shared practices (Hirschheim & Klein, 1989:1201). The four paradigms are demonstrated in figure 3.6. This section examines each of these paradigms.

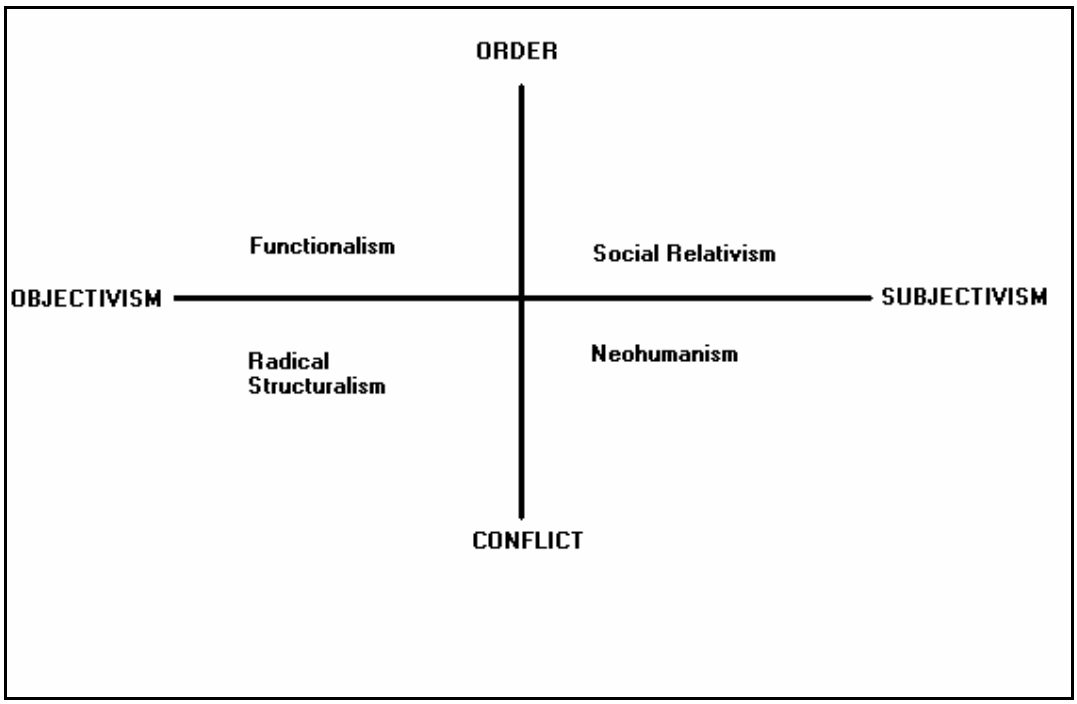


Figure 3.6 Information systems development paradigms (Hirschheim & Klein, 1989:1202)

3.3.3.1 Functionalism (objective – order)

Functionalism explains the status quo, social order, social integration, consensus, and the need for satisfaction and rational choice. The way in which elements interact to form an integrated whole, is investigated.

3.3.3.2 Social relativism (subjective – order)

Social relativism explains the problem situation from the role of individual consciousness and subjectivity and within the frame of reference of the social artiste, as opposed to the observer of the action. Social roles and institutions exist as an expression of the meanings humans attach to their world.

3.3.3.3 Radical structuralism (objective - conflict)

Radical structuralism emphasises the need to overthrow or transcend the limitations placed on existing social and organisational arrangements. It focusses on the structure and analysis of economic power relationships.

3.3.3.4 Neohumanism (subjective – conflict)

Neohumanism seeks radical change, emancipation and potentiality, and stresses the roles that different social and organisational forces play in understanding change.

3.3.4 Paradigm differences in system development

The role of a systems analyst may differ according to each of these paradigms. The following section describes typical systems analysis views for each of the paradigms.

3.3.4.1 Functionalism (objective – order)

The epistemology is that of positivism and the ontology that of realism. The systems analyst is seen as an expert in technology. The management of the client organisation provides the system objectives and is responsible for clarifying any contradictions or opposing views of the problem situation. The aim is to set up an objective problem statement or specification that models reality in an objective manner. Politics in the organisation is ignored. The success of the system is tested by means of objective predetermined tests. The chief objective of the system is to increase profitability through effectiveness (Hirschheim & Klein, 1989:1212).

The main shortcoming of this view is the assumption that it is possible to define the problem clearly and objectively. It is assumed that the objectives are agreed upon. The social conventions of the organisation are reduced to economic laws. This approach leads to a situation where new systems are forced upon users by the management of the organisation, which in turn leads to end-user resistance to change.

3.3.4.2 Social relativism (subjective – order)

The epistemology is that of anti-positivism and the ontology that of nominalism. There is no single reality, only different perceptions about it. System objectives emerge as part of the organisational construction of the reality where the systems analyst works from within the user's perspective. The system is successful if it meets with the approval of the affected parties. Different perceptions help to clarify the problem situation.

The main shortcoming of this approach is that it is completely uncritical of potential dysfunctional side effects of using particular tools and techniques (Hirschheim & Klein, 1989:1204). It does not look for hidden agendas of people and view the situation as harmonious.

3.3.4.3 Radical structuralism (objective - conflict)

The epistemology is that of positivism and the ontology that of realism. It assumes that fundamental social conflict is endemic to society. There is conflict between those who own the sources of production and labour. This is viewed from outside the organisation as an objective economic reality. The developers should choose to side with management and become their agent, or to join the interests of labour. When they side with managers, they affect the interest of work by changing the instruments of work or changing the objective of work to be more profitable. Most often they choose to side with labour to enhance traditional skills and craftsmanship, thus making their work more rewarding economically and psychologically. Productivity gains must benefit the workers. The purpose of systems development should be to overcome the constraints of capitalism by supporting labour activism. This reflects the principles of Marxism. The systems analyst reflects a critique of the status quo with the aim of providing the rationale for radical change (Hirschheim & Klein, 1989:1210).

The major shortcoming of this approach is that it reduces the possibility of a justified consensus where co-operation instead of conflict is sought. It is uncritical of the effects of social differentiation introduced by organising class interests into unions. Finally, it assumes that there are immutable nature-like laws that determine the future of society (Hirschheim & Klein, 1989:1207).

3.3.4.4 Neohumanism (subjective – conflict)

The epistemology is that of anti-positivism and the ontology that of nominalism. The analyst can be seen as emancipator or social therapist. Through systems development, organisational life is changed, but the reality of this change is heavily constrained by social influences which channel the values, norms and perceptions of all participants (Hirschheim & Klein, 1989:1207). The concepts of work, mutual understanding and emancipation are the three fundamental domains around which society and other forms of social organisation are arranged. Interest in technical

knowledge directs the developer to be sensitive to issues associated with effective and efficient management of the system project, such as communicative difficulties.

This view is hypothetical and it is constructed from theory in reaction to the three previous scenarios (Hirschheim & Klein, 1989:1207). This view also compliments the critical social theory as described by Lee (1999:24).

3.3.5 The problem environment: Organisational structures

Every information system operates in some form of organisation. There are two major organisational structures that influence the role of the systems designer, namely the bureaucratic and the organic structures.

Dahlbom and Mathiassen (1993:16) explain the bureaucratic organisation as one where the behaviour of its actors is predetermined and predictable. The organisation relies on rules to prescribe behaviour and to achieve co-ordination. The assumption is that the actors know in advance what to do and therefore uncertainty in the organisation should be minimised. Management is separated from production and workers should not make decisions. A bureaucratic system adapts very slowly to a changed environment because everybody follows a set of predetermined rules. A computer is the perfect bureaucrat and it inspires us to think like bureaucrats.

The organic approach, in contrast to the bureaucratic approach as an extension of the mechanistic worldview, is an extension of the romantic worldview. The organisation is seen as a network of informal and direct interactions between individuals or groups. The assumption is that the task uncertainty is high. Information is shared among everyone as soon as it is available. Organic systems are designed to cope with dynamic environments. Electronic mail as informal communication medium is an example of the use of computers in an organic organisation.

3.4 Systems thinking methodologies[1]

There are three different ontological views of a system, i.e. hard systems, soft systems and critical systems. Checkland (1981) initially described the differences

between hard and soft systems. Jackson (1991) extended these views on systems to include the critical systems approach, thereby also extending Ulrich's (1983) critical systems heuristics. Ontologically hard systems can be described as realistic and soft systems as nominalistic. Critical systems can be viewed as nominalistic in the radical change or conflict dimension.

Different epistemological views on system development do not correspond necessarily to the ontological views of systems. However, there are similarities between the system views and the development approaches. In this section, construction, evolution and intervention are discussed as views on system development. Construction can be seen as a positivistic approach in contrast to the anti-positivistic evolution process. Intervention is viewed as the application of the critical systems approach.

3.4.1 Ontological views of systems

This section introduces hard, soft and critical systems thinking. Midgley (2000:224) explains the differences in these systems approaches. The first wave of systems approaches can be referred to as hard systems approaches which supported one particular human interest, namely our technical interest in predicting and controlling our environment. Second wave systems thinking involves managing debate between people so that learning may be facilitated, ideas evaluated, and plans for action developed. The third wave of systems thinking, critical systems heuristics, is concerned with subjecting assumptions in planning ethical critique. In order to get a better understanding of the three types of system thinking, it is necessary to examine the ontological views of hard, soft and critical systems and systems thinking.

3.4.1.1 Hard systems thinking

The term "hard systems" is used by Checkland (1981) as an alternative to "soft systems". Hard systems thinking refers to systems engineering thinking where a systematic process of problem solving is followed. Checkland (1981:125) refers to a hard systems approach as an approach to problem solving with the assumption that the problem task is to select an efficient means of achieving a known and defined end. Systems engineers attempt to solve social problems as if they were scientific problems. Their view of a system differs greatly from the soft systems approach.

The work of realists, such as Popper, can be viewed as the foundational philosophy of hard systems thinking.

True to its realistic nature, hard systems form an exact and true representation of the world. Each system can be seen as a hierarchically organised set of elements (Dalhbom & Mathiassen, 1993:48). This implies that a system can be taken apart to be understood. If one is able to describe the basic elements of a system, one should also be able to describe the functionality of the system. The hard systems approach emphasises the internal structure of the system. If the function of the system is understood, the system itself is understood. A model is seen as a true representation of the world, and all attempts should be made to improve the model to be a more accurate representation of the world.

The development of information systems has been influenced mainly by hard systems thinking. The major method of problem solving is top-down design, in which the problem is broken up into smaller, more understandable sub-problems. If the problems on the lowest level of the hierarchy can be solved, the entire problem can be solved. This approach is known as stepwise refinement (Dahlbom & Mathiassen, 1993:50). Structured programming and structured design techniques are both examples of the hard system approach in information systems. The waterfall method for systems engineering views the systems development process as an objective approach that will yield objective, testable, and effective systems, answering to the problem specification. Formal problem descriptions and design methods, such as entity relational diagrams, are all part of the hard systems approach.

Information according to the hard approach is seen as processed data or signals, and the main task of an information system is to process raw data into useful information. The development of an information system is seen as a technical project, which can be done outside the context of the environment. This is in contrast with the soft systems view of a cultural, rather than a technical, phenomenon (Checkland & Scholes, 1999:54).

3.4.1.2 Soft systems thinking

One of the major shortcomings of the hard systems approach is that the problem is not always well defined. This makes it very difficult to reach consensus on the requirements for the new computer system. The soft systems approach views a

system as a representation of the human mind to make sense of the reality (Dahlbom & Mathiassen, 1993:53). The work of Churchman (1968) and Ackoff (1971) can be described as the foundation of the soft systems methodology$_2$ as described by Checkland (1981).

Where hard systems thinking views models as representations of reality, soft systems thinking views models as aids for the development of inter-subjective understanding. The view of human beings in a hard system environment is that of parts in a machine, or objects that could be manipulated as parts of larger systems. Soft systems thinking views human beings as individuals with their own goals which may or may not harmonise with organisational priorities (Checkland, 1981:117).

When soft systems methodologies$_2$ are used, consensus is reach by using a facilitator to guide the users of the proposed system, through a process of learning, to a requirements specification. The system analyst fulfils the role of a facilitator. The soft systems approach is nominalistic in that it describes the system as a person's perception of the real world. Although these perceptions may differ, the differences are not an indication of unsolvable conflict, but rather a way of better understanding the problem situation.

The soft systems approach is holistic in that the lowest level of a system hierarchy cannot define the system. The system's purpose cannot be determined by looking at the purpose of the individual components. The systems' emergent properties give purpose to the system. In an information system environment, this means that user success, as opposed to requirements conformation, is used as a measurement of success.

Various authors use different philosophers as foundation for soft systems thinking. Midgley (2000:26) uses Kelly, while Churchman (1970) refers to the work of Leibniz, Locke, Kant, Hegel and Singer. Checkland (1981:259) supports the work Churchman has done in studying foundational philosophies of soft systems.

Critics of the soft systems approach argue that this approach supports only one interest. It is not predicting and controlling the environment (as in hard systems thinking), but our practical interest in achieving human understanding. They argue that typical soft methodologies$_2$ do not emphasise power relationships in problem situations strong enough.

3.4.1.3 Critical systems thinking

Critical systems thinkers believe that the world is not fundamentally harmonious. Therefore, to understand, explain and make possible changes, one must think in terms of contradictions. Different perceptions can be seen as expressions of, and the means in, an irreconcilable conflict and power struggle between management and workers, or system developers and users (Dahlbom & Mathiassen, 1993:59). Contradictions are analysed in detail to find prospects for alliances; different types of interventions and suggestions for change are examined and evaluated. These considerations are used to select a strategy. Actions will be performed and the situation will change, as will our conceptions and beliefs. The world, rather than people's perceptions of it, is our primary source of learning. Trade-offs in computer systems are manifestations of contradictions inherently related to the use and development of such systems.

The philosophy of Habermas can be seen as the underpinning of critical system thinking (Midgley, 2000). Flood and Jackson (1991a) uses Habermas' theory of knowledge-constitutive interest and Ulrich (1983) uses Habermas' theory of communicative action. Midgley (2000) and Mingers (1995) use Habermas' theory of 'three worlds' to support methodological$_2$ pluralism.

Jackson (1991:184) discusses the five major commitments of critical systems thinking:

1. Critical systems thinking seeks to demonstrate critical awareness. This critical awareness means that the assumptions and values of current and future designs should be critically examined. The strengths and weaknesses of the theoretical underpinnings of available systems methods, techniques and methodologies$_{1\&2}$ need to be examined.
2. Critical systems thinking shows social awareness. This social awareness means that the organisational and societal pressures that lead to certain system theories and intervention methods used at particular times, should be recognised. System practitioners should also study the possible consequences of their actions more carefully than before.
3. Critical systems thinking is dedicated to human emancipation. It seeks to achieve for all individuals the maximum development of their potential. This is accomplished by raising the quality of work and life in organisations and societies in which they operate (Jackson, 1991:186). Methodologies$_2$ aim to

improve the technical, practical and emancipatory interest in organisations and society.

4. Critical systems thinking is committed to the complementary and informed development of all the different stands of systems thinking at the theoretical level. This means that different points of view of systems must be respected.
5. Critical systems thinking is committed to the complementary and informed use of systems methodologies$_2$ in practice. A methodology$_2$ that respects the other four features of critical systems thinking is required.

3.4.1.4 Disclosive systems thinking

Strijbos (2000:159) introduced disclosive systems thinking as a methodology$_1$ to address the responsibility of people (whom he calls "societal agents") for particular developments. He asks how the responsibilities of different agents relate to one another and more importantly: "What are the norms for actions by the various agents?" He states that every systems methodology$_1$ implies a particular normative idea of systems ethics. This means that ethics are not just an afterthought, but that it is part of the chosen methodology$_1$.

Strijbos investigates the systems ethics and thus the normative principles that are implicit to hard, soft and critical systems thinking. He follows Dooyeweerd's idea of the clash between the ideal of personality and the science ideal. Strijbos claims that "human freedom is at risk of being destroyed rather than conformed by human scientific intervention in reality aiming to set people free. This tension between the two poles of freedom and control manifests itself through the whole history of modern Western thought." Hard systems thinking is oriented towards the pole of control, while soft systems thinking tries to shift to the opposite pole of freedom, but since it does not accommodate the underlying power struggle in the environment, it accepts the existing power relationships in the environment. As critical systems thinking is oriented towards the pole of freedom, seeking radical change in the environment, it is based on the "ethics of liberation" (Strijbos, 2000:168).

In contrast to critical systems thinking, disclosive systems thinking views the human being not as an autonomous law-giver or meaning-giver, but rather as a part of created reality. Man is searching for norms, not just creating them (Pothas *et al.*, 2002:158). Strijbos (2000:168) states that "'disclosive systems thinking' and the systems ethics entailed in it proceed from the normative view that the various

systems receive their meaning from the pre-given reality and order of which these systems are a part. In other words, the idea of an intrinsic normativity is accepted as a leading principle for human intervention in reality and the endeavour to shape the world. Or, better: human action forms a response to this intrinsic normativity and may as such disclose structural possibilities that are enriching for human life and culture." The fact that man is not able to change or intervene in every aspect of the problem situation, differentiates disclosive systems thinking from critical systems thinking.

Strijbos (2000:169) defines four principles of disclosive systems thinking which are quoted and explained in the following paragraphs.

"Primary for the development of human society and culture is the norm for the opening or *disclosure of everything in accordance with its inner nature or its intrinsic normativity*". In every situation there are natural laws governing that situation that people cannot ignore. However, there are also structure and norms in the situation that were formed over time; the situation can be seen as historically conditioned. There are certain given circumstances that were formed by tradition, culture and history. The expert guiding intervention in the situation must first identify this intrinsic normativity of the situation and secondly, be sensitive to the structure of the situation. Although other systems methodologies[1] see freedom as a result of control, disclosive systems thinking acknowledges that human intervention aimed at liberating people, often put human freedom at risk. A major difference between critical systems thinking and disclosive systems thinking is that in critical systems thinking, formative activity is seen as a way of imposing man's will on a situation, whereas disclosive systems views formative action as a sensitive response to the situation of which one is an intrinsic part.

"Characterising cultural formative activity as 'disclosure by response' leads to the identification of a second normative principle namely, the *simultaneous realisation of norms guided by the qualifying norm* for a particular area of human life." There are two ontological distinctions to guide understanding of the intrinsic normativity of a situation. First is the distinction between God, law and created reality, where law expresses the relation between God and reality, and secondly a distinction between entities and aspects. These coincide with the aspects of Dooyeweerd that were discussed in the previous section. It was explained that all aspects are present in reality and that these aspects are used to understand the intrinsic normativity of the reality. Disclosive systems thinking states that the simultaneous realisation of norms

in an action must be led by the distinctive character of the action, i.e. by the qualifying aspect and its accompanying norms for action.

”A third principle relates to the fact that systems methodology$_1$ usually concerns human activity in which a diversity of human actors is involved. So *disclosure results from a multi-actor process* in which the actor bears the responsibility to build a framework of co-operative responsibility for human action”. In a hard systems approach, the systems expert is seen as an outsider who is able to objectively determine what is good for those in the problem situation. In soft systems thinking, the expert spends time in determining which actors are involved and what their respective roles are. The expert is still an outsider but responsible to determine the different role players in the situation. In critical systems thinking, the expert becomes a participant in the situation. The expert uses a critical discussion to reach consensus on how to change the situation in the best interests of all involved. The relationship between actors is based on power. Disclosive systems thinking views the expert also as part of the situation, but with the purpose of identifying or disclosing the responsibilities of the different actors. Strijbos (2000:177) argues that the abolition of power will not lead directly and automatically to responsible action.

“Fourth, in building such a common framework the experts need a *critical awareness of the social-cultural context*.” This view, suggesting that the social-cultural context influences the actors, is similar to that of critical systems thinking. However, there is also an awareness of the fact that norms do not have the status of purely human constructs and that the intrinsic normative structure of reality always pertains, although it can be ignored, even suppressed (Pothas *et al*., 2002:167).

Disclosive systems thinking is the latest in systems thinking methodologies$_1$, and Pothas, De Wet and Strijbos are currently working on methodologies$_2$ for practising disclosive systems thinking.

3.4.1.5 Summary

Jackson (2001:233) summarises the differences between hard, soft and critical systems thinking methodologies$_1$ in terms of systems ideas, the role of models, the use of quantitative techniques, the process of intervention and the testing of solutions. His summary is given in table 3.3 below.

Hard (functionalist) methodology$_1$	**Soft (interpretive) methodology$_1$**	**Emancipatory (critical) methodology$_1$**
An assumption is made that the real world is systemic.	No assumption that the real world is systemic.	An assumption that the real world can become systemic in a matter alienating to individuals and/or groups.
Analysis of the problem situation is conducted in systems terms.	Analysis of the problem situation is designed be creative and may not be conducted in systems terms.	Analysis of the problem situation is designed to reveal who is disadvantaged by current systemic arrangements.
Models aiming to capture the logic of the situation are constructed, enabling us to gain knowledge of the real world.	Models are constructed which represent some possible "human activity systems."	Models are constructed which reveal sources of alienation and disadvantage.
Models are used to learn how best to improve the real world and for the purposes of the design.	Models are used to interrogate perceptions of the real world and to structure debate about changes which are feasible and desirable.	Models are used to "enlighten" the alienated and disadvantaged about their situation and to suggest possible improved arrangements.
Quantitative analysis is useful since systems obey mathematical laws.	Quantitative analysis is unlikely to be useful except to clarify implications of world views.	Quantitative analysis may be useful especially to capture particular biases in existing systemic arrangements.
The process of intervention is systematic and is aimed at discovering the best way to achieve a goal.	The process of intervention is systemic, is never-ending, and is aimed at alleviating unease about the problem situation.	The process of intervention is systemic, is never-ending and is aimed at improving the problem situation for the alienated and/or disadvantaged.
The intervention is conducted on the basis of expert knowledge.	The intervention is best conducted on the basis of stakeholder participation.	The intervention is conducted in such a way that the alienated and/or disadvantaged begin to take responsibility for the process.

Solutions are tested primarily in terms of their efficiency and efficacy.	Changes that might alleviate feelings of unease are evaluated primarily in terms of their effectiveness, elegance and ethicality.	Changes designed to improve the position of the alienated and/or disadvantaged are evaluated in terms of ethicality and emancipation.

Table 3-3 Summary of systems thinking methodologies$_1$ (Jackson, 2001:241)

3.4.2 Epistemological views of systems development

3.4.2.1 Construction

True to its positivistic nature, construction follows a rational and analytical strategy towards problem solving. Systems developers are rational thinkers, solving complex abstract problems in order to bridge the conceptual gap between the world and the computer. The process is specification-driven, and the systems developer uses rational thinking in choosing the optimal action, given what we know what we want (Dahlbom & Mathiassen, 1993:76). The users of the system have a passive role during development.

It is not considered to be part of the development process to implement a system in an existing technological and organisational environment. Systems analysts are seen as computer experts who, rather than identifying data processing needs, use computers to meet them. Construction relies on the hard systems approach, and a computer system is viewed as a hierarchical system of ordered subsystems, by breaking programs down into modules and defining interfaces between the modules.

Construction is seen as a bureaucratic approach to systems development. Methods in use are, for example, chief programmer teams, phase models, documentation standards, structural techniques, and traditional life cycles. This leads to the problem that constructed systems do not handle change in the environment very well.

3.4.2.2 Evolution

Being an anti-positivism approach, evolution follows an experimental approach to systems development. Since real data processing problems are not clear and well

defined, a major part of the development process should focus on the definition of the problem. The evolution approach recognises and emphasises the uncertainties related to the specific problem and systems development in general. Trail and error is used to supply a concrete solution to a partial problem by means of prototyping (Dahlbom & Mathiassen, 1993:94). The problem is understood and defined as iterations of the prototype, each iteration being completed and then overhauled to represent reality more closely. Sensory experiences are the main source of knowledge.

Evolution relies on an organic approach in managing the development process (Dahlbom & Mathiassen, 1993:105). Communication and co-ordination between the users and developers occur throughout the development process. Evolution can be viewed as a compromise between the hard and soft systems approaches. The increased awareness of the roles human beings play, moves evolution towards the romantic worldview and therefore the soft systems approach.

3.4.2.3 Intervention

In situations where the problem is ill defined, and various actors have different motivations for wanting change, information systems play an important role in changing the environment. Systems developers become consultants and agents of change and should be skilled as such. Breakdowns and conflicts are seen as opportunities for breakthroughs and changing the way the organisation operates, by analysing the business and developing a new computer system.

The users are really the designers, and the systems developers give technical advice and facilitate learning about the problem (Dahlbom & Mathiassen, 1993:119). Responsibility for the design and implementation of the system is shared between the users and the systems developers.

3.5 Systems practice

Systems thinking methodologies$_1$, such as hard, soft, critical and disclosive systems, can be viewed as theoretical rationales (Jackson, 2001:241). In an attempt to make these theoretical rationales more practical, leading authors (Checkland (1981), Midgley (2000), Jackson (1991), and Pothas *et al.* (2002)) designed methodologies$_2$

for applying these methodologies$_1$ to everyday problem situations. Jackson (2001:241) gives the following guidelines for the development of such systems methodologies$_2$:

"1. Systems methodologies are structured ways of thinking, related to different theoretical rationales, focused on improving some real-world problem situations.
2. Systems methodologies use systems ideas (system, boundary, emergence, hierarchy, communication, control, etc) during the course of intervention and frequently employ systems methods, models, tools, and techniques, which also draw upon systems ideas.
3. The claim to have used a systems methodology according to a particular rationale must be justified according to given guidelines *(These guidelines were given as a summary to section 3.4.1 as table 3.3).*
4. Since each generic type of methodology can be used in different ways in different situations and interpreted differently by different users, each should exhibit conscious thought about how to adapt to the particular circumstances.
5. Each use of a systems methodology should yield research findings as well as changing the real-world problem situation. These research findings may relate to the theoretical rationale underlying the methodology, to the methodology itself, to the methods, model, tools and techniques employed, to the system to use each methodology, or to all of these."

This section describes methodologies$_2$ for practising systems thinking. The mapping between systems thinking methodologies$_{1\&2}$ and systems thinking methodologies$_2$ developed in chapter 5 is based on the information presented in this section. Although methodologies$_2$ for hard, soft, critical and disclosive systems thinking are discussed, most attention is given to the soft systems methodology (SSM) of Checkland (1981), since the SSM is most widely used in information systems development of all the methodologies$_2$ discussed.

3.5.1 Hard systems methodologies$_2$

Jackson (1991:121) names three types of hard systems thinking methodologies$_2$ commonly applied to social systems, namely systems engineering, systems analysis, and traditional operational research. The methodology$_2$ of Jenkins (1969) can be categorised as a systems engineering methodology$_2$; it consists of four phases,

namely systems analysis, systems design, implementation and operation. The roles of the phases are to study the transformation of the environment of the system into the future environment in order to optimise the performance of the system. Jenkins' methodology$_2$ is an attempt to apply methods used in natural sciences to social systems. The problem analyst in hard systems methodologies$_2$ is typically somebody outside the problem situation. Such a person views the problem situation objectively.

Methodologies$_2$ and methods used in traditional operational research aim at the prediction and control of environmental variables. Queuing theory and simulation are typical "predict and control" methods. Jackson (1991:124) argues that these methods and methodologies$_2$ are hard systems approaches.

Checkland (1981:130) describes the systems engineering methodology$_2$ presented by Hall (1962) as a hard systems methodology$_2$, which consists of the following phases:

1.	Problem definition	(definition of a need)
2.	Choice of objective	(definition of physical needs and of the value system within which they must be met)
3.	Systems synthesis	(creation of possible alternative systems)
4.	Systems analysis	(analysis of the hypothetical system in the light of objectives)
5.	Systems selection	(selection of the most promising alternative)
6.	Systems development	(up to the prototype stage)
7.	Current engineering	(system realisation beyond prototype stage and including monitoring, modifying and feeding back results into the system)

Hard systems methodologies$_2$ are suitable for solutions to well-defined problems, but fail to take the complexity of social problems into consideration. Hard systems methodologies$_2$ accept the existence of a system in the real world, which soft systems thinkers do not take for granted. A model is seen as a true representation of the real world problem situation. Soft system methodologies$_2$ accept that every individual has his/her own perceptions of the real world, which leads to a different view of a model. Because of the contextuality of problems, it is very difficult, if not impossible, for an objective outsider to fully understand the nature of the problem and to develop solution strategies. Therefore, the problem situation is best addressed by involving all parties involved in the situation.

3.5.2 Soft systems methodologies$_2$

Traditional hard systems approaches from systems engineering failed to face up to the complexity of management problem situations. Soft systems thinking illustrates that in all problem situations, people are trying to take purposeful action in spite of all the ambiguity, uncertainty, disagreement and conflicts (Checkland, 1995:8).

Peter Checkland (1981) developed the soft systems methodology$_2$ (SSM) for the analysis and design of social systems. SSM is a methodology$_2$ that aims to bring about improvement in areas of social concern by activating a learning cycle, ideally never-ending, in the people involved in the situation (Stowell, 1995:5). This methodology$_2$ uses action research to study the problem environment. Figure 3.7 shows the basic ideas of the original SSM. After the problem situation has been investigated, a conceptual evaluation of holons (models of the system) is done. These conceptual models are then compared with the real world situation to determine the changes that should take place to improve the problem situation.

There are many similarities between Churchman's (1968) systems approach and the SSM. The five characteristics of Churchman's approach are woven into the SSM. The SSM can be seen as a practical methodology$_2$ for the implementation of the Churchman's approach.

Industry started to use the original SSM depicted in figure 3.7 as a rigid seven-step recipe for the solution of managerial problems. Since this is against the basic ideas of the methodology$_2$, the University of Lancaster's Department of Systems under guidance of Peter Checkland changed the original soft systems methodology$_2$ to what they called "The developed form of the soft systems methodology". For the purposes of this thesis, the latter, as described by Checkland and Scholes in 1999, will be used. We will refer to this developed form simply as the SSM.

The following section starts with a short introduction to the soft systems methodology$_2$. The relation between systems thinking and the SSM will be explored. The enquiring process of the SSM is discussed, and the section concludes with remarks about the application of the SSM.

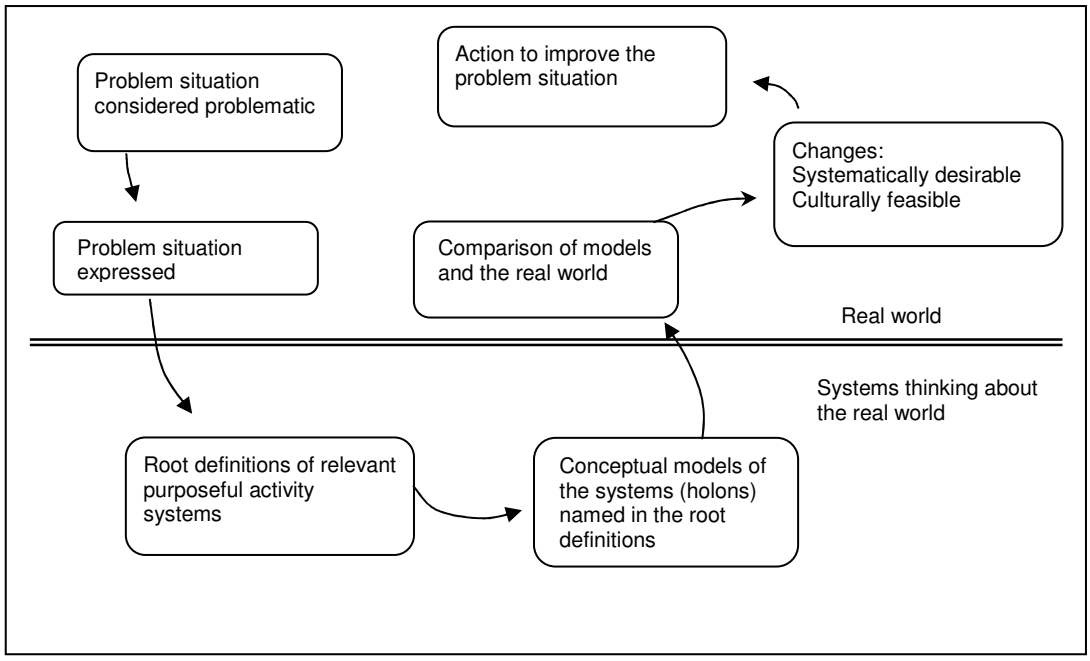


Figure 3.7 Seven stages of the SSM (Checkland, 1995:11)

3.5.2.1 Introduction to the soft systems methodology$_2$

The soft systems methodology$_2$ was developed to help managers make sense of difficult undefined problems in their environment. It is not restricted to a specific area of business, and the aim is to assist decision-making in any problem situation. The SSM models human thought in decision-making.

Checkland and Scholes (1999:2) declare that human beings learn from their experience. The knowledge that is gained from past experience is used to make decisions in new situations. Human beings add meaning to their experiences, thus forming an interpreted world. This leads to intentions, which guide us to decide one thing rather than another (purposeful action), and to choose among alternative actions. We use previous actions to help us select the best action in a new situation. The results of our actions in the new situations then become new experiences that are added to our body of experience for use in future situations. This experience action-cycle is depicted in figure 3.8.

Experience-based knowledge differs from scientific knowledge in that it is not formed from repeatable experiments. Checkland and Scholes (1999:3) argue that repeatable experiments are difficult to achieve, and virtually all knowledge gained by social science is heavily meaning bearing. The SSM seeks to provide help in

articulating and operating the learning cycle from meanings to intentions to purposeful action, without imposing the rigidity of a technique (Checkland & Scholes, 1999:8).

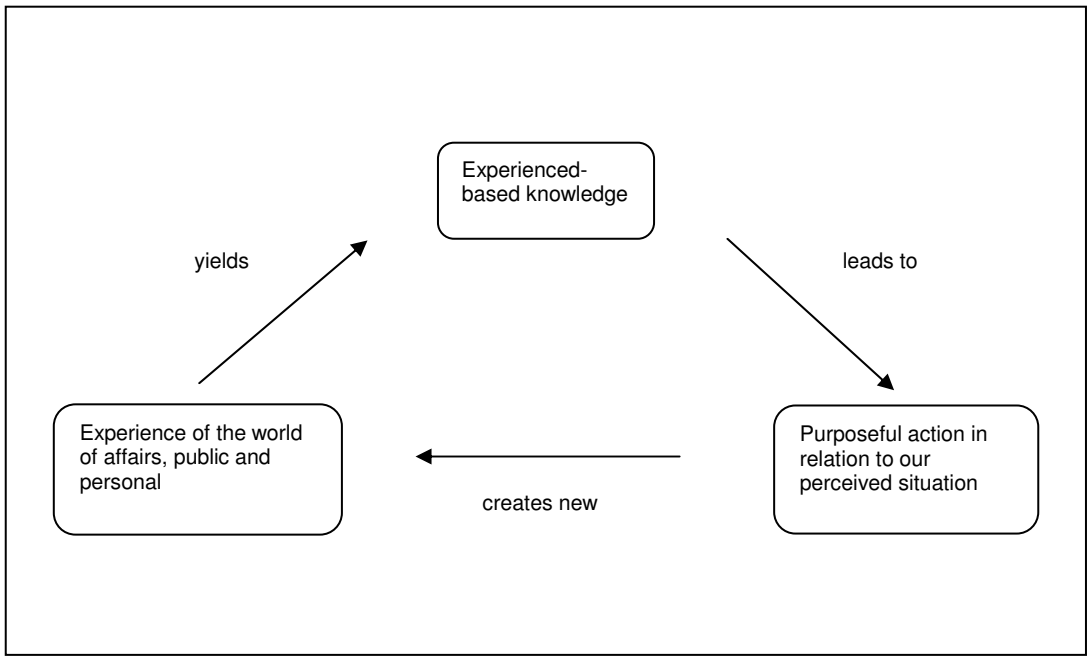


Figure 3.8 The experience-action cycle (Checkland & Scholes, 1999:3)

Purposeful activity is central to the SSM. Checkland and Scholes (1999:6) identify five role players in purposeful activity:

1. The person or persons whose intent leads to the purposeful action
2. The person or persons who take the action
3. The person or persons who are influenced by the action
4. Constraints in the environment of the action
5. The person or persons who can stop the action

By identifying the different role players in a problem environment, one generates a better understanding of that environment, and one is able to model action. Figure 3.8, the experience-action cycle, can be extended to form the basic shape of the SSM (refer to figure 3.9).

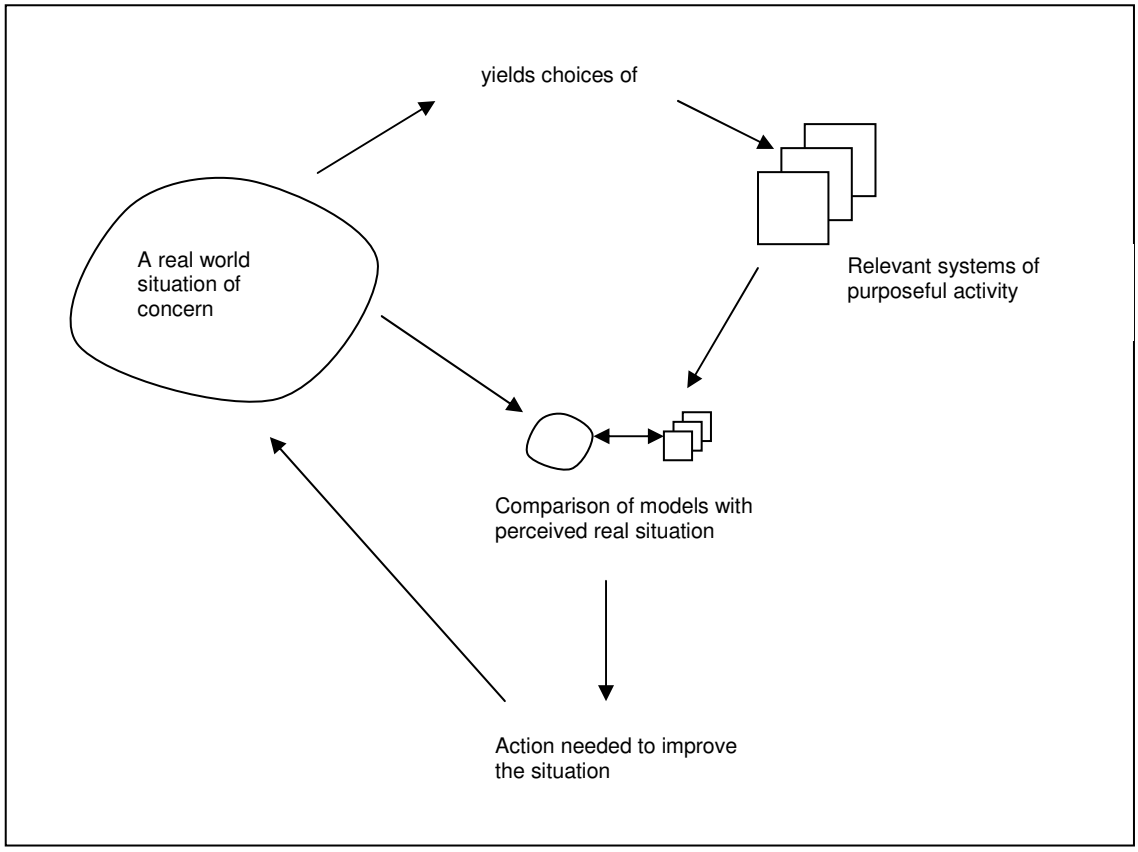


Figure 3.9 The basic shape of SSM (Checkland & Scholes, 1999:7)

3.5.2.2 Systems thinking and the SSM

Systems thinking ideas can be identified in two different ways in the above illustration of the SSM. Figure 3.9 can be seen as a cyclic learning system, and systems models are used to initiate and orchestrate the debate about purposeful change (Checkland & Scholes, 1999:7). Just as systems thinking was refined from its early days, where the idea of a system moved away from a real life representation to a vehicle of understanding the complexities of the situation, the SSM moved from an approach aimed at optimising a system to an approach based on articulating and enacting a systemic process of learning.

The SSM was developed at the University of Lancaster. Through initial application of systems engineering processes and later systems thinking ideas, it became apparent that problem definitions are less clear than previously thought of. It is not so much the "how" but rather the "what" of the problem that causes the difficulties for management (Checkland & Scholes, 1999:18). The SSM aims to answer both the

"how" and the "what" through the system of enquiry outlined in figure 3.9. By focussing on the "what" question, the relativism of the problem environment is acknowledged. Previous attempts at systematic processes by systems engineers worked well for structured problems but failed at describing and solving unstructured social problems.

Checkland and Scholes (1999:18) prefer the use of the adjective "systemic" rather than "systematic". They define "systemic" as "of or concerning a system as a whole". The use of the word "systemic" indicates that a system is involved, where "systematic" indicates the use of a methodology$_2$ or a detailed plan.

All of us have experience, as well as a filter of our own beliefs, through which we look at the world. This filter influences the way we perceive and make sense of our environment. We make use a framework of ideas which is internal to us. These internal ideas were formed by perceiving the outside world. Figure 3.10 indicates this cyclic process of the world, interpreted by ideas which source is the world itself. It shows that we use a methodology$_2$ "M" (on figure 3.10) to make sense of the world, to create ideas of the world. These ideas (each 'x' on figure 3.10) can be seen as interconnected systems.

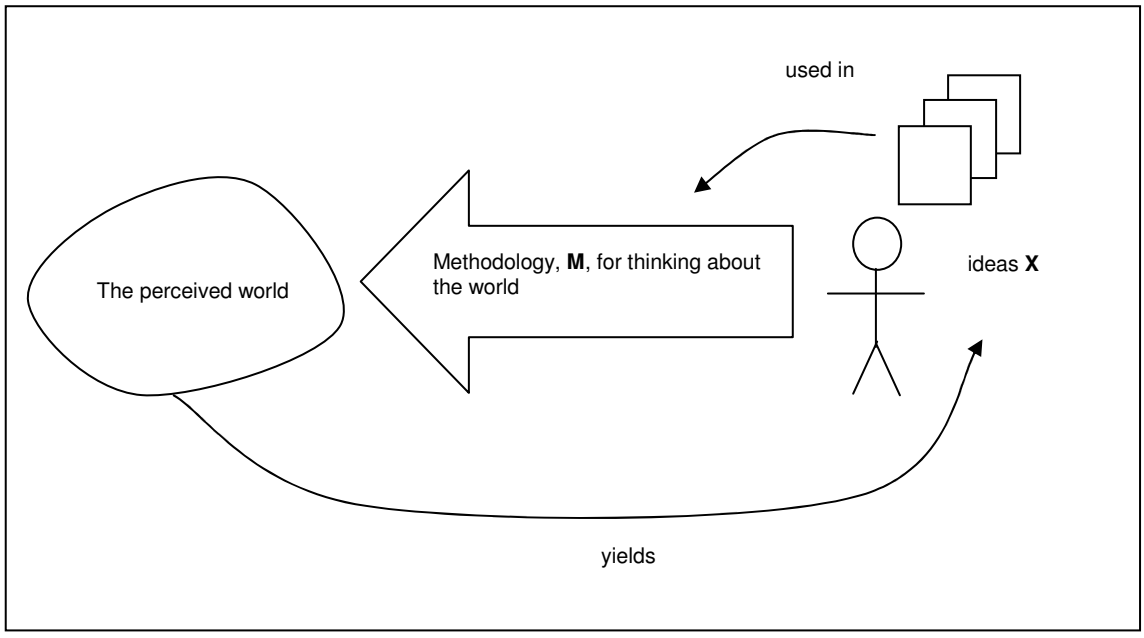


Figure 3.10 The world interpreted by ideas of the world (Checkland & Scholes, 1999:21)

Checkland and Scholes (1999:22) argue that the word "system" has too many different meanings associated with it, and that a new term is required to describe the system that makes sense of the world. They decided to use the word "holon" to describe the description of the perceived reality as indicated by "x" in figure 3.10.

"Holons" should be seen as a way of understanding wholes in the world, to be able to facilitate learning about the perceived world. Checkland (1995:10) accentuates the difference between the hard systems view and the soft systems view when he states that a true understanding of SSM starts with understanding the crucial difference between models that strive to be part of the perceived world (hard view) and those models relevant to debate and argue the perceived world (soft view).

The SSM uses a particular kind of holon, namely a so-called "human activity system". The Lancaster group found that all problem situations have one shared characteristic. They all feature human beings in social roles, trying to take purposeful action (Checkland & Scholes, 1999:24). A holon is a set of activities connected to make a purposeful whole and constructed to meet the requirement of the core system image (emergent properties, layered structure, processes of communication and control). It should be noted that human activity systems do not exist in the world; they are abstractions that can be compared with the world. This is the core of soft systems thinking. The emergent property of a human activity system is the ability to pursue the purpose of the whole. The purpose of the whole is dependent on the worldview of the participants. This will be discussed in the following section.

3.5.2.3 The SSM as enquiring process

The SSM should be seen as an enquiring process into an every day problematic situation. The problem situation is typically ill-defined and the SMM will focus on the "what" and the "how" of this situation. Figure 3.11 depicts this process. The SSM differs from historical management sciences by taking various viewpoints on the history of the problem situation into account, thus adding to the richness of the problem description. The people wishing to improve the situation can be seen as the users of the SSM. It is important to understand that they will not work in isolation, but rather collaborate with other role players in the situation.
From figure 3.11, two streams of enquiry are evident; the right-hand side shows the logic driven enquiry stream and the left hand side the culture driven enquiry stream.

Although the two streams will be evaluated separately, there is interaction between them.

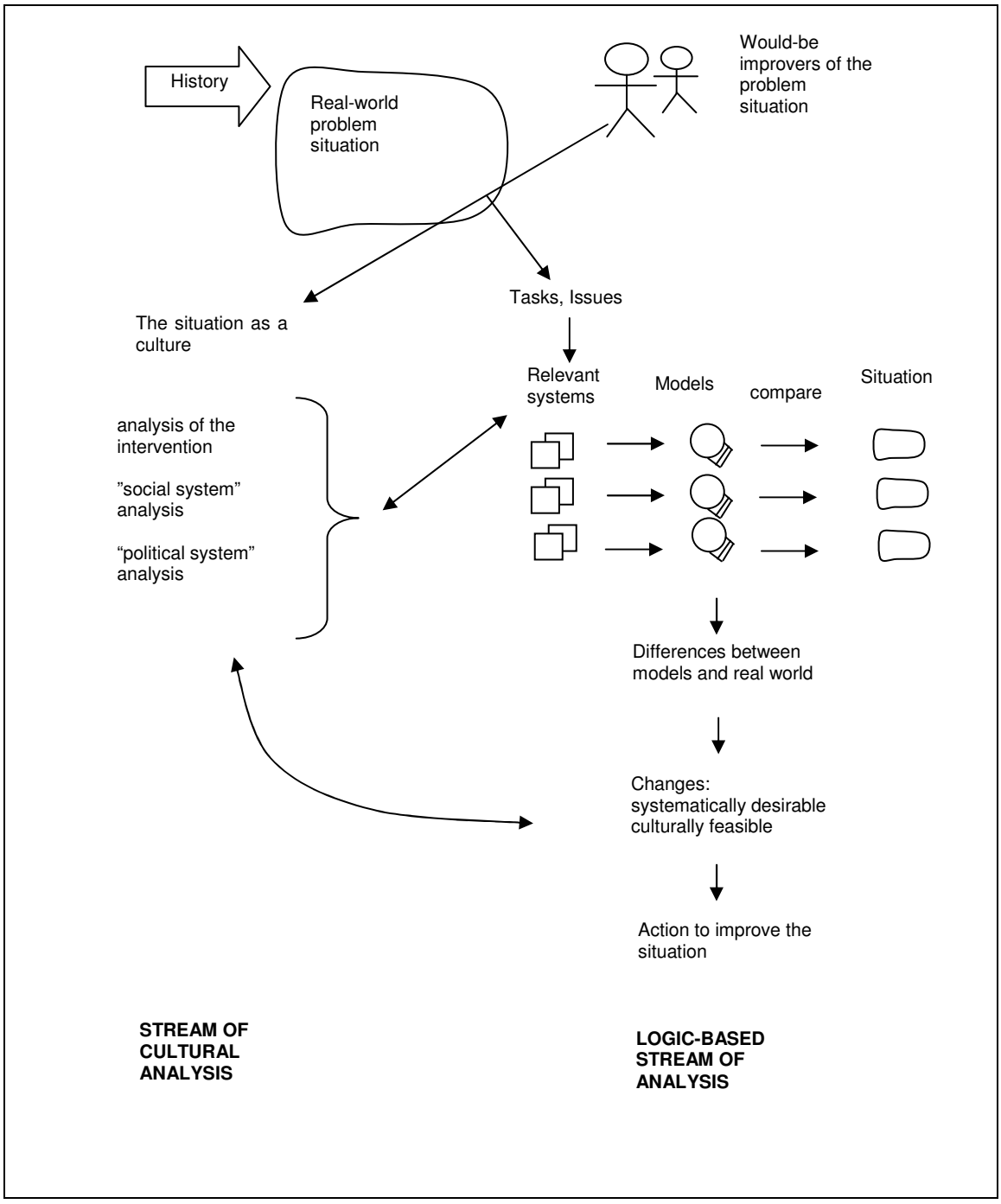


Figure 3.11 The SSM as enquiring process (Checkland & Scholes, 1999:30)

3.5.2.4 The stream of logic-base enquiry

In the logic driven stream, a number of purposeful holons are named to model human activity. These models are compared with perceptions of the real world to illuminate the problem situation. The aim of these comparisons is to identify changes that can be implemented to improve the real life situation and which would represent an accommodation between different interests (Checkland & Scholes, 1999:29).

The first step is to select relevant systems. Checkland and Scholes (1999:31) emphasise that no human activity system is intrinsically relevant to the problem situation and that the decision of relevancy is always subjective. It is neither required, nor advisable to arrive at a single relevant system. There are two kinds of relevant systems, namely tasks and issues. Tasks refer to common perceptions of various purposeful actions in the situation, while issues refer to various matters of disagreement.

The issues very often arise from different viewpoints on the general objectives of the problem situation. Understanding of the problem situation is aided by thinking through metaphors.

After selecting relevant systems, these systems need to be described. The first step is to select a root definition of the system. The root definition expresses the core purpose of the purposeful activity system (Checkland & Scholes, 1999:33). The purposeful activity should be seen as an input-output system as described earlier in this chapter, where certain inputs are transformed to yield required outputs. Activity in the organisation can be described by answering questions from the so-called CATWOE test. This test is used to determine the intended transformation of the organisational elements (West, 1995:151).

The “C” in CATWOE represents the customers who are affected by the transformation (“T”) process. The “A” represents the actors who carry out the transformation. The “O” refers to the owners or the people responsible for the overall process. The “E” represents the environmental constraints of the activity. Finally, the “W” is the worldview or perspective from which the transformation is meaningful (West, 1995:152). Checkland (1995:8) argues that, because any purposeful or intentional action in real life can be perceived in many different ways, every model of a notional purposeful whole will have to be built according to a declared worldview or

W*eltanschauung*. West (1995:152) tests the worldview of a person with the following questions: "Why is this activity important?" and "Why does it have to be done this way?"

The modelling process consists of assembling and structuring the minimum necessary activities to carry out the transformation process in terms of the definitions of the CATWOE elements (Checkland & Scholes, 1999:36). After identification of the activities, performance measures need to be identified. Three different dimensions of performance checks are relevant. The first one (referred to as efficacy) tests if the desired result is produced. The second dimension (referred to as efficiency) tests if the results were achieved with little waste of effort or resources. Finally the third dimension (referred to as effectiveness) tests if the long-term aims will be achieved. These dimensions are known as the "3Es". Other performance measures such as ethics and aesthetics can be added.

The model should not be seen as a description of part of the real world (and therefore cannot be tested against the real world), but as a holon relevant to debating perceptions of the real world. Such models cannot be valid or invalid but can be technically defensible or not. Whether or not they can be defended, depend on each phrase in the root definition being linked to particular activities and connections in the model and vice versa (Checkland & Scholes, 1999:41).

When the models are compared with the real world, the aim is not to improve the models but rather to find accommodation between different interests in the situation. The accommodation should constitute an improvement to the initial problem situation. This can be achieved only through knowledge of the culture in the problem situation.

3.5.2.5 The stream of cultural enquiry

Throughout the logical enquiry process, the investigators should learn as much as possible about the myths and meanings associated with the problem situation. These myths and meanings constitute the cultural enquiry. The cultural stream on the left hand side of figure 3.11 consists of three examinations of the problem situation, i.e. "the intervention", the "social system" and the "political system".

The intervention is the action that will be taken in the problem situation. Checkland and Scholes (1999:47) argue that to investigate the intervention itself, three role players need to be identified. The "client role" is the person who caused the study to take place. The motivation of the client for the study to take place should be taken into account. The "would-be problem solver" is the person(s) who wishes to do something about the problem situation. His perceptions, knowledge and willingness to make resources available are of great importance. The final role is that of the "problem owner". Ownership needs to be assigned to somebody. The role analysis is known as "Analysis One" in the SSM.

"Analysis Two" of the SSM is an enquiry into the "social system" of the problem situation. The social system is seen as a continually changing interaction between three elements: roles, norms and values. Each continually defines and redefines the other two, and is itself defined by the other two (Checkland & Scholes, 1999:49). Here, role is the social position recognised as significant by the people in the problem situation. A role is characterised by expected behaviours in it, or norms. Performance in roles will be judged by local standards or values. Analysis Two is not performed by asking questions but rather by observing behaviours throughout the process.

Every human situation has a political dimension which needs to be explored. "Analysis Three" of the SSM views politics as a process by which differing interests reach accommodation. It can be seen as a power-related activity concerned with managing relation between different interests (Checkland & Scholes, 1999:50). It is difficult to identify the sources of power in the problem situation, and the public identification could itself be such a source of power. Examples of power in the problem situation include: formal authority, intellectual authority, personal charisma, external reputation, commanding access (or lack of access) to important information, memberships of committees, etc.

The logical and cultural streams join in proposing desirable and feasible changes to improve the desirability of the situation. These changes will lead to action in the problem environment. The changes should be "systemically desirable" and "culturally feasible". Because systemic changes are proposed after comparing the so-called relevant models with the problem situation, the changes can only be desirable if the models are found to be truly relevant to the problem situation.

Cultural feasibility of changes refers to the meaningfulness of the changes within a specific cultural environment (Checkland & Scholes, 1999:52).

3.5.2.6 Other soft systems methodologies$_2$

Churchman (1970) advocates a process of thesis, antithesis and synthesis. The role of the world view, or *Weltanschauung*, is very important in this process. Ackoff's (1979:55) social systems sciences (S^3) methodology$_2$ advocates the recognition of a "value-full" approach. He advocates that "objectivity is not the absence of value judgements in purposeful behaviour. It is the social product of an open interaction of a wide variety of subjective value judgements. Objectivity is a systemic property of science taken as a whole, not a property of individual research or researchers". One may summarise the move from hard systems methodologies$_2$ to soft systems methodologies$_2$ as a process away from optimisation towards learning (Checkland, 1985:59).

3.5.3 Critical systems methodologies$_2$

Different attempts were made to create a methodology$_2$ for the practice of critical systems thinking. Flood and Jackson's (1991b) total systems intervention is one such an attempt. Another one is the systemic intervention of Gerald Midgley (2000). Midgley (2000:129) argues that a methodology$_2$ for systemic intervention should be explicit about three things. "The first is for agents to reflect critically upon, and make choices between boundaries. … The second is the need for agents to make choices between theories and methods to guide action that requires a focus on theoretical and methodological pluralism. …Finally, an adequate methodology for systemic intervention should be explicit about taking action for improvement (action for the better, which cannot of course be defined in an absolutely objective manner)." These three aspects can be summarised as "critique" (boundary critique), "judgement" (which theories and methods are most appropriate) and "action" (implementation of methods to create improvement in the local context).

Two of the most important attempts to develop a critical systems thinking methodology$_2$ are total systems intervention (TSI) developed by Flood and Jackson (1991b) and Ulrich's (1987) critical heuristics of social systems design. The following provides an overview of the key aspects of these methodologies$_2$.

3.5.3.1 Total systems intervention

The TSI is based on critical systems thinking, which implies that it has a social awareness, and it has emancipation and human well-being as aim. The most important characteristic is that it accepts "complementarism" of methodologies$_2$. This entails that, as long as the theoretical characteristics of different aspects of a problem situation are understood, one may use different systems methodologies$_2$ to address those different aspects. The TSI is a process that can aid the intervener to select an appropriate systems thinking methodology$_2$ for each aspect of the problem situation.

The process of TSI is depicted in figure 3.12. It consists mainly of three phases; creativity, choice and implementation, which are conducted iteratively to address a problem in an organisation.

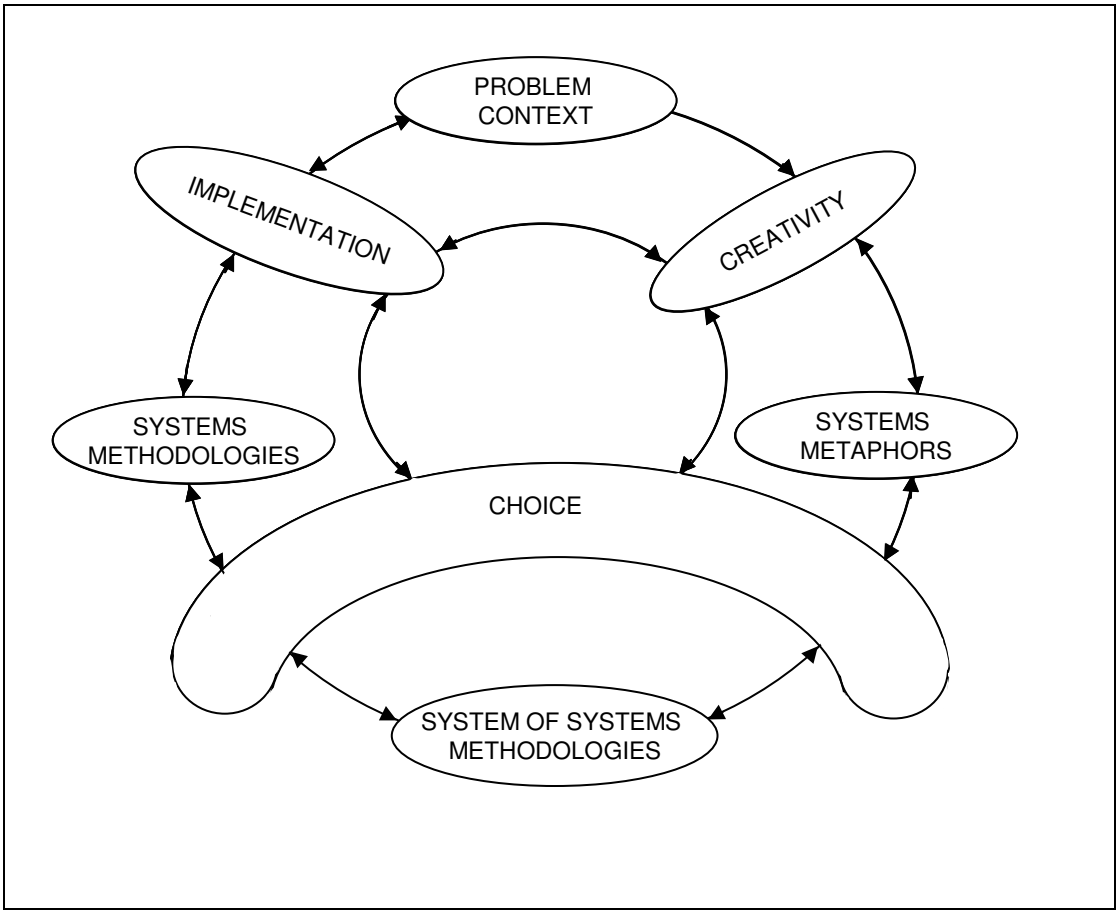


Figure 3.12 The process of the TSI (Flood & Jackson, 1991b:330)

During the creativity phase, the objective is to highlight the aims, concerns and problems in an organisation, by using metaphors to aid creative thoughts of role

players. The role players are urged to assign metaphors to different aspects of the organisation's functioning, for example, the organisation is viewed as a "machine", an "organism", a "brain", a "culture", a "team", a "coalition", or as a "prison". The metaphors are divided into "dominant" and "dependent" metaphors to prioritise the issues.

After the identification of the metaphors, a framework is used to choose relevant systems methodologies$_2$ to address the specific aspect described by the metaphor. This framework, known as "the system of systems methodologies$_2$", classifies problem situations according to two dimensions. The first dimension is the "simple" versus "complex" dimension used to classify the problem context. The second dimension classifies the actors as "unitary", "pluralist" and "coercive". These two dimensions yield six cells in a matrix to which systems methodologies$_2$ can be assigned. The matrix is given in figure 3.13. By combining the information gained during the creativity phase and the "system of systems" thinking methodologies$_2$, one can make an informed choice on an appropriate systems thinking methodology$_2$. This is done as a result of understanding the underlying assumptions of the different systems thinking methodologies$_2$.

The implementation phase is aimed at constructive change in the problem situation according to the selected set of methodologies$_2$. The result of the application of the TSI is "highly relevant and coordinated intervention" (Flood & Jackson, 1991b:330).

	UNITARY	**PLURALIST**	**COERCIVE**
SIMPLE	**S-U** • Operational research • Systems Analysis • Systems Engineering	**S-P** • Social systems design • Strategic assumption surfacing and testing	**S-C** • Critical systems heuristics
COMPLEX	**C-U** • Cybernetics • General systems theory • Socio-tech • Contingency theory	**C-P** • Soft systems methodology$_2$ • Interactive planning	**C-C**

Figure 3.13 A System of systems methodologies (Flood & Jackson, 1991b:327)

3.5.3.2 Critical heuristics of social systems design

Ulrich (1987) developed a methodology$_2$ for the practicing of critical systems thinking based on the concept of boundary judgement. He argues that both the involved and the affected of a situation should be involved in the "justification" of that situation. Ulrich (1987:104) accepts that "every chain of argumentation starts and ends with some judgements of which the rational justification must remain an open question."

The critical heuristics of social design were designed by Ulrich (1987) as a means to deal critically with justification break-offs. It aims to reflect on the normative implications of systems design, problem designs, and evaluations of social programs. Ulrich's (1987:105) critical heuristics consider three requirements to be essential to guide practitioners to practice practical reason:

"1. to provide applied scientists in general, and systems designers in particular, with a clear understanding of the meaning, the unavoidability and the critical significance of justification break-offs;
2. to give them a conceptual framework that would enable them systematically to identify effective break-offs of argumentation in concrete designs and to trace their normative content; and
3. to offer a practicable model of rational discourse on disputed validity claims of such justification break-offs, that is to say, a tool of cogent argumentation that would be available both to "ordinary" citizens and to "average" planners, scientists, or decision takers."

Ulrich (1987) gives a critical view of Churchman's (1968) boundary concept by not only asking "what is" but also asking "what ought to be" part of the system. All the affected parties should be regarded as part of the system. Boundary judgement is seen as a subjective process which needs to be transparent in order to identify all possible normative consequences of specific boundary judgments. In order to facilitate systematic identification and examination of justification break-offs (requirement 2 stated above), Ulrich (1987:108) has developed a checklist of twelve boundary questions:

"1. Who ought to be the *client* (beneficiary) of the system S to be designed or improved?
2. What ought to be the *purpose* of S; i.e. what goal stated ought S be able to achieve so as to serve the client?
3. What ought to be S's *measure of success* (or improvement)?

4. Who ought to be the *decision taker*, that is, have the power to change S's measure of improvement?
5. What *components* (resources and constraints) of S ought to be controlled by the decision taker?
6. What resources and conditions ought to be part of S's *environment,* i.e. should not be controlled by S's decision taker?
7. Who ought to be involved as *designer* of S?
8. What kind of *expertise* ought to flow into the design of S; i.e. who ought to be considered an expert and what should be his role?
9. Who ought to be the *guarantor* of S; i.e. where ought the designer seek the guarantee that his design will be implemented and will prove successful, judged be S's measure of success (or improvement)?
10. Who ought to belong to the *witnesses* representing the concerns of the citizens that will or might be affected by the design of S? That is to say, who among the affected ought to get involved?
11. To what degree and in what way ought the affected be given the chance of *emancipation* from the premises and promises of the involved?
12. Upon what *world-views* of either the involved or the affected ought S's design be based?"

These twelve questions can be divided into four groups of three questions each enquiring the sources of motivation, control, expertise, and legitimation respectively.

Contrasting "is" and "ought to" boundary judgements provides a systematic way to evaluate the normative content of planning as well as identifying the normative basis of the evaluation itself (Ulrich, 1987:110). Since experts and affected parties in a system have to justify their boundary judgements, the power of the expert is reduced. The affected party can argue on the same level as the expert on the consequences of specific boundary judgements.

3.5.4 Disclosive systems methodology$_2$

Disclosive systems thinking is based on four normative principles given in section 3.4.1.4. Methodologies$_2$ for the practising of disclosive systems explore methods to incorporate these foundational normative principles. Groundwork for such a methodology$_2$ was done by Pothas *et al.* (2002). These authors developed each of

the normative principles, developed by Strijbos (2000), in terms of action words. Their revised (action driven) principles are the following:

"1. The *unfolding* of everything in accordance to its intrinsic normativity.
2. The simultaneous *realising* of norms led by the qualifying aspect, and its accompanying norms, for a particular area of human life.
3. The *constructing* of a co-operative framework of responsibility for concerted human action within the multi-actor process of unfolding.
4. The cultivating of a critical awareness of the social cultural context."

In analysing the process and results of the work done by Pothas *et al.* (2002), the following aspects should be taken into account when practising disclosive systems thinking:

1. The intrinsic normativity is not always clear to all the role players in a problem situation. The systems practitioner should facilitate the process of identifying the intrinsic normativity. The is done by asking questions such as: "What is the single most important value of the organisation?"
2. Disclosive systems thinking disregards the absolutisation of human freedom. This implies that the systems practitioner is not in full control of the problem situation, but reacts to the intrinsic normativity of the situation.
3. The practitioner describes the reality in an attempt to disclose or to open up the intrinsic normativity. This leads to an array of different scenarios descriptive of the problem situation.
4. A diversity of norms should be taken into account. The supporting functions to the qualifying norm should also be disclosed and critically evaluated in terms of the qualifying function. This means that if a school's purpose is "to serve the interests of the pupils", other functions such as budgeting and administration should also be critically evaluated in terms of "the interest of the pupils."
5. Although the systems practitioner takes responsibility for the intervention, other actors should be involved.
6. Relations between actors are identified by their different responsibilities.
7. The practitioner should have a critical awareness of contextual influences that may cause action inconsistent to the actor's responsibilities. This may be in accordance with, or in contrast to the intrinsic normativity of the situation. The practitioner is responsible to ensure that all responsibilities, and therefore actions, are guided (determined) by the intrinsic normativity of the problem

situation. That means that every action taken in a school is "to serve the interest of the pupils".

8. Disclosure of the intrinsic normativity is an ongoing process of refinement.

Although disclosive systems thinking has only been introduced recently and has not yet been established as an accepted systems thinking methodology$_1$, it is clear from the principles presented here that it holds dear advantages for the field of information systems development.

3.6 Systems practice in information systems development

This thesis explores the relationships between philosophy, methodology$_1$ and practice applied to data warehousing. A thorough literature search did not yield any current research on the practising of systems methodologies$_1$ in data warehousing. However, literature is available on the practising of systems thinking methodologies$_{1\&2}$ (excluding disclosive systems thinking) in the more general field of information systems development. Although chapter 4 illustrates the specific differences between general information systems and data warehouses, lessons may be learned from the practising of systems thinking methodologies$_1$ in general information systems.

3.6.1 Hard systems methodologies$_{1\&2}$ and information system development

The systems development lifecycle (SDLC) for traditional information systems consists of phases similar to those of Jenkins' (1969) methodology$_2$, and can be classified as a hard systems approach to systems development. Typical phases of the SDLC according to the "waterfall" mode (Royce, 1970) include:

1. Requirements analysis
2. System and software design
3. Implementation and unit testing
4. Systems testing
5. Operation and maintenance

User participation is normally restricted to the first phase and testing is done according to the user specifications.

Information systems developed according to the SDLC, normally have very restrictive project management plans using traditional operational research methods, (such as PERT), to predict and control the environment of the information systems development project.

Most authors covering information systems analysis methods still define a model as a representation of reality (e.g. Whitten *et al.*, 2004:69). However, there is a move towards acceptance of multiple views of a specific system. These views are defined from the perspectives of role players, such as owners, users, builders, etc.

User specification is still regarded a success criterion, as it is seen as representative of all the user's needs (Sommerville, 1989:7). Most information systems development methods presume the role of end-users to be limited to the systems analysis and training phases. Very few information systems development methods accept that the problem addressed is one of a social nature and very often ill-defined.

Methods based on general engineering principles are considered to be hard system methods, since these methods are based on positivistic methodologies$_2$.

3.6.2 Soft systems methodologies$_{1\&2}$ and information system development

3.6.2.1 The SSM and information systems development

The SSM has often been used to assist the development of information systems. Stowell (1995) edited a monograph on the role of the SSM in information systems development.

The SSM accentuates the difference between information systems and information technology. Information systems are seen as part of the business strategy. The information system is a major part of the success of the business and therefore one of the most important areas in the business. It is no longer something that is planned and done by a small department of technicians (Lewis, 1995:188). Information technology can be seen as the computer tools used to implement and apply the information strategy and the information system in the organisation.

Information systems development is traditionally seen as a hard approach, where stages of a lifecycle can be identified to simplify the development process. Hard systems thinking starts at the means (the computer), rather than the end (the organisation's conceptualisation of its world) (Checkland & Scholes, 1999:54). However, there is a school of thought where information systems creation is seen as a cultural, rather than a technical phenomenon. Information is seen as a symbol rather than a signal.

Information is data that has been given meaning in the context of the problem environment. The purpose of creating an organised information system is to serve real-world action by giving meaning to data in the context of the problem environment. If we want to develop an information system, we have to start with studying the worldviews of the people in the problem situation, in order to be able to identify the meanings they attribute to their perceived world. We then need to determine what action they would regard sensible and purposeful. Holons will be used to determine what purposeful action will be widely regarded as truly relevant. The identification of a truly relevant human activity system is followed by a description of the information flows within the system. The next step is to determine data structures to accommodate these information flows. This leads to the design of an appropriate data manipulation system, conventionally known as the "information system".

3.6.2.2 Soft information systems development methods

Whitten *et al.* (2004:97) propose an information systems development method where the user is active in each of the life cycle phases and where the strategic information systems plan forms part of the systems development building blocks.

Whitten *et al.* (2004:88) give the following principles for information systems development:

"1. Get the system users involved
2. Use a problem-solving approach – understand the problem
3. Establish phases and activities
4. Document throughout the development
5. Establish standards
6. Manage the process and projects
7. Justify information systems as capital investments

8. Divide and conquer
9. Design systems for growth and change"

Although some of these principles indicate a hard systems approach, the first and most important principle advocates end-user activity in each of the phases of the development process. Whitten *et al.* (2004:88) argue that one must prevent the "us-versus-them" attitude of the technical team towards the system's users. These two groups should rather form a single team who has common objectives in realising the success of the system. Such a statement reflects a soft systems thinking perspective.

3.6.3 Critical systems methodologies$_{1\&2}$ and information systems development

Hirschheim and Klein (1994:83) discuss the expansion of current information systems development (ISD) methods to accommodate critical systems or emancipatory principles. They argue the necessity of expanding information systems development methods based on functionalism, to include neohumanistic principles. In order to expand a functionalistic (hard) ISD method, one needs to investigate the underlying assumptions and identify the building blocks thereof. Once these assumptions have been identified, improvements can be made to overcome the limitations of the method.

Hirschheim and Klein (1994) argue that a method should take the underlying political differences of the role players into account. In practising neohumanistic methods, one needs to overcome communicative distortions. In order to overcome these distortions, equality of participants is required. All participants must have equal opportunity to raise issues or react to other participants. All participants must be equal in position to give and refuse orders, to ask and give permission, or to make promises. All participants must be able to question correctness, truthfulness and sincerity of the others by asking for reasons and explanations. All participants must be able to express their feelings, such as concerns and doubts about the ISD project.

In theory, one should be able to expand any ISD method to include emancipatory principles. Hirschheim and Klein (1994:87) give the following conditions for a method to be considered emancipatory (they refer to methods as methodologies):

"1. An emancipatory methodology must support an active process for individual and collective self-determination.
2. An emancipatory methodology must support a process of critical self-transformation.
3. An emancipatory methodology must encompass a broader set of institutional issues relating particularly to social justice, due process and human freedom.
4. An emancipatory methodology must incorporate explicit principles for the critical evaluation of claims made throughout the systems development process."

Data warehouse development methods are discussed in chapter 4. Although these methods differ from typical ISD methods targeted by the conditions above, emancipatory principles can be accommodated in these methods. The case study reports presented in chapter 5 illustrate the presence or absence of emancipatory principles in data warehousing projects in different organisations.

3.6.4 Disclosive systems methodologies$_{1\&2}$ and information systems development

Disclosive systems thinking and practice have not yet been applied to information systems development. However, research has been done by Basden (2002) on the application of Herman Dooyeweerd's philosophy (specifically the modalities presented in section 3.3.1.3) in the field of information systems development. This thesis aims to contribute to the use of disclosive thinking practice in information technology. Chapter 5 reports on data warehousing practices from a disclosive systems point of view.

3.7 Summary

This chapter introduced systems to the reader. Systems were defined as sets of interrelated elements that have emergent properties, which cannot be identified in any of the elements of the system when viewed individually. When a systems approach is used to view a problem situation, it means that a broad view of the problem situation is taken. It was the work of Von Bertalanffy (1968) that formalised systems concepts.

The relationship between philosophy, methodology$_1$, and practice is a central theme of this thesis and was therefore used to present systems concepts to the reader. A philosophical foundation was laid through a discussion of influential philosophers, as well as a discussion of four paradigms of thought used throughout this chapter.

The term methodology has different interpretations and more than one interpretation were accommodated in this chapter. In the first instance, different views on systems, namely hard, soft, critical and disclosive systems thinking were discussed. Secondly, "methodology$_2$" indicates a generalised set of methods. Such generalised sets of methods exist for the practising of systems thinking methodologies$_1$, such as the soft systems methodology$_2$ and others. Methodologies$_2$ for practising systems thinking were discussed for each of the systems thinking methodologies$_1$ presented in this chapter.

Although no research could be found in the practising of systems thinking methodologies$_{1\&2}$ in data warehousing, literature describing the practising of some methodologies$_{1\&2}$ in information systems development were explored and presented in this chapter. This thesis aims to contribute to the use of specific systems thinking methodologies$_{1\&2}$ in data warehousing practices.

Chapter 4 introduces the user to data warehousing practices in order to guide the user to establish the link between systems thinking methodologies$_{1\&2}$ and data warehousing practices.

CHAPTER 4 DATA WAREHOUSING

4.1 Introduction

In this chapter, the nature of data warehousing is discussed. The purpose of the chapter is to provide background knowledge for the forthcoming chapters on the relationship between data warehousing and systems thinking, rather than to give a complete description of data warehousing design methods.

The terms data warehouse and data warehousing may be confusing. Therefore, it was decided to use the term data warehouse as a noun and data warehousing as the process to create a data warehouse. A data warehouse is throughout this thesis regarded as a system.

The first section investigates the definition of a data warehouse. Data warehouses are then compared with operational information systems. The explanation of data warehousing is clarified by a discussion on data warehousing architecture. The main stages in the data warehousing lifecycle, namely requirements collection, data modelling, data staging and data access are discussed to highlight different views on data warehousing methods.

Data warehousing success is of critical importance to the industry. The Cutter consortium (Anonymous, 2003:1) reported that 41% of data warehousing professionals has experienced data warehousing projects that failed. A review of current literature on data warehousing success factors is given to highlight the problems and opportunities in this field. An Internet research study on perceived critical success factors and main causes of failures serves as a link between the formal literature and the practices of data warehousing professionals.

The chapter concludes with a literature investigation into the combination of systems thinking and data warehousing practices, which serves as an investigation of current research for the overall study presented in this thesis.

This chapter represents the practice level of the philosophy, methodology$_1$ and practice model presented in this thesis. Although IS professionals would recognise

the information presented in this chapter as data warehousing *methodology*, it is viewed as a generalisation of practices of data warehousing professionals and therefore as *practice.* The term "method" is used to indicate data warehousing *methodology*. The practice layer in the model can be divided into generalised practices and individual practices. The generalised practices are presented in this chapter and the individual practices in the next chapter.

Although the association between data warehousing practices and systems thinking is only done in chapter 5, it is possible to identify systems thinking ideas in data warehousing practices as presented in this chapter. The educated systems thinker is able to identify conflicts in the definitions given for key data warehousing terminology.

Different systems thinking ideas are already visible in definitions of information systems. Mallach (2000:88) defines information systems as "a system whose purpose is to store, process, and communicate information". This definition can be compared to that of Du Plooy *et al.* (1993:01): "Information systems is an inter-disciplinary field of scholarly inquiry, where information, information systems and the integration thereof with the organisation is studied in order to benefit the total system (technology, people, organisation and society)." It is clear that the system in Mallach's definition has a tighter boundary than that of Du Plooy *et al.* (1993). The latter follows a more holistic (soft systems) approach to IS.

4.2 What is a data warehouse?

Data warehouses are examples of decision support systems (DSS). A DSS can be defined as a "computer-based information system whose primary purpose is to provide knowledge workers with information on which to base informed decisions." (Mallach, 2000:13). DSS can be divided into data-oriented DSS, model-oriented DSS and process-oriented DSS. A data-oriented DSS uses data base systems as source of the decision support, in contrast to a model-oriented DSS which uses mathematical models to support business decisions and a process-oriented DSS which simulates human decision making processes (Mallach, 2000:143). Data warehouses are the primary example of data-oriented DSS today.

This literature study indicated two main authors in the field of data warehousing, namely William Inmon, who is known as the father of data warehousing, and Ralph Kimball. Their approaches to certain aspects of data warehousing differ greatly. Industry practitioners are aware of these authors and their differences. Practitioners choose to follow either an Inmon approach, or a Kimball approach. Other data warehousing literature can easily be labelled as more towards Inmon's, or more towards Kimball's ideas. Some of these differences will be highlighted in this chapter. The literature study given in this chapter is mainly based on the work of these two authors.

Inmon (1996:33) defines a data warehouse as a subject oriented integrated, non-volatile, and time variant collection of data in support of management decisions. McFadden *et al.* (1999:531) explain each of the parts of this definition:

"1. *Subject oriented:* A data warehouse is organised around the key subjects (or high level entities) of the enterprise. Major subjects may include customers, patients, students and products.
2. *Integrated:* The data housed in the data warehouse is defined using consistent naming conventions, formats, encoding structures, and related characteristics.
3. *Time-variant:* Data in the data warehouse contains a time dimension so that it may be used as a historical record of the business.
4. *Non-volatile:* Data in the data warehouse is loaded and refreshed from operational systems, but cannot be updated by end-users."

Kimball *et al.* (1998:19) simply define a data warehouse as "the queryable source of data in the enterprise."

Poe *et al.* (1998:6) define a data warehouse as "a read-only analytical database *that is used as the foundation of a decision support system.*"

The majority of literature (excluding Kimball *et al.* (1998) and Poe *et al.* (1998)) uses the Inmon definition to define a data warehouse, as well as their own explanation of the key terms, as for example quoted above from McFadden (1999:531).

Markus (2000) discusses a data warehouse as an example of business-driven enterprise systems. She argues that the development process looks more like a

large-scale organisational development or change management project, rather than a traditional IS project (Markus, 2000:44).

4.3 Data warehousing versus online transaction processing (OLTP)

Data warehouses are also known as online analytical processing (OLAP) systems because they serve managers and knowledge workers in the field of data analysis and decision making.

Online transaction processing (OLTP) systems, or operational systems, are those information systems that support the daily processing that an organisation does. OLTP systems' main purpose is to capture information about the economic activities of an organisation. One might argue that the purpose of OLTP systems is to get data into computers, whereas the purpose of data warehouses is to get data or information out of computers.

Han and Kamber (2001:43) describe the differences between data warehouses and OLTP systems. The key differences are summarised in table 4.1.

Feature	OLTP	OLAP
Characteristic	operational processing	informational processing
Orientation	transaction	analysis
User	clerk, data base administrator (DBA), data base professional	knowledge worker (e.g. manager, executive, analyst)
Function	day-to-day operations	long-term informational requirements, decision support
Data base (DB) design	entity relational (ER) based, application oriented	star / snowflake, subject oriented
Data	current; guaranteed up-to-date	historical; accuracy maintained over time
Summarisation	primitive, highly detailed	summarised, consolidated
View	detailed, flat relational	summarised, multidimensional
Unit of work	short, simple transaction	complex query
Access	read / write	mostly read
Focus	data in	information out

Operations	index / hash on primary key	lots of scans
Number of records accessed	tens	millions
Number of users	thousands	hundreds
DB size	100 MB to GB	100 GB to TB
Priority	high performance, high availability	high flexibility, end-user autonomy
Metric	transaction throughput	query throughput, response time

Table 4-1 Comparison between OLTP and OLAP systems (Han & Kamber, 2001:43)

Han and Kamber (2001:42) argue that an OLTP system is customer-oriented as opposed to a data warehouse that is market-oriented.

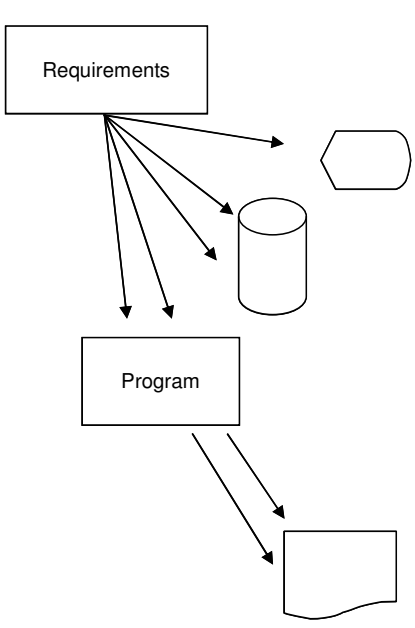
It is difficult to combine data warehousing (OLAP) and OLTP capabilities in one system. The dimensional data design model used in data warehouses is much more effective for querying than the relational model used in OLTP systems. Furthermore, data warehouses may use more that one data base as data source. The dimensional design of a data warehouse is not suitable for OLTP systems, mainly due to redundancy and the loss of referential integrity of the data. Organisations choose to have two separate information systems, one OLTP system and one OLAP system.

Poe *et al.* (1998:3) stress the fact that analysis using OLAP systems, are primarily done through comparisons, or by analysing patterns and trends. For example, sales trends are analysed along with marketing strategies to determine the relative success of specific marketing strategies with regard to sales patterns. Such analysis is difficult to perform with OLTP systems since the information accessed is stored in different systems across several departments in the organisation.

Corey *et al.* (2001:16) highlight the fact that usage of OLTP systems is very predictable. For example, a bank clerk always performs the same actions on the system. The usage of a data warehouse system on the other hand is very unpredictable. It is not possible to predict which trends will be analysed by which managers during which time period.

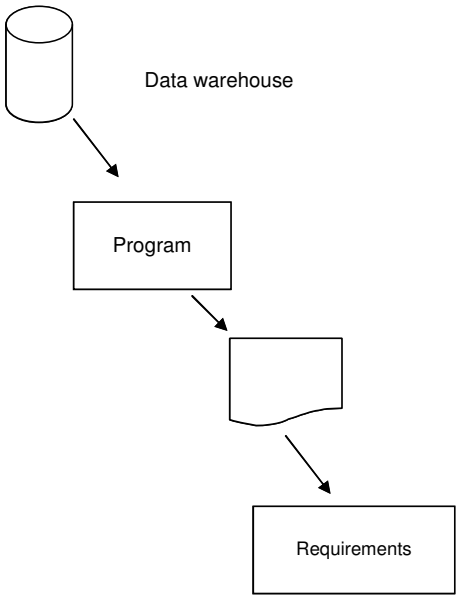
Eckerson (2003:7) argues that the most important difference between OLTP and OLAP systems is that an OLTP system forces business process structure which should not be changed, while OLAP systems need to be changed regularly. He argues that the more often business intelligence (BI) systems are changed, the better they become. They should change often to meet the ever changing needs of the business.

Kimball *et al.* (1998:14) highlight similar differences to those presented in table 4.1. Inmon (1996:24) presents a total different approach to the development of a data warehouse system. He argues that although OLTP are developed from requirements as a starting point, data warehousing starts at implementing the data warehouse and ends with a clear understanding of the requirements. The data warehouse development lifecycle is data-driven and OLTP are requirements driven. Inmon (1996:24) gives a graphical representation of this argument which is given in table 4.2.



Classical systems development lifecycle (SDLC)

- Requirements gathering
- Analysis
- Design
- Programming
- Testing
- Integration
- Implementation



Data warehouse SDLC

- Implement data warehouse
- Integrate data
- Test for bias
- Program against data
- Design DSS system
- Analyze results
- Understand requirements

Table 4-2 The SDLC for OLTP vs. OLAP systems (Inmon, 1996:24)

Kimball *et al.* (1998) differ from this approach by following a requirements-driven development lifecycle. This difference will feature strongly in the arguments presented in chapter 5.

4.4 High level data warehouse architecture

This discussion aims to give a holistic view on data warehousing. The section begins with a high level view presented by The Data Warehouse Institute (TDWI) of businesses intelligence (BI). This is followed by a discussion based on the proposed high level architecture given by Kimball *et al.* (1998). Differences to this approach will be discussed in section 4.5 where a more detailed view is taken on the key issues of data warehousing.

Eckerson (2003) from TDWI did a study on the success factors in implementing BI systems in organisations and the role of data warehouses in this process. Eckerson (2003:4) views the BI process holistically as a "data refinery". Data from different OLTP systems are integrated, which leads to a new product called information. The data warehouse staging process is responsible for this transformation. Users equipped with programs such as specialised reporting tools, OLAP tools and data mining tools transform information to knowledge. This is done through analysis that identifies trends, patterns and exceptions. Kimball *et al.* (1998:329) include this process as part of the data warehouse project. The next step is to transform knowledge to rules. Users create rules from knowledge; these may be simple rules such as "Order 50 new units whenever inventory falls below 25 units", or complex rules generated by statistical algorithms or models. Rules lead to plans of action that implement these rules. The actual implementation of these plans creates a cycle when new data enters the data warehouse, to be transformed once again into information and so forth. Although a data warehouse is only one tool in this process, it illustrates the value and purpose of a data warehouse in the organisation.

Kimball *et al.* (1998:329) give a graphic representation of data warehouse architecture. Figure 4.1 depicts the operation of the data warehouse in the organisation. The aim of the data warehouse is to give end-users (mostly managers) easy access to data in the organisation. In order to do this, it is necessary to capture everyday operational data from the operational systems of the organisation. These are transactional systems (OLTP), for example point of sale systems that are

designed around relational databases. Such systems become the source systems of the data warehouse.

The data from the source systems go through a process called data staging to the presentation servers (Kimball *et al.*, 1998:345). Data staging involves four very important actions. Firstly, the data is extracted from the source systems. The data required for the data warehouse is usually distributed in various different source systems with different file formats running on different hardware and operating system platforms. Secondly, the data is transformed to the data warehouse format. Errors and inconsistencies are removed during this phase. Thirdly, the data is loaded into data marts in the presentation server. The final task of data staging is to schedule this process.

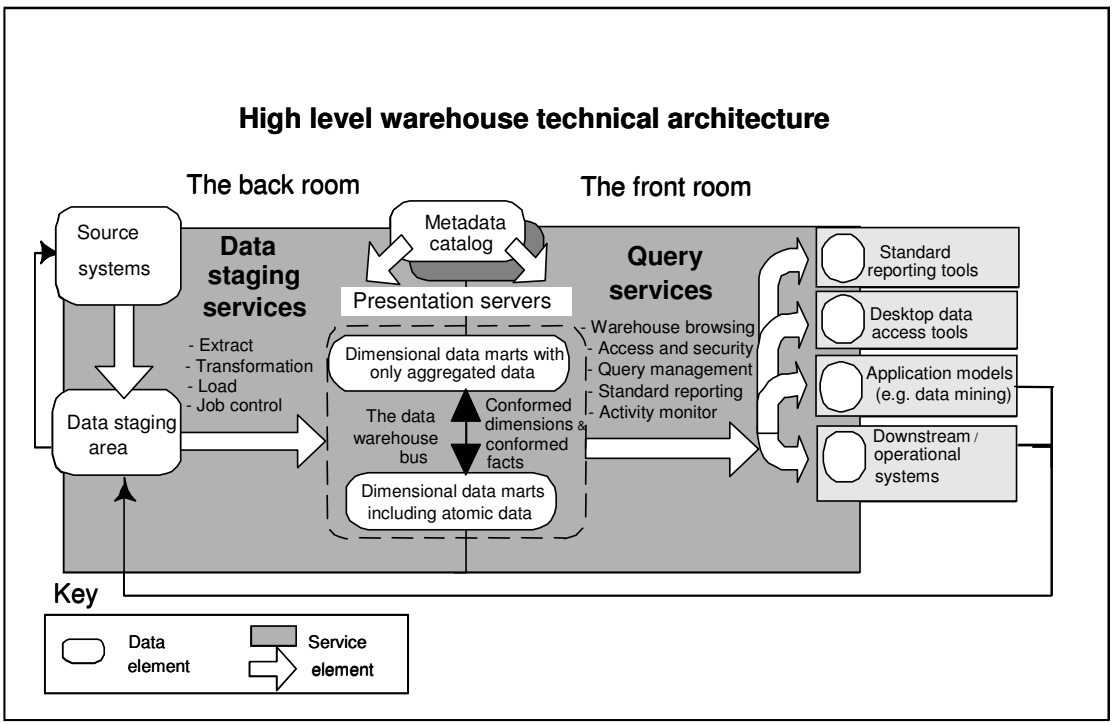


Figure 4.1 High level data warehouse architecture (Kimball et al., 1998:329)

The extraction of data from the operational source system influences the availability of these systems, therefore these processes should be done during off-peak times and as quickly as possible. High quality data warehouse output is dependent on high quality data in the data warehouse (Redman, 1996:32). Therefore, the staging process is most important from a data quality perspective.

The presentation server is the heart of the data warehouse. Data marts are stored here. Data marts are representations of business areas in the organisation. Data is stored as star schemas consisting of fact and dimension tables. This is radically different from the entity relational diagrams (ERD) used in traditional systems. Some of the data marts contain atomic data, which is data of the highest level of detail in the organisation, and which is normally transactional data. Other data marts contain aggregate data, which are summaries, or totals representing longer periods of time. The aggregate star schema is stored together with the atomic star schema in a data mart that models a specific business process (Kimball *et al.*, 1998:211). A detailed discussion of data modelling and the differences between the authors are given in section 4.5.3.

When the data is organised in data marts in the presentation server, it can be accessed with end-user tools. Access methods differ greatly between operational systems and data warehouses. In operational systems, fixed access methods are pre-built as standardised reports. The users use the data in a predetermined way. In data warehouses, very few standardised reports are written. The end-users use browsers and *ad hoc* queries to access the data. Activity monitoring of the data access helps the development team to streamline the warehouse by building appropriate aggregate tables to speed up queries (Kimball *et al.*, 1998:381). Data in the data warehouse cannot be altered by the end-users, because of the historical nature of the data. However, it is possible to add some of the report outputs to data marts, thus enhancing the data warehouse's functionality. These are usually results from data mining that are stored in analytical data marts.

Metadata is data about all the data stored in the data warehouse. The metadata repository contains all the data definitions, as well as information about the data staging area. The metadata repository is very important for the maintenance and change of the data warehouse and should contain technical data, as well as business rules and contacts.

The functions of the data warehouse development team can be classified as front room architecture or back room architecture. The back room is responsible for data services including data staging and data modelling (Kimball *et al.*, 1998:350). The front room architecture comprises all the functions that deal with end-users. These are mainly concerned with application development of data access tools (Kimball *et al.*, 1998:373).

A data warehouse is a read-only data source, which means that end-users may not change the value of data elements in the data warehouse. However, figure 4.1 does contain a feedback arrow from the end-user systems towards the data staging area. Specialised users may add data to the warehouse. A typical example is clustering information that may be associated with customers, as a result of data mining procedures that were carried out on the data in the data warehouse. For example, risk factors might be assigned to customers in a financial institute's data warehouse.

Inmon's (1996) approach to data warehouse architecture differs from that of Kimball *et al.* (1998). Kimball *et al.* (1998) describe a data mart as a subset of the data warehouse. The data warehouse is the sum of all the data marts, each representing a business process in the organisation. Inmon (1996) views a data mart as an interface between the data warehouse and the end-user.

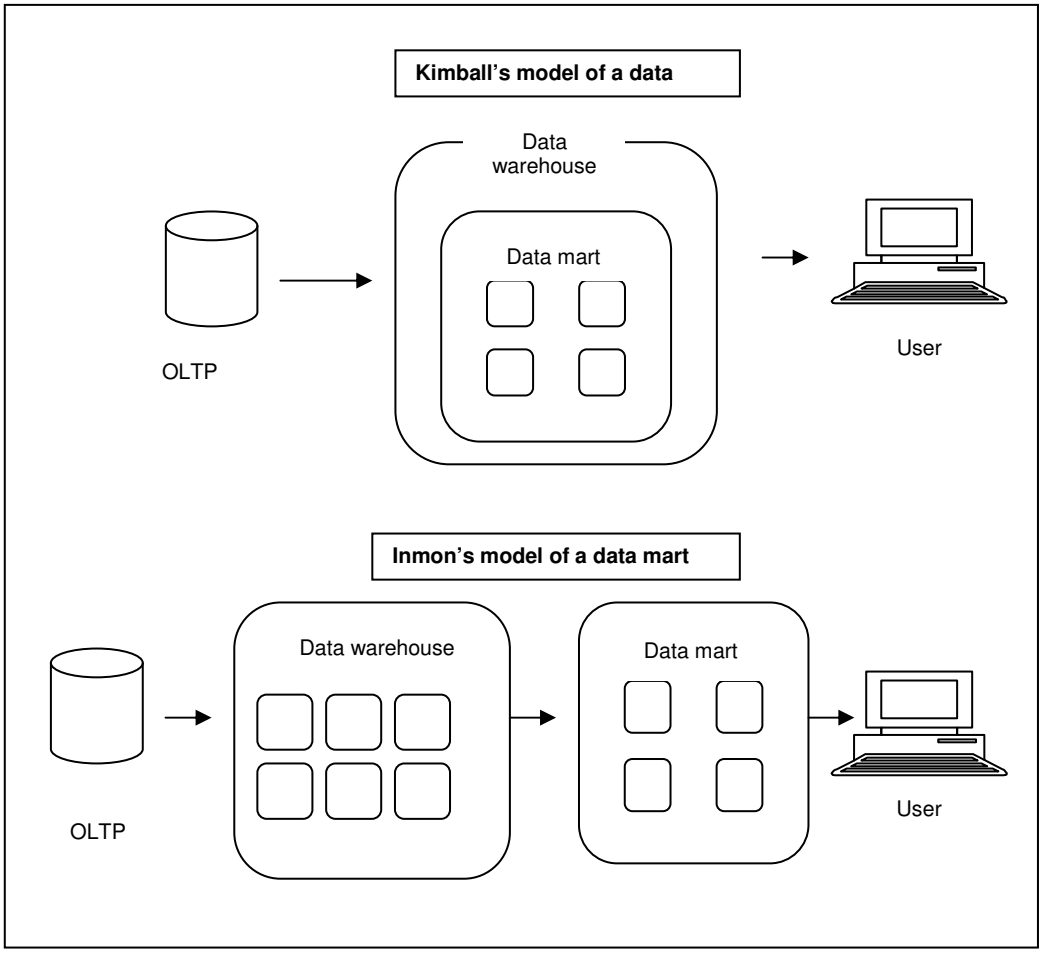


Figure 4.2 Data marts: Inmon vs. Kimball (adapted from Mailvaganam, 2003:2)

A data mart is a separate copy of a subset of the data in the data warehouse, organised in a star schema to be accessed by end-users. This difference is illustrated graphically in figure 4.2.

4.5 Aspects of data warehousing

This section contains different views of different authors on data warehousing aspects. It will be shown in chapter 5 that these different views can be traced back to different systems thinking methodologies[1&2]. The aim of this section is to give a practice level description of different views on various data warehousing aspects.

4.5.1 The data warehouse development lifecycle

A data warehouse development lifecycle is a sequence of high-level tasks required for effective data warehouse design, development, and deployment (Kimball *et al.*, 1998:33). Different authors have radically different views on the order of these tasks in the development lifecycle for data warehouses. These differences are presented in the following paragraphs.

Inmon (1996:290) advocates the use of a data-driven method. This means that DSS processing begins with data and ends with requirements. Inmon calls this method the CLDS (the reverse of SDLC) as depicted in table 4.2. According to Inmon (1996:44), a data warehouse starts with building a central data store for one subject-area, which is populated from operational systems. As the analytical ability of the new data warehouse is discovered, demand for an integrated data store for another subject area will grow and this process will repeat itself until a complete data warehouse has been developed. Although Inmon (1996) presents the lifecycle of a data warehouse to be opposite to the requirements-driven lifecycle of OLTP systems, it is interesting to note that in his data warehouse review checklist (Inmon, 1996:297), the second question (of a 54 question - checklist) is whether the end-user requirements have been anticipated, or not.

In contrast to Inmon's approach, Kimball *et al.* (1998:33) advocate the use of a requirements-driven method. The process is depicted in figure 4.3. The data warehouse starts with project planning to determine the readiness of the organisation

for a data warehouse and to set the staff requirements for the data warehousing team. A clear understanding of business requirements is the most important success factor, and Kimball *et al.* (1998) state that this process of requirements collection differs substantially from data-driven requirements analysis. The business requirements establish the foundation for the three parallel tracks focussed on technology, data and end-user applications.

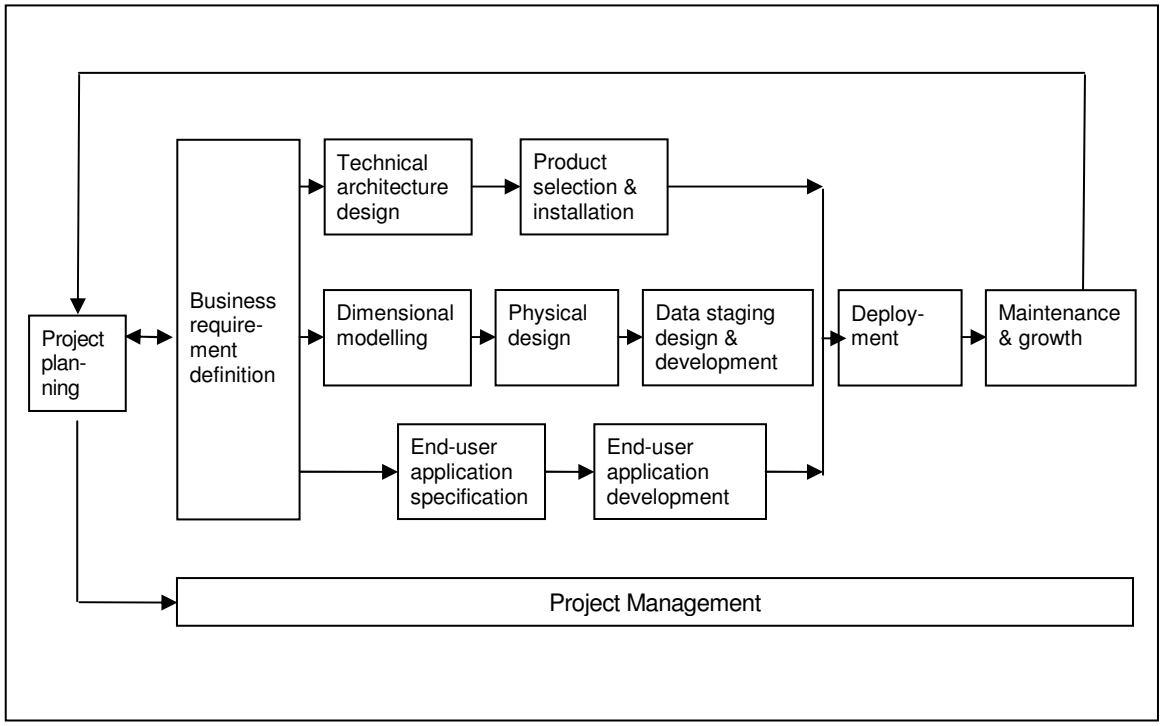


Figure 4.3 The business dimensional lifecycle diagram (Kimball et al., 1998:33)

Bischoff and Alexander (1997:66) argue that the data warehouse development lifecycle differs from the development lifecycle of on-line transaction processing systems (OLTP). The stages they propose are:

Stage 1: Investigation
Stage 2: Analysis of the current environment
Stage 3: Identify requirements
Stage 4: Identify architecture
Stage 5: Data warehouse design
Stage 6: Implementation
Stage 7: Ongoing data administration

It is clear that the requirements-driven method differs from an OLTP system's design method in the amount of time and effort spent on feasibility studies. Kimball *et al.* (1998:43) argue that a certain degree of readiness of the organisation for a data warehouse is essential for the development effort to succeed. This would include the presence of a strong business management sponsor, a compelling business motivation, a well functioning business and IS department partnership, the current analytic decision making culture in the organisation, and technical feasibility based on the current infrastructure of the organisation.

4.5.2 Collecting requirements

Collecting requirements is the foundation for all subsequent stages according to Kimball *et al.* (1998:96). Kimball *et al.* (1998:97) state, "You can't just ask users what data they would like to see in the data warehouse. Instead, you need to talk to them about their jobs, their objectives, and their challenges and try to figure out how they make decisions, both today and in the future".

Bischoff and Alexander (1997:67) advise that only requirements that support the initial business area and nothing more should be investigated. This statement will be used in the mapping of systems thinking methodologies$_{1\&2}$ in chapter 5, because Kimball *et al.* (1998:266) accentuate the advantages of an investigation into the entire organisation's data usage, before deciding which business area and therefore which data mart to develop initially. It is clear that this difference of opinion is rooted in different systems views. Bischoff and Alexander's opinion is motivated by hard systems thinking and Kimball's by soft systems thinking.

Inmon (1996:144) states, "Requirements for the data warehouse *cannot* be known a priori." The main idea of the data-driven method is to create a data warehouse from existing data and to supply the decision makers with data to satisfy their needs, without having to specify those needs upfront.

Kimball *et al.* (1998:97) give a detailed description on requirements collection for data warehouse projects. The data warehousing team should begin by talking to the business users, rather than talking to source systems experts. Business users are not technically skilled and the data warehousing team should talk to them about their jobs, rather than the data warehouse. The team may use facilitated sessions and/or

personal interviews for this process. Both these techniques require the interview team to gain prior knowledge on the operations of the organisation. Kimball *et al.* (1998:101) advise the interviewing team to do research into prior data warehouse development attempts, since business users might feel that the current team is duplicating previous work. Business users as well as IS personnel should be interviewed.

Interviews with business users should involve users on different levels in the organisation. When business executives are interviewed, the first question should be to establish the objectives of the organisation. Success measures for measuring the current status should be discussed. Business opportunities and causes for concern should be identified. A very important part of the interview is to discover future developments in the organisation, as well as the information needs thereof (Kimball *et al.*, 1998:116). Heads of departments should be interviewed with a strong focus on identifying routine decisions and current reports used for analysis. They should also be questioned on their need for analysis in addition to the current available information.

Interviews with IS personnel are conducted to determine the availability of data in support of the business users' requirements. These interviews serve as a reality check, since the requirements of the business users are tested against the available data. During the data staging phase, IS interviews will be followed up by detailed sessions to work out all the technical problems embedded in the data. During this first round of IS interviews, the team aims to understand the source systems in the organisation, as well as to investigate current analysis methods. Questions are asked to determine what type of analysis is done routinely. The current procedures for handling *ad hoc* queries are investigated. It is very important to establish and manage the expectations of IS personnel about the intended data warehouse (Kimball *et al.*, 1998:121).

During the closure of the interviews, users should be asked about the success criteria for the project. One needs to determine measurable criteria for the success of the data warehouse, which can be used as success metrics for the completed project. These success criteria should specify availability of the data warehouse, ease of use, data availability and business impact metrics. Interview information should be written down as quickly as possible following the interview. The individual interview write-up documentation is followed by a requirements finding document.

Kimball *et al.* (1998:136) suggest the following headings for the requirements finding documentation:

- Executive overview
- Project overview (including requirements definition approach and participants)
- Business requirements
    - High level review of business objectives
    - Analytic and information requirements (typically organised by business process)
- Preliminary source system analysis (tied as often as possible to a business requirement)
- Preliminary success criteria

Before data modelling can begin, the users need to confirm that the requirements documentation accurately describes their requirements. The business users need to aid the data warehousing team in prioritising and scoping the project.

4.5.3 Data modelling

After the requirements definition is agreed upon, the next task is the data modelling. The soft requirements must now be modelled into hard diagrams. The success of the data warehouse depends on whether these models represent the agreed upon problem situation. Traditional models were set up using ERDs, which are very technical. Kimball *et al.* (1998:141) advocate the use of star schemas, also known as dimensional modelling, to model data marts.

There are many technical advantages for using star schemas, which are mostly concerned with the performance of the data warehouse. Two of these advantages are of special importance. Firstly, designs that consist of star schemas are easily changeable. Kimball *et al.* (1998:149) describe how to make various changes to star schemas effortlessly. This is not the case with ERDs. Changes to relationships between entities normally involve major changes to the system. This means that evolution as development method, and therefore the use of prototyping, is more feasible when star schemas are used. The second advantage of star schemas is that it is easy to understand. The non-technical business users are able to understand the detail of the star schemas with very little technical guidance.

The above can be illustrated by setting up an ERD and a star schema for the same organisation. The organisation manufactures products and sells them to chain retailers. The chain retailer's sales are also measured. Comparing the ERD in figure 4.4 to the star schema in figure 4.5, the first problem with the ERD is that the entire enterprise entity structure is represented on one diagram. Although this is acceptable from a soft systems approach, it makes it very difficult to understand. The star schema represents only one business process, i.e. the retail sales process. Another major advantage of the star schema is that it includes the attributes of each dimension. These, for example, may refer to the detailed information about the products or the stores. There is simply no space to put this information on the ERD. By looking at the star schema, the user will easily spot missing data fields.

The centre table in the star schema contains the numerical data, such as dollar amounts of the event represented by the star schema, while the other fields in the centre table are links to all other aspects of interest. The table in the centre is called a fact table and the other descriptive tables dimension tables. This brief explanation suffices for a non-technical business user to fully understand the star schema. It would be extremely challenging to come up with a two-, or three-sentence explanation of an ERD, especially since the cardinality of the relations is always important.

It should be noted that there are various technical differences between ERDs and star schemas that make star schemas very effective to use in data warehouses, but also very ineffective to use in production systems. ERDs are much more effective in production systems, mainly because of the limited redundancy of data compared to the star schema.

Inmon (1996:85) proposes the use of an ERD data model for a data warehouse. The corporate ERD of the data warehouse is a composite of many individual ERDs that reflect the different views of people across the organisation. Inmon (1996:143) also describes star schemas (which he refers to as star joins). A brief discussion on star joins follows a detailed discussion on ERDs. Inmon concludes that a combination of star joins and ERDs will lead to an optimal warehouse design. He offers little explanation on how exactly this is achieved.

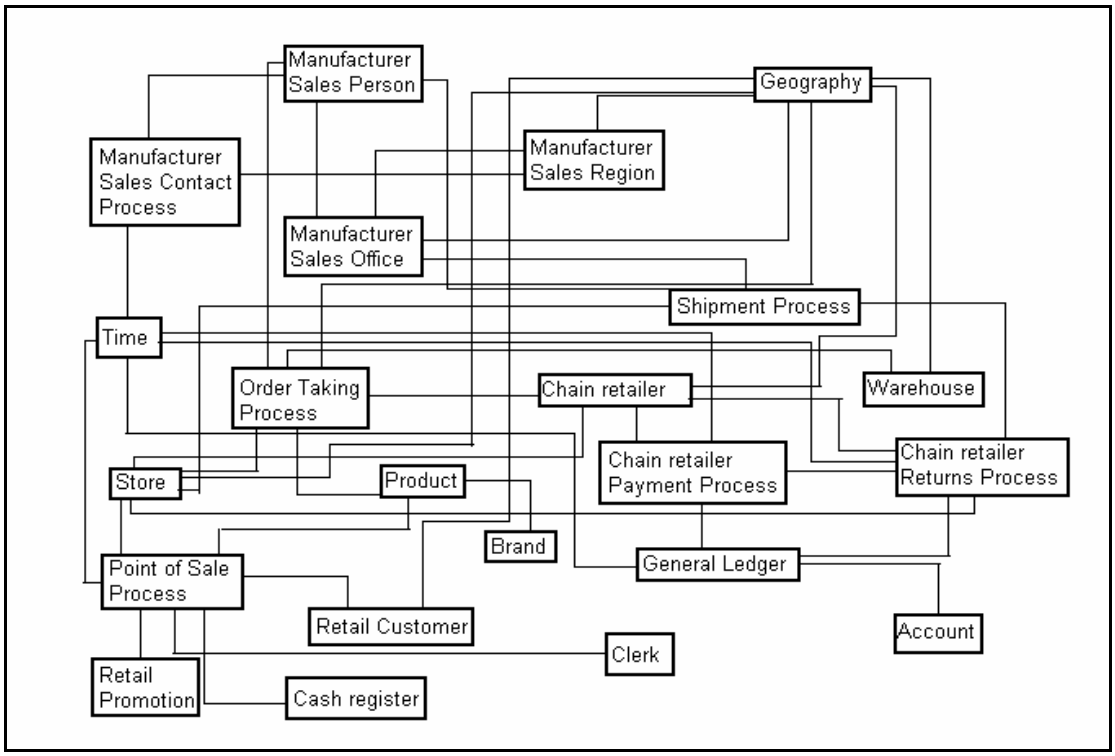


Figure 4.4 An entity-relationship model of an enterprise that manufactures goods (Kimball et al., 1998:143)

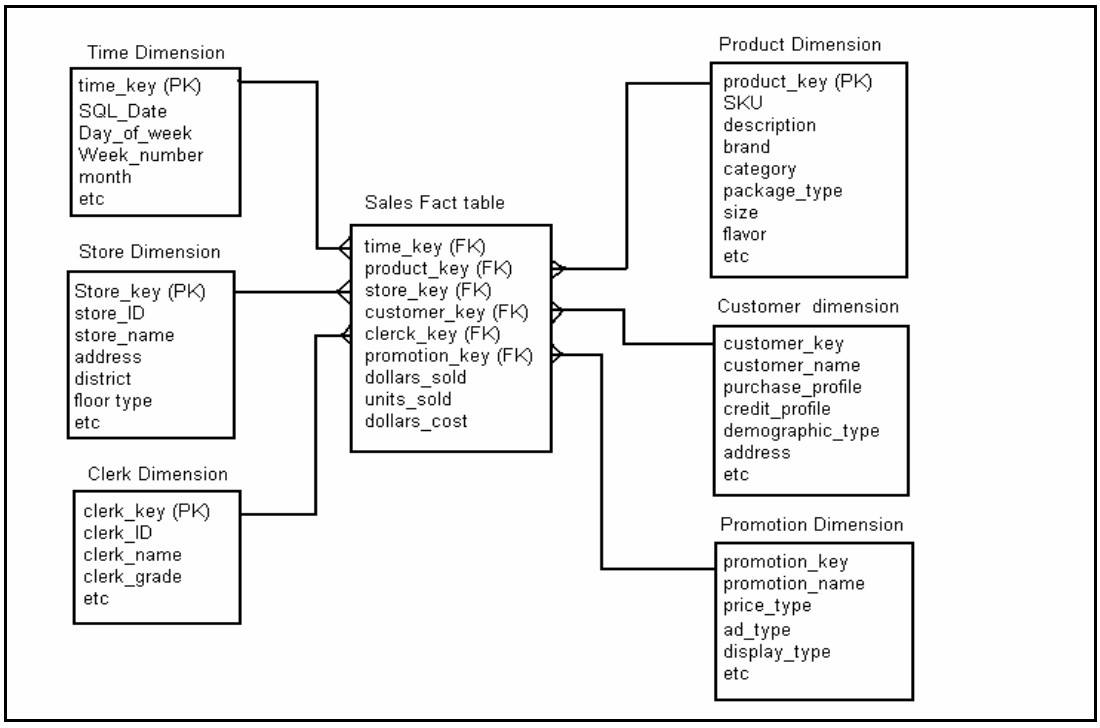


Figure 4.5 A star schema isolating the retail sales process from figure 4.4 (Kimball et al., 1998:145)

Most prominent data warehousing authors follow the approach of Kimball *et al.* (1998) to modelling (Corey *et al.*, 2001; Adamson & Venerable, 1998). The data warehouse is seen as a collection of data marts. Each data mart represents a business process in the organisation by means of a star schema, or a family of star schemas of different granularity. Granularity is the level of data stored in the fact table. Anatomic fact tables store data on transaction level and aggregate fact tables store summarised totals in the fact table.

An area of discussion in data warehousing is whether it is feasible to only have data marts without a separate data warehouse. The model proposed by Kimball *et al.* (1998) can be viewed as such a data warehouse, whereas the model of Inmon (1996) distinguishes between a data warehouse and separate data marts. Corey *et al.* (2001:171) argue that the different data marts share information and if these need to be loaded separately, errors are likely to occur because of the duplication of data. A central data warehouse also allows for easier enforcement of data standards and changes to data.

The model proposed by Kimball *et al.* (1998) does not sacrifice the advantages of a central entity-relationship data warehouse. Instead of having central normalised tables, the model of Kimball *et al.* (1998) has central denormalised dimension tables, which he calls conformed dimensions. Figure 4.6 indicates how different data marts share dimension tables.

The main difference between the approach of Kimball *et al.* (1998) approach and that of Inmon (1996), is that Kimball's conformed dimensions are denormalised, whereas Inmon uses a highly normalised central data base model. Inmon's data marts store a second copy of the data from the centralised data warehouse tables, whereas the dimensions of Kimball used in the data marts, are not copies of the conformed dimensions, but the dimension tables themselves. Kimball *et al.* (1998:153) refers to the set of conformed dimensions as the data warehouse bus.

Any organisation planning to develop a data warehouse needs to make a decision on the design model they will use. Both models proved to be successful in industry. From a systems thinking perspective, the model proposed by Kimball *et al.* (1998) represents a softer approach because of increased user participation. While users are able to verify the design comfortably when star schemas are used, they find it extremely difficult to verify entity relational diagrams.

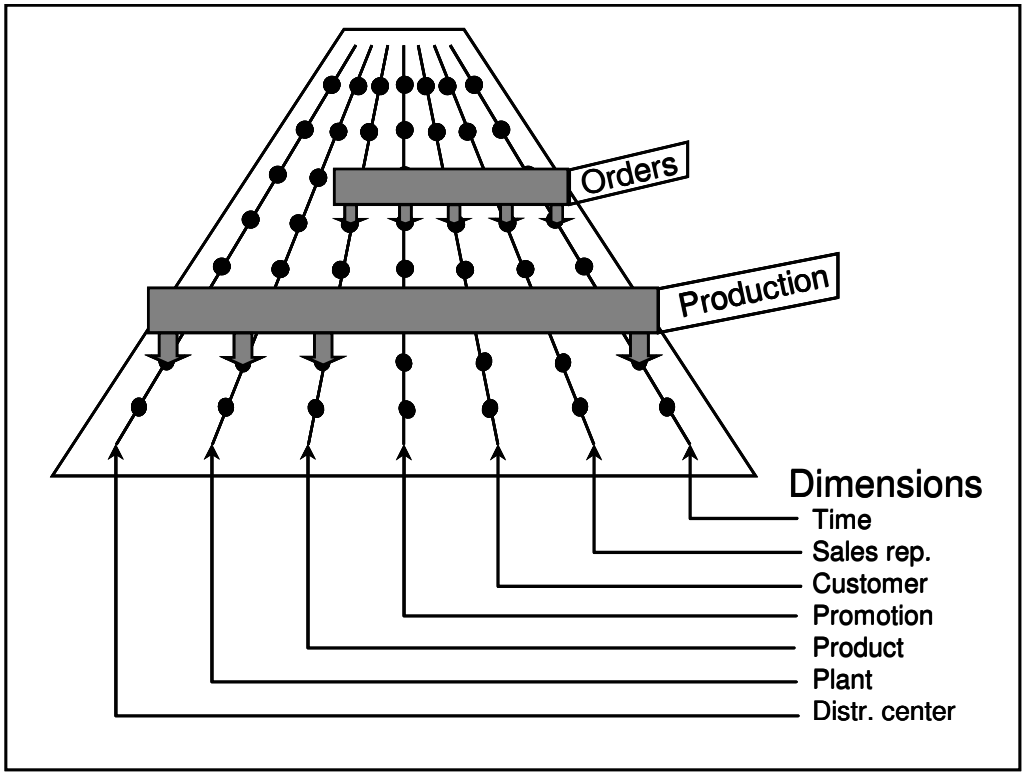


Figure 4.6 Conformed dimensions used by two data marts (Kimball et al.,1998:347)

4.5.4 Data staging

Data staging is the process of moving data from the operational database to the data warehouse. The main tasks in this process are extracting the data from the source systems, transforming the data to the data warehouse standards and loading the transformed data into the data warehouse. The transformation process also includes cleansing of the data. The data staging process is often called the ETL process (extract, transform, and load). The ETL process is a very technical part of the data warehouse development process, and although many different procedures are followed, most authors have reached consensus about the technical detail of the process. The market is overloaded with ETL-tools that are designed to assist the data warehouse development team in the data staging process. Although the technical detail of data staging is not of great importance to this study, each of the aspects will be discussed briefly in order to familiarise the reader with the key concepts. Since data quality assurance and the ownership thereof in the

organisation is of greater importance to the study, this section will be concluded with a description of quality issues of data warehousing.

Extraction is the process of copying relevant data from the source systems. It is essential to perform this process with as little disruption as possible to the source system. This process soon becomes very technical when changes to data loaded earlier in the data warehouse, needs to be managed. Technology of the source systems may differ substantially from the data warehouse technology. The causes of the problems include operating system platforms supporting only specific programming languages and different data formats. Since the availability of the source systems is of major importance to the organisations, the transformation of data is done as a separate stage. The data is copied from the source systems without any transformation to an intermediary storage system.

Since most data warehouses receive data from more than one source system, the data needs to be transformed before it is loaded into the data warehouse. Data attribute formats must be consolidated, for example date formats of source systems may be different. Measurements, such as currency, need to be consolidated. Data fields might have to be separated or joined, for example name fields. Most data warehouse text books contain detailed descriptions on data transformation.

Data quality is addressed during the transformation process. Good quality data is essential to the success of the data warehouse. Mallach (2000:121) discusses eleven information quality factors:

- *Relevance:* The degree to which the information applies to the task being performed.
- *Correctness:* The degree to which the information matches the reality.
- *Accuracy:* A measure of the difference, if any, between an information item and the reality it represents. Inaccuracies may arise from computational processes.
- *Precision:* The potential accuracy conveyed by internal or external data representation.
- *Completeness:* The inclusion of all relevant data in arriving at information.
- *Timeliness:* The availability of information in time for its intended use, as well as the currency of the information at the time of that use.
- *Usability:* The ease of using the information for its intended purpose.

- *Accessibility:* The degree to which information is available to users when and where needed.
- *Conformity to expectations:* Measures how closely the creation of an information item matches the expectations of the people using it.
- *Consistency:* An information item based on data elements that refer to the same time frame, organisational entity, and assumptions.
- *Cost of information:* This refers to both the costs of the computers, networks, and more, that are used to obtain that information, and the cost of the time users spend working with that information.

Cost can usually be traded off against other information quality factors (Mallach, 2000:122). Although these factors are aimed at information rather than data quality, they should be applied to the data in the transformation phase to ensure that high quality information is accessed by the end-users. English (1999) highlights the importance of data quality standards and data ownership in achieving a high quality data warehouse.

After the data is transformed into the correct format, it needs to be loaded into the data warehouse. Loading refers to the initial loading of the data warehouse data, as well as the incremental updates done on a daily basis after the data warehouse is in operation. The loading operation is simplified by the thoroughness of the transformation phase. Data transformation should solve all the problems that may arise during loading. Tools for bulk-loading of data into a data warehouse are used commonly and are very effective.

Metadata plays a vital role in the data staging process. This metadata includes source to target mappings, detailed descriptions of all transformations, as well as loading information. The final task in the data staging process is scheduling and automation of the process. Logs are kept to handle exceptional cases during the ETL-process.

It is vital for the quality of the data warehouse data to monitor the changes in the source data systems. Changes to the source system data format will have a considerable influence on the data warehouse staging functions. To ensure ongoing quality of the data warehouse data, responsibility for the data quality from the source systems should be explicitly assigned to an IS professional.

4.5.5 Data access and deployment

Data access involves the creation of access applications for the business users to access the information in the data warehouse. Users access information in a data warehouse for analytical purposes. OLAP (online analytical processing) was discussed in section 4.3. Tools for end-user access focus on trend analysis and *ad hoc* queries.

Data access tools for standard capability are available from reputable vendors. Organisations have to make a decision as to whether off-the-shelf products will be able to satisfy their information access needs, or not. Training of business users on these applications can also be outsourced. The type of access tool used (off-the-shelf or custom made) and the training of the users (in-house or outsourced), is indicative of the underlying systems thinking orientation of the data warehouse development team. These factors will be explored in the mapping between systems thinking methodologies$_1$ and data warehousing practices presented in chapter 5.

The deployment of a data warehouse is another critical success factor. If the users' perceptions are negative towards the data warehouse, they are unlikely to ever use the warehouse. Such negativity normally results from a low quality system released to the entire user population. It is therefore beneficial to make use of a small group of users, mainly those who have been part of the development process, to test the data warehouse. Having been involved from the start, these users adopted ownership and are therefore highly motivated to ensure a successful implementation of the data warehouse.

Once the data warehouse is implemented successfully, it is interesting to study the use of the warehouse by the users. This can be done electronically, without the knowledge of the users (Kimball *et al.*, 1998:381). Questions that may be answered include who is the lowest level employee using the data warehouse? How often does top management use the warehouse to back decisions? Does the data warehouse change the way people do their work? How many users upgrade their skills to be able to access data from the data warehouse more effectively? These questions, and many more, are influenced by the manner in which end-users access the data in a data warehouse. As stated previously, there are very few standardised reports readymade in the data warehouse. Users use templates to build their own reports, which they are able to store and re-use. Users also access the data by

using query tools that generate database query language. As users grow in confidence, they normally request more training to enable them to use the data warehouse optimally.

The above aspect of data warehouse applications has two effects on the development team. Firstly, the development team never finishes the project; there are always requests for more data marts and more functionality. This coincides with the soft systems methodology$_2$ of continuous learning. The second effect is that management takes an even deeper interest in the data warehouse. This is beneficial to the development team in that it normally helps them to get high level support for their problems. The responsibility for the quality of the source data gets moved around until management assigns it to a specific department.

4.6 Critical success factors in data warehousing

This section aims to report on current research related to success factors in data warehousing. The first part focuses on peer reviewed academic research in the field of data warehousing, and the second part reports on formal industry-driven research. The section concludes with perceptions found in Internet publications.

4.6.1 Peer reviewed research: Critical success factors in data warehousing

This section reports on two recent publications on success factors in data warehousing by Shin (2003), and Wixom and Watson (2001). Since these papers only focus on the practice level of the philosophy, methodology$_1$ and practice schema, they are complementary but fundamentally different to the study reported in this thesis.

Shin (2003) conducted a study on system success factors in data warehousing. He collected data from three data sources in a large Fortune 500 enterprise with 65 000 employees in the United States of America (Shin, 2003:142). Firstly, a survey was designed to collect relevant information from data warehouse users, which was analysed through descriptive statistics. Secondly, unstructured group interviews with end-users were performed to supplement the survey. Finally, frequent informal interviews were held over a two month period with the information technology manager responsible for the data warehouse. Shin (2003:146) studied system

quality with regard to system throughput, ease of use, ability to locate data, access authorisation and data quality. He also included information quality, service quality (including user training) and user satisfaction in his study.

Shin (2003:153) found that user satisfaction is strongly influenced by data quality, ability to locate data and system throughput (the time to get a result after launching a query). Data consistency proved to be the most important aspect of data quality from the end-user perspective. A lack of data consistency influenced the confidence in the data warehouse results dramatically. The main problem with data location experienced by the users, was a lack of knowledge regarding the structure of the data warehouse. This problem was aggravated by a lack of metadata descriptions about the tables in the data warehouse. The users preferred access tools above writing their own SQL code, and they accentuated the importance of a single point of query where a designated staff member could assist them with data location problems. Slow response time proved to be a negative factor in user satisfaction. Shin (2003:156) gives a summary of all difficulties encountered with the systems design, as disclosed through informal interviews. These include: slow response time, too many steps to get information, poor data modelling, lack of audit trails such as the time of last update, and a general lack of metadata. The users complained about limited access to the data warehouse, as well as the following data quality problems: lack of recency, low data accuracy and missing data, data format anomalies, duplicate records, inconsistent field names, and low data reliability and consistency.

Shin (2003:154) found that the average daily access frequency was 15 times, which proved that information recovered from the data warehouse was vital for the increased work productivity of many knowledge workers. More users used the data warehouse for advanced data analysis than for routine daily tasks. Although specific problems were identified in the data warehouse, the high usage frequency indicated that the data warehouse project was successful.

Wixom and Watson (2001:21) argue that a data warehouse project is designed to lay down the architecture for all management decision support systems in the organisation. Therefore, the nature of a data warehouse is different to other information systems, which leads to different success factors in data warehousing as opposed to other types of information systems.

Wixom and Watson (2001) conducted a survey among 111 organisations on implementation factors in data warehousing success. The survey contained two open ended questions where respondents were asked for a list of critical success factors and obstacles to data warehouse success. These findings were used, together with a literature review, to create an initial research model and to structure interviews with ten data warehouse experts. The interviews confirmed the accuracy of the research model, which is presented in figure 4.7.

The model indicates that perceived net benefit of the system is influenced by both systems quality and data quality. They found that management support (including a strong business sponsor) and resources address organisational issues that arise during data warehouse implementation.

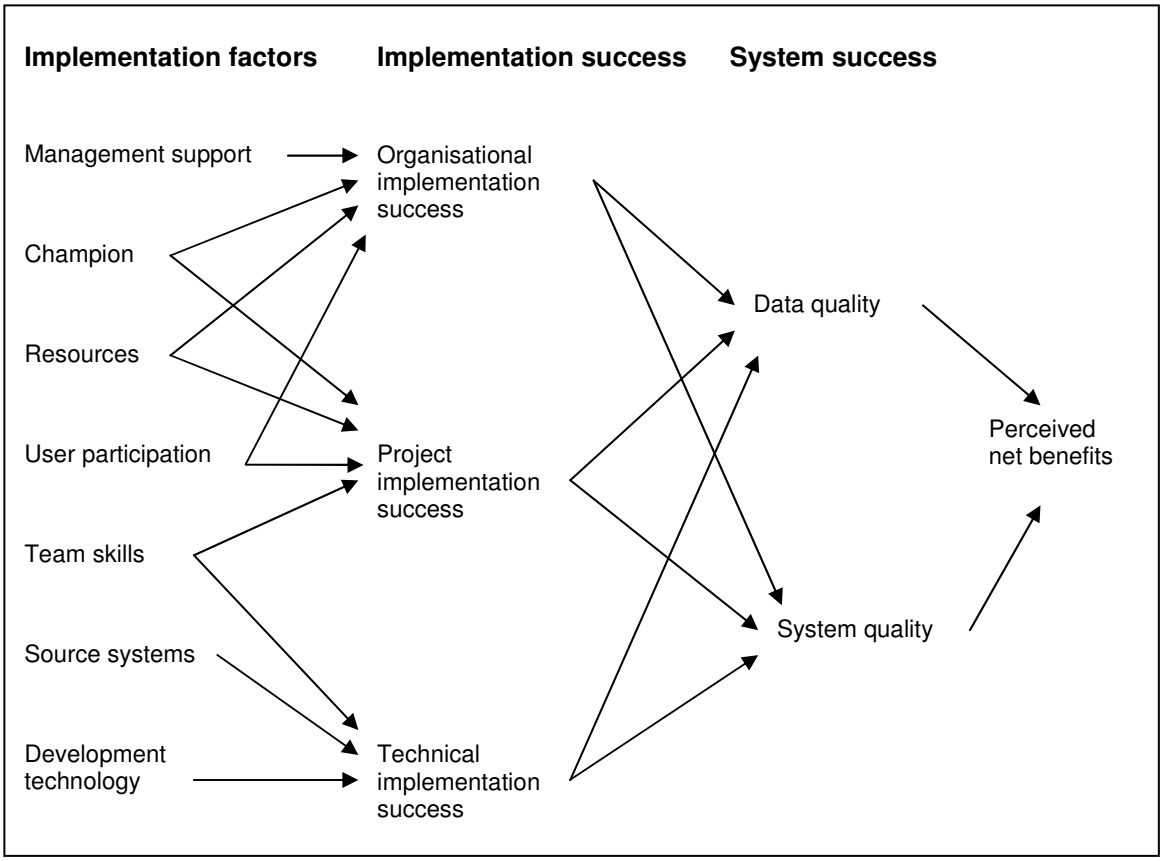


Figure 4.7 Research model for data warehousing success (Wixom & Watson, 2001:20)

Wixom and Watson (2001:20) found that sufficient resources, a high level of user participation and highly skilled team members increased the likelihood that data warehousing projects will finish on time, within budget, and with the correct

functionality. The model also indicates that diverse non-standardised source systems and poor development technology will increase the technical problems that project teams must overcome.

Another study by Little and Gibson (2003) identified the following eight factors important to implementing a data warehouse:

"1. Top level management commitment and support
2. Complete organisational representation in the data warehouse
3. Prototyping the data warehouse use
4. External support for implementing data warehousing
5. Disciplined preparation for and completion of the data warehouse implementation
6. Integrated enterprise-wide data model
7. Complete reusable metadata
8. Recognising potential inhibitors to data warehousing implementation"

4.6.2 Industry released research: Critical success factors in data warehousing

The data warehouse institute (TDWI) is a major provider of in-depth, high quality education and training in the business intelligence and data warehousing industry. Their services include among others, educational conferences and onsite training. Their reports are vendor-neutral and they aim to benefit the entire data warehouse industry. They recently (2003) published a report on the research of Wayne Eckerson (the director of TWDI research) on successful business intelligence solutions. This report includes a description of the research methods that was used to conduct a survey involving 540 business intelligence professionals. The report contains the demographics of the respondents in terms of position, organisation revenues, country, years of experience and industry. It is however not clear how the data was analysed.

The report features six guidelines for success when developing business intelligence (BI) solutions. Firstly, one needs to establish a vision. This means that a business sponsor in the organisation, who is influential in motivating top management, should be identified. Kimball *et al.* (1998) identify this as a readiness factor. Secondly, one should "evangelise" the vision. The business sponsor should advocate the need for change in the analytical culture of the organisation without creating unrealistic

expectations. Thirdly, one should prioritise the "BI portfolio". The BI portfolio is the set of BI applications that fulfils the sponsor's vision. The important aspect is to manage the scope of the initial project. The report reiterates the importance of top management's motivational role in the project. One needs to develop a BI marketing plan. Fourthly, enough resources should be allocated to launch the project and funding must be available throughout the development of the BI portfolio. Continuous funding for maintenance and growth has been identified as a negative influence on BI application success. Fifthly, Eckerson (2003:33) states that one should "align business and IT for the long haul". He argues that extremely successful BI applications take years to implement on enterprise-wide level. Such applications integrate data from dozens of systems across geographic, organisational and political boundaries. Their aim is to create a single version of the truth from a range of incompatible systems and processes. This integration is not achieved overnight, and it is therefore important not to underestimate the time and commitment involved in creating successful BI applications. Finally, one needs to build trust in the system. The business sponsor should facilitate the marketing of the new system. It is important not to undermine its credibility by allowing entry of poor quality data. Inaccurate data proved to be one of the main excuses for users not using the BI application.

Other factors users identified for not using the BI application include (Eckerson, 2003:33):

"1. The data looks different even though it is accurate.
2. There is no way to discover the origins of metrics or data in the solution.
3. The user interface is confusing and the analytical tool is hard to use.
4. Users find it difficult to locate the reports they want.
5. Users are not shown how to use analytical tools in context of their own data.
6. Users can't leverage the BI data in other applications they use.
7. There is no easy way to get assistance when using the BI solution.
8. User feedback doesn't get implemented.
9. The BI system is slow and not always available."

Eckerson (2003:34) concludes with a task list for the BI team to ensure that the BI solution is used optimally by the business users:

"1. Implement a rigorous plan to ensure data quality.
2. Create a dictionary of data elements and metrics for business users.
3. Iteratively prototype the user interface and incorporate feedback.

4. Make the BI solution or relevant reports available via the organisation's intranet.
5. Tune the performance of the BI solution to meet response time requirements.
6. Architect the system to scale seamlessly and inexpensively as usage grows.
7. Develop a training program that provides customisable instruction via multiple modes of using real-life business scenarios and data.
8. Train and support power users in every department to create custom reports for their colleagues and answer questions about the data.
9. Establish a help desk to answer technical questions.
10. Architect the BI solution so it can be easily updated and changed in response to user requests.
11. Implement backup procedures and disaster recovery plans to maintain availability.
12. Provide a scalable, reliable, and high performance solution."

The survey results given by Eckerson (2003), as well as the model given by Wixom and Watson (2001) confirm information given by Kimball *et al.* (1998). It proves the acceptance and the importance of the work by Kimball *et al.* (1998). The section on data warehousing success factors is concluded with a summary of informal Internet publications on this topic.

4.6.3 Non-peer reviewed research: Critical success factors in data warehousing

There are a large number of web sites that list data warehouse success factors, as well as reasons for failure of data warehousing projects. Some focus success or failure on technical issues, such as inappropriate architecture, and others on business sponsorships and user participation. From a systems thinking perspective, these indicate either a hard systems thinking approach, or a soft systems thinking approach.

It is important not to always equate communications with users supporting a soft systems approach. Adelman (2001:1) states that the number one critical success factor in a data warehousing project is to manage user expectations with regard to performance, availability, functionality in terms of level of detail, historical data, data quality, timeliness and final date of completion. The same author states that it is

most successful to involve users all the way through the project. It is impossible to tell without further investigation whether the type of user participation is a sign of a soft, or a hard systems thinking approach. The complete list of success factors given by Adelman (2001:2) is:

"1. Expectations are communicated to the users.
2. User involvement is ensured.
3. The project has a good sponsor.
4. The team has the right skill set.
5. The schedule is realistic.
6. The right tools have been chosen.
7. Users are properly trained."

One website (Anonymous, 2001) gives the following reasons for failure:

"1. Underestimating the complexity of the project.
2. Failure to understand the key element – the data.
3. Viewing it from a systems development lifecycle (SDLC) approach.
4. Organisations try to go from nothing to a complex system in a single project."

It is clear that these reasons for failure focus on the technology used and not on the participation of the business users.

Mimno (2001:1) state that the key factor in data warehousing success is to ensure that the data warehousing application is business-driven and not technically driven. He stresses that the data warehousing application must solve a strategically important business problem, which coincide with a critical systems thinking approach as indicated in chapter 5.

4.7 Literature investigation: Systems thinking and data warehousing practices

The link between systems thinking methodologies$_{1\&2}$ and data warehousing practices is the central theme of this study. It is therefore important to investigate the existence of literature combining these fields.

Mallach (2000:84) defines a system as a "group of interacting components with a purpose" in his monograph on decision support and data warehouse systems. He

explains that a decision support system is a system according to this definition. He uses systems, for example the human body and a transportation system, to relate the systems idea to decision support systems. Mallach (2000) does not refer to systems thinking, or systems thinking methodologies$_{1\&2}$, and therefore cannot be viewed as relevant to the theme of this study.

Chapter 3 refers to literature on systems thinking and information systems. None of the sources refer to data warehousing or decision support systems explicitly. A comprehensive academic data base search, combined with an Internet search, did not yield any useful results.

4.8 Summary

There are many differences between a data warehouse and an operational information system. Operational systems should be able to access and update the data in real time, and it is very important to minimise the duplication of data in the system to ensure integrity of the data. Users access the data by using fixed pre-designed methods. In contrast, data warehouses contain duplicate data to speed up the query process. The integrity of the data is preserved, because users do not update the data in the warehouse. A data warehouse contains historical, quality controlled data, and many of the design principles are designed to optimise the accessibility of the data. Users may access the data through *ad hoc* queries to satisfy the decision support needs. These queries are not pre-designed, and the warehouse team should monitor the use of the data warehouse in order to update the design for optimal efficiency.

A review of peer reviewed and non-peer reviewed literature identified success factors in data warehousing. It is clear that while some follow a business-driven approach to data warehousing, others follow a technology-driven approach. Inmon (2000:1) states that alternative storage to cope with more and more data is the future of successful data warehousing projects.

None of the literature reviewed, gave philosophical or methodological$_{1\&2}$ motivation for data warehousing practices. It is the aim of this study to investigate the links between philosophy, methodology$_1$ and data warehouse practice for the purpose of furthering data warehousing practices.

CHAPTER 5 CASE STUDY REPORT

5.1 Introduction

The aim of the research project is to develop a framework for the explicit use of specific system thinking methodologies$_{1\&2}$ for data warehousing. As indicated in chapter 1, the first part of reaching the objective is to understand current practices of data warehouse practitioners from a systems thinking point of view. After doing literature studies on systems thinking and data warehousing, the researcher now aims to explore the systems thinking nature of current data warehousing practices.

After reviewing research methodology in terms of philosophy, methodology and practice, it was indicated in chapter 2 that while typical positivistic methods were not suited to this cause, interpretive and critical social theory methods also had shortcomings. It was argued that this research problem leans more to the critical social theory paradigm. The aim of the methodological mapping given in chapter 2 (tables 2.2 and 2.3 in section 2.5.2) was to orientate the problem with regard to typical IS research paradigms. This chapter reports on the actual data collection and data analysis done in the study on the systems thinking influences of data warehouse practitioners. Since section 2.5 (specifically section 2.5.3) described the selection of appropriate methods, this chapter aims to demonstrate how the selected methods were used in the research activity.

The chapter reports on the data warehousing practices in terms of systems thinking methodologies$_{1\&2}$. The aim is to understand data warehousing practices according to hard, soft, critical and disclosive systems thinking methodologies$_{1\&2}$. This understanding is essential for the development of a framework for the use of specific systems thinking methodologies$_{1\&2}$ in data warehousing practices presented in chapter 6. This chapter represents the deconstruction part of the critical social research methodology for this study described in chapter 2, section 2.5.2.

The first part of the chapter defines general guidelines for the mapping of data warehousing practices to systems thinking methodologies$_{1\&2}$. Section 5.2 explores the pattern-matching scheme used in terms of a high level mapping that serves as a guideline for the detailed mapping given in table 5.1. This table constitutes the basis

for the analysis of case study data. It includes the different systems thinking methodologies'$_{1\&2}$ typical responses to specific data warehousing questions. The table is organised in different segments coinciding with the data warehousing concepts presented in chapter 4 (section 4.5).

The first part of the chapter was submitted and accepted in research paper format for the systemics track of the annual systemics, cybernetics and informatics (SCI) conference of 2004 held in Orlando, Florida from 18-22 July 2004.

The second part of the chapter reports on the interpretive case study data that was collected at organisations in South Africa. Three case studies were conducted in the banking sector, health sector and at a data warehousing consulting firm respectively. Background information on each of the organisations is given, including the specific circumstances of each case study. The responses of the respondents are then mapped to the table developed in section 5.2.

Each case study's result is presented on a separate copy of the table to identify trends with regard to specific systems thinking methodologies$_{1\&2}$ used at that specific organisation. The responses of people interviewed are identified by individual notations to illustrate that different people in the same organisation have different motivations from a systems thinking point of view. Each case study report is concluded with an overall analysis of the systems thinking methodologies$_{1\&2}$ used in that organisation.

It is assumed that data warehousing professionals are not familiar with systems thinking methodologies$_{1\&2.}$ The case study data proved the assumption to be true. Section 5.3 concludes with a section on problems encountered during data analysis.

Section 5.4 describes the research results and serves as link between the current practices of the data warehousing practitioners and the final framework presented in chapter 6.

5.2 Interpretive pattern matching

It was shown in chapter 2 that the nature of this study differs from typical interpretive research since typical interpretive data abstraction would not link data warehousing

practices to systems thinking methodologies$_{1\&2}$. The discussion on grounded theory given in chapter 2 demonstrated that an interpretive researcher gathers data to be able to arrive at a theory which is grounded in reality. If such an approach was followed in this research design the resulting theory would describe the practices of the data warehousing professionals in general, but not in relation to systems thinking methodologies$_{1\&2}$. Therefore, the aim of the data collection was not to generate a theory by analysing and coding the data, as is typical in interpretive methods such as grounded theory, but rather to be analysed through pattern matching to reveal the underlying systems structures of the data warehousing practices.

Prior to data collection a mapping was done between systems thinking methodologies$_{1\&2}$ and data warehousing practices to guide data collection and to serve as basis for data analysis.

This mapping was done on two levels of detail to guide the researcher. Firstly a high level mapping between each systems thinking methodology$_{1\&2}$ and data warehousing practice was done. The aim of these mappings (presented in section 5.2.1) is to give an overall perspective of a certain systems thinking methodology$_{1\&2}$ on data warehousing. The mappings were compiled by applying the hard, soft, critical, and disclosive systems practices described in section 3.5 on data warehousing practices. Since the methodology$_2$ for practicing disclosive systems thinking is not yet completed the mapping was done from the principles guiding disclosive systems thinking described in section 3.4.

After the high level mapping was completed a detailed level mapping (presented in section 5.2.2) was done in the form of 60 questions grouped in six categories. This mapping is given in Table 5.1. The motivation for selecting these specific questions is twofold. Firstly, after studying data warehousing (presented in chapter 4) certain questions were designed to determine the overall data warehousing methods used by the organisation. Examples of such questions are questions A1, B1, C1, E1 and F1 given in Table 5.1. The data warehousing literature study also led to the selection of the specific 6 categories for the questions. Secondly, after studying systems thinking in terms of its underlying philosophy, methodology and practice (presented in chapter 3) certain questions were designed to enquire about the specific systems orientation of the data warehousing team. Specific questions were designed to enquire about specific systems concepts, for example questions A7, A8, C7 and D7 regarding boundary judgement.

During the design of each question three aspects were considered and tabulated in working notes. The purpose of this process was to ensure that no leading questions were asked as well as to document the thought process behind the formulation of specific questions. Each question had three aspects:

- The systems thinking concept that is examined by the question.
- The "real" question to be asked.
- An open ended formulation that is the actual question asked to the respondent.

Consider question A2 of table 5.1 as an example:

- The concept to be tested is the role of overall objectives in the selection of the data warehouse as well as the role of the data warehouse as a subsystem of a greater system in the organisation.
- The "real" question would have been: "Was management involved in the decision to develop a data warehouse?"
- The actual open question asked was: "Who decided the organisation needed a data warehouse?"

For each of the 60 questions a typical answer was formulated for each of the systems thinking methodologies$_{1\&2}$. Since no literature on data warehousing from systems thinking perspectives could be found the researcher of this study needed to formulate these answers very carefully. The philosophical underpinning of each systems methodology$_{1\&2}$ (described in section 3.3) was taken into account when the answers to these questions were formulated to incorporate the correct ontological assumptions in the respective answers. Available literature on systems thinking methodologies$_{1\&2}$ applied to information systems in general (discussed in section 3.6) also guided some of the formulations of the answers.

5.2.1 High level mapping between systems thinking methodologies$_{1\&2}$ and data warehousing practices

Figure 5.1 (described in chapters 1 and 3) depicts the relationship between philosophy, methodology$_1$, practice and information systems, specifically data warehousing. This chapter involves the two bold-printed arrows in figure 5.1. The solid line represents the relationship between practical systems methodologies$_2$, such

as the SSM and data warehousing. The broken line indicates the relationship between hard, soft, critical and disclosive systems thinking methodologies$_1$ and data warehousing. The broken line indicates that the relationship between systems thinking methodologies$_1$ and data warehousing can be more direct without the use of practical systems methodologies$_2$. This view is motivated by the fact that methodologies$_2$ for the practising of disclosive thinking are not yet completed, as well as the existence of multiple methodologies$_2$ for the practising of hard, soft and critical systems thinking.

This section aims to give a high level overview of the relationships depicted by bold lines in figure 5.1.

It should be noted that the perspectives presented here are the interpretations of the researcher and are subject to the understanding of systems thinking methodologies$_{1\&2}$ by the researcher. Since the systems thinking methodologies$_{1\&2}$ are rooted in philosophy, the underlying philosophy was used to provide guidelines for the mapping of certain data warehousing practices to specific systems thinking methodologies$_{1\&2}$.

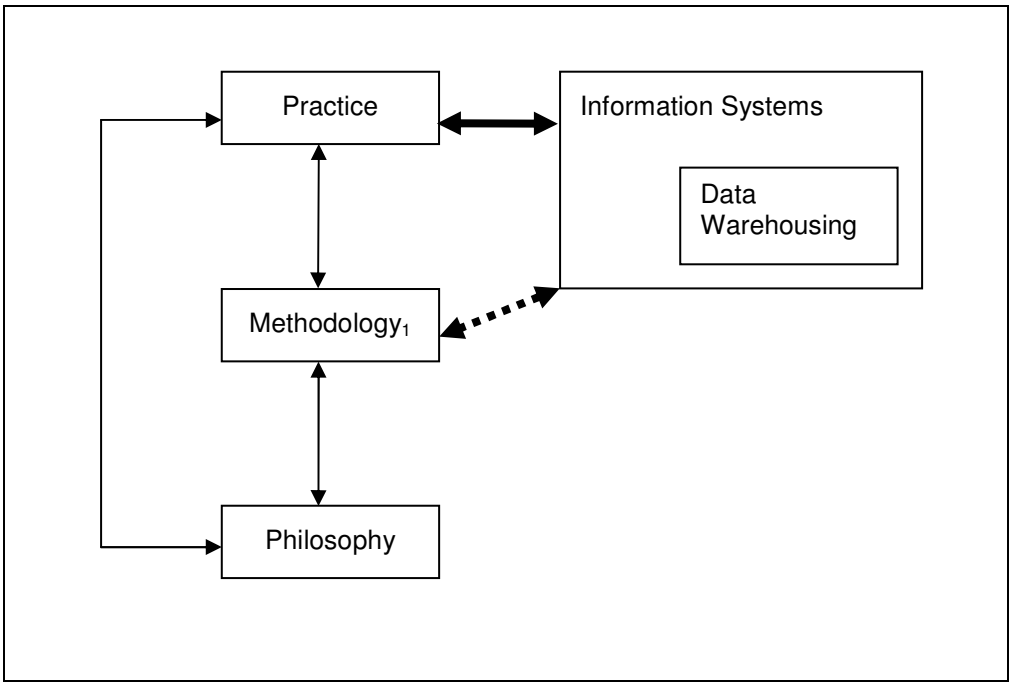


Figure 5.1 The relationship between philosophy, methodology$_1$, and practice

5.2.1.1 Data warehousing from a hard systems thinking perspective

Hard system thinking is common in information systems development. Problems are seen as well defined, and end-user participation is limited to requirements specification. The rigid application of the typical systems development lifecycle (SDLC) is an example of a hard systems approach to data warehousing. Inmon's (1996:24) idea of the reverse SDLC (the CLDS), where requirements emerge from the application of technical rules on data, can also be viewed as a hard systems approach.

Hard systems thinkers are motivated by efficiency of the design in terms of technical performance. Models are seen as a true reflection of reality. Hard systems thinkers would typically use ERDs to model the data warehouse and star schemas to model separate data marts according to Inmon's (1996) methods.

Systems are seen as collections of parts of which the overall functionality is the sum of the functionalities of the individual parts. A data warehouse is then also a system built from parts that achieves its functionality from the functionalities of the parts. It is unlikely that a hard systems thinker would view people as part of the data warehouse.

Any political power conflict in the organisation is ignored. Differences of opinion, for example the accuracy of data and the standard of data quality, are resolved through rational thought.

The main success criteria for the data warehouse are vested in the compliance with end-user specification documentation.

The main disadvantage of a data warehouse built according to hard systems thinking ideas is that a single view of the organisation's objectives is represented in the data warehouse. Problems to be solved by the data warehouse are typically ill-defined and only a one-sided view is represented by the specification given to the data warehousing team by a specific business unit. When different business units give their requirements, the data warehousing team focusses on one business unit at a time, resulting in a group of independent systems that are not compatible.

5.2.1.2 Data warehousing from a soft systems thinking perspective

The soft systems methodology$_2$ (SSM) (Checkland (1981) and its modification (Checkland & Scholes, 1999)) provides guidelines for the practising of soft systems thinking. The SSM advocates an iterative process where the users are involved, refining models to represent the real-world problem situation. It is possible to apply the "CATWOE" method to data warehousing. A soft systems approach will define the customers ("C") of the data warehouse as the customers of the organisation, as well as the decision makers using the data warehouse. The actors ("A") involved are the data warehouse team, the business sponsors and the information technology department in the organisation. Transformation ("T") implicates the transformation of source data into information presented to the decision makers. Another kind of transformation is the way business decisions are made in the organisation before and after the development of the data warehouse. The *Weltanschauung* ("W"), or world view, represents different views that motivate the development of the data warehouse. Different people in the organisation have different motivations for the development of the data warehouse, such as the improvement in quality of the data, a change in the decision making methods, or just the overall improvement of profitability of the organisation. Ownership ("O") of the data warehouse is a very important aspect of the success of a data warehouse. Ownership of various data warehouse aspects should be defined, such as source system ownership, data staging ownership (including data quality), data warehouse data ownership and end-user application ownership. The environmental ("E") constraints in data warehousing include factors, such as current operating systems platforms, current software usage agreements, resistance to change and budget constraints. Since the SSM views systems as holons or human activity systems, people are seen as part of the systems. This implies that the business user, the data staging manager and others are seen as part of the data warehouse system.

Although the latest version of the SSM advocates sensitivity to the political system in the organisation, soft systems thinking still operates in the order dimension of Burrell and Morgan (1979) and is not focussed on the emancipation of specific groups in the organisation.

The work presented in chapter 2 of Churchman (1968) can also be viewed as a methodology$_2$ for practising soft systems thinking. The objectives of the data warehouse need to be real objectives that are not contradictory to other objectives of

the organisation. Each of the subsystems of the data warehouse (e.g. data staging and end-user applications) should have measurable objectives supporting the overall objective of the data warehouse. Resources of the data warehouse are defined and should be used optimally to support the overall objective of the data warehouse. Since the boundary of the data warehouse is defined as everybody and everything influenced by the data warehouse, it implies that the business users are also viewed as part of the data warehouse. The environment of the data warehouse is similar to the environment discussed as part of CATWOE, i.e. those factors that cannot be changed by the data warehouse system.

It should be noted than one can follow a soft systems thinking approach to data warehousing without practising the SSM explicitly. Table 5.1 contains soft systems answers to data warehousing questions independent of the SSM.

5.2.1.3 Data warehousing from a critical systems thinking perspective

The literature studies of chapters 2 and 3 indicate three complimenting strategies for the practicing of critical systems thinking in data warehousing. The work of Harvey (1990), Flood and Jackson (1991) and Ulrich (1987) can be applied to data warehousing.

Although Harvey's (1990) work is presented in chapter 2 to guide critical social research, the principles of critical social theory also apply to critical systems thinking. According to Harvey (1990), structure is an important aspect of critical thinking. The critical systems thinker aims to deconstruct the problem situation to expose the underlying oppressive structures. In data warehousing terms this implies that the data warehousing development team needs to study the structure of both the data warehouse and the total structure of the organisation. They have to look beneath the surface to determine the real purpose of the data warehouse in the organisation. Decision taking strategies are often taken for granted but they could be manifestations of the oppressive structures enforced by management. Therefore, the motivations of specific decision strategies should be investigated by the data warehousing team. It is important that the data warehousing team realises the danger of their efforts being a tool in the reinforcing of specific structures in the organisation that might be harmful to individuals or groups inside the organisation or the general public. This critical awareness is achieved among others by studying the

history of decision making as well as the construction of history in order to understand the advantages and disadvantages of current decision making strategies in the organisation.

During data staging, the data warehousing team should similarly try to look beneath the surface of data quality issues. They should determine why certain parties are satisfied with data that is not totally accurate. They should also determine which interests are served by data that has been historically unreliable. The data warehouse team should strive to take all the role-players' interests into account when deciding on standards for data definitions and quality.

Flood and Jackson (1991) presented total system intervention (TSI) as a method for selecting appropriate methodologies to achieve positive change in a problem situation (discussed in chapter 3). TSI is an iterative process consisting of three phases: creativity, choice and implementation. During the creativity phase the data warehousing team should take a broad view of the problem situation in the organisation. They should investigate the decision making strategies and motivations thereof. TSI proposes the use of metaphors to understand the problem situation. The data warehouse team should ascertain whether the organisation is seen as a machine or organism with a brain, or some other metaphor. During the choice phase of TSI an appropriate methodology will be chosen. The "system of systems methodologies" is used to select the most appropriate methodology for the particular problem situation. The chosen methodology is implemented and the results are evaluated. A critical data warehouse team will be cautious of the inherent weaknesses of different methodologies and the impact thereof. During each iteration the focus of the project is sharpened. A critical data warehousing team would be willing to combine different methodologies to compliment each other while being critically aware of the weaknesses of each methodology.

Data warehousing from Ulrich's (1987) point of view would focus strongly on critical boundary judgements. The data warehouse team will take the inevitability of argumentation break-offs into account. Critical heuristics (discussed in chapter 3) gives practical guidelines for the involvement of all the affected parties in the solution of argumentation break-offs. A major part of the data warehousing effort will be to determine the boundary of the data warehousing effort in the organisation. Critical heuristics differs from soft methods in that it does not ask "what is part of the data warehouse?" but rather "what ought to be part of the data warehouse?" These

boundary judgements are only possible if the organisation as a whole is understood. The data warehousing team will be critical rather than objective in determining the boundary of their effort as boundary judgements are often personal value judgments. The data warehousing team would be very aware of the rights of all the affected parties of the data warehouse and would include such "witnesses" (see list of questions in section 3.6.3.2) in the data warehousing process.

These three strategies towards practicing data warehousing from a critical systems point of view are complimentary toward one another and are all considered in the detailed mapping of critical systems thinking and data warehousing presented later in this chapter.

Since critical systems thinkers believe that the world is not fundamentally harmonious, they are aware of power struggles in the organisation. Specific measures are taken to eliminate the negative effects of power struggles in data warehousing projects. These include the project team meetings where everyone is seen as of equal importance in the organisation. All stage outcome documents, for example the requirements specification, are critically examined by all the team members for specific elements that might be harmful to certain groups in the organisation.

Critical systems thinking has a foundation in intervention and emancipation. Therefore, the data warehouse is also viewed as a tool for intervention and emancipation. The aim of the data warehouse is to change inefficient decision making in the organisation and to expose and rectify data quality problems in the operational information systems. The data warehousing team view themselves as emancipators in the organisation.

5.2.1.4 Data warehousing from a disclosive systems thinking perspective

Since the disclosive systems thinker does not regard human freedom to be absolute, the data warehousing team leader does not belief that he controls the problem situation. His role is to facilitate the disclosure of the intrinsic normativity of the situation and to ensure that team member's responsibilities are performed in harmony with such intrinsic normativity. The disclosive systems thinker views his

facilitation as a response to structural conditions in the situation. Although other systems thinkers might not be aware or even choose to ignore the intrinsic normativity, the disclosive thinker aims to disclose the intrinsic normativity.

The intrinsic normativity is the essence or the meaning of the organisation. One might ask: "What is the main benefit of this organisation?" The intrinsic normativity of a hospital system is ethical in nature and focuses on patient care. A disclosive systems thinker keeps the intrinsic normativity in mind during every phase of the data warehousing project. Strijbos (2000:174) states that: "each entity functions in a diversity of modalities or modes of being, which are aspects of one and the same entity". The qualifying norm of an organisation guides the different aspects of that organisation. A data warehouse also has different aspects such as an analytical, economic, and a juridical aspect according to the list of aspects given in section 3.3.1.3, but the qualifying aspect is found in the intrinsic normativity of the organisation in which the data warehouse functions such as a hospital. The data warehouse should be designed to support the qualifying function of the organisation.

In a hospital, requirements collection will focus on how the daily actions of managers can be improved with the aim of improving patient care. Disclosive systems thinking emphasises the responsibilities of various actors. Various people from different sections in the organisation will be included in the process to ensure that the data warehousing team better understands the circumstances to which the data warehouse forms a response. The requirements team needs a clear understanding of the social-cultural context in which the data warehouse will be used. The data staging phase will focus on how data quality can be improved to improve patient care. Once again other modalities such as the arithmetic and analytic aspects of data staging are guided by the ethical modality of patient care.

The choice of a data modelling method will be influenced by the degree to which each of the possible methods advance patient care. One might argue that data modelling is very far away from patient care in a hospital. However, it is clear that patient caretakers are able to understand a star schema and therefore to test the model. They are able to ensure that all the information required by management to improve patient care, is available.

The intrinsic normativity of every type of organisation is not as easy to determine as that of a hospital. It is the responsibility of the data warehousing team to disclose the

intrinsic normativity, or the internal meaning of the organisation, before starting to develop a data warehouse. It is often found that the intrinsic normativity becomes more clear (is more clearly disclosed) as the development continues. This is only possible when end-users are involved in the development process.

The ideas presented here coincide with Churchman's (1968) systems objective that needs to be central to all the subsystems. The difference however, is that Churchman's central objective is not subject to ethical scrutiny. The disclosive systems thinker accepts the given reality (intrinsic normativity) and also that man cannot change everything. He aims to involve different actors and gives responsibility to people ensuring accountability for actions with regard to the intrinsic normativity. Consensus is used to determine what is best for everybody involved. This is in contrast with the work of Churchman (1968) that uses a central measurable objective, which implies that the main objective should be quantifiable.

5.2.2 Detailed level mapping between systems thinking methodologies$_{1\&2}$ and data warehousing practices

The high level mapping of the previous section is extended to give detail on how specific data warehousing concepts are viewed from each of the discussed systems methodologies$_{1\&2}$. This mapping is given in table 5.1. The table is broken down in segments that coincide with the different data warehouse concepts discussed in chapter 4.

There are five aspects to consider when observing table 5.1.

1. The answers to the questions presented in the table need to be probable answers that can be expected from industry professionals. It also needs to be a true reflection of the specific systems methodology$_{1\&2}$ it represents.
2. In certain instances, similar answers are given for more than one methodology$_{1\&2}$ since the practice level of the methodologies$_1$ are similar. This however does not imply that the ontological motivation for the practices is similar.
3. Systems thinking methodology$_{1\&2}$ literature does not give clear answers to many of these questions; therefore, the foundational philosophy was used to formulate an answer.

4. The questions contained in the different segments of the table were typically directed at different people in the organisation. Some of the questions were repeated to different people, mainly to ascertain the degree to which a holistic approach was followed.
5. The term "essence of the organisation" used in the disclosive systems thinking perspective, refers to the intrinsic normativity or meaning of that organisation which differs from a human assigned objective of the organisation.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
SECTION A: Data warehouse adoption					
1	What is a data warehouse?	A data warehouse is an integrated data source to fulfil the reporting needs of business units. It consists mainly of data, metadata, and technology such as computers.	A data warehouse is a system to improve decision making in the organisation. It consists of people, data and technology.	A data warehouse is a tool to affect positive change in the organisation as a whole. It consists of everything required to succeed in the realisation of the proposed change.	The essence of a data warehouse depends on the organisation. A data warehouse in a bank and a data warehouse in a hospital are fundamentally different because the essence of a bank is fiduciary services and the essence of a hospital is patient care.
2	Who decided the organisation needed a data warehouse?	The IT (IS) department decided that integration of data will aid their reporting to management. The implementation of a data warehouse will decrease their data conversion problems.	Data warehousing is only a tool for solving the business problem of management information accessibility. It was decided to select a data warehouse as a business intelligence tool, not as a data management tool.	It is important to identify the decision taker since it provides clues to the underlying structures and the boundary judgments.	This information will assist the data warehouse team in disclosing the qualifying norm in the organisation.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
3	What is the root problem to be solved by the data warehouse?	Data quality issues.	To aid the organisation's strategic objectives.	To solve a specific problem in the organisation through active intervention or change.	To perform better in the essence of the organisation.
4	If any, what other solutions to the problem were considered?	Mostly technical solutions.	Solutions focussed on a holistic approach, with strong user participation.	Solutions aimed at identifying structures and boundary judgments	Solutions that accept that man does not control everything but has to respond to the intrinsic norms in the organisation.
5	Who owns the data warehouse?	The development team.	More than one party, but mostly the users.	Both the involved and the affected.	The data warehouse is a joint responsibility in the organisation, owned by developers and users.
6	What is the impact of the data warehouse on other systems or business?	Not sure, mostly technical.	Impact study was performed. Overall data quality is improved.	Groups that were previously regarded as outside the data warehouse are now part of the data warehouse depending on the scope or boundaries.	Detailed impact study (with regard to the qualifying norm) was performed with emphasis on ethics.
7	Is everything the data warehouse influences, part of how you view the data warehouse?	No.	Yes.	Yes, but also those affected by the data warehouse.	Yes.
8	Do people form part of the data warehouse?	No.	Yes.	Yes, both the involved and the affected.	Yes, but the power of humans is not absolute.
9	How do you determine whether the data warehouse is successful?	Mostly a quantitative answer, or when the specification is achieved.	Qualitative answer; when the business users are satisfied.	When the problem that caused the initiation of the data warehouse project is solved.	When the intrinsic normativity of the organisation is furthered.
10	What are the main advantages of the data warehouse?	Technical answer.	Reach organisation's objectives.	The answer will expose the initiating group or the intended emancipation as well as the underlying structures and boundary judgments.	The data warehouse provides a method for decision making that is guided by the qualifying norm of the organisation.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
11	Which department is responsible for the development of the data warehouse?	Typically the information technology department.	A dedicated business intelligence department.	A detailed process was followed to set up a team consisting of all the involved and affected parties. The question was asked: "Who ought to be part of the team?"	A team is formed consisting of various people representing various functions in the organisation to maximise the understanding of the essence of the organisation.
SECTION B: Data warehouse development methods					
1	Describe the lifecycle of the development of the data warehouse.	Inmon's lifecycle or a strong waterfall model where user participation is limited to the requirements collection phase.	Strong focus on user participation and the organisation's objectives. Definitely an iterative process.	This would be an iterative approach, but more than one methodology could be used according to the applicability. There is a critical awareness of the weaknesses of each methodology.	The context and qualifying norm of the organisation will be initially investigated. Thereafter methods that are usable by technical and non-technical staff will be selected to further the essence and to allow the fulfilment of responsibilities in the organisation.
2	Describe the relationships between people in the data warehousing team.	People are assigned tasks by the project leader in order to achieve maximum efficiency.	Because consensus is of utmost importance, a facilitator approach is adopted by the project leader to assign roles to team members.	People are motivated to look beyond the organisational structure and hierarchy in order to discuss the project freely. Team members are motivated to discuss all aspects of the work openly and critically by requesting explanations by others.	Responsibilities are awarded to different people. This is done in accordance with the essence of the organisation. The project leader is responsible to ensure that each person performs his/her duty according to the intrinsic normativity or essence of the organisation.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
3	What is the role of end-users in the development lifecycle of a data warehouse?	End-users are responsible for the requirements definition. They are not involved in the development process. They are involved in the final stages of testing of the system.	End-users are involved in as many phases as possible, including requirements collection and modelling, as well as end-user application development. An incremental process is used to accommodate end-user views in the system.	End-users are motivated by their specific goal and involve themselves to ensure their goal is achieved. Participation and emancipation go hand in hand. End-users are on equal status in the data warehousing team. They are central to the boundary judgment of the project.	End-users are involved to disclose the essence of the organisation to the development team and to ensure that ethics are built into the system.
4	What is the role of outside consultants?	They are used to ensure efficiency.	They might help to gain consensus, but they should be clear on the organisation's objectives.	If the in-house technical team cannot deliver the desired outcome, consultants will be used.	It is imperative that the consultants should take ownership of the essence of the organisation. Somebody from within the organisation needs to ensure that the consultants act accordingly.
5	Explain how you divided the project into smaller projects.	Typically according to the SDLC or Inmon's model.	Typically according to Kimball's model of dividing projects in line with business processes.	The key business problem will always enjoy highest priority.	Care is taken not to loose sight of the importance of the qualifying norm or to take it out of context when dividing the project into smaller tasks.
6	How did you specify performance objectives for each of these projects?	Each project's performance objectives are determined independently from the others.	The performance objectives of each sub-project are highly measurable and support the objective of the overall system and that of the organisation.	The performance measures form part of the different methodologies used in different phases. The performance measures depend on subjective judgments of the boundaries of the warehouse.	The objectives of the sub-projects are in line with the essence of the organisation, as in soft systems, but with less emphasis on measurability.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
7	How is the project financed?	Centralised.	Decentralised.	Centralised.	Decentralised.
SECTION C: Requirements definition					
1	Describe the process of requirements collection.	Inmon's idea of the requirements resulting from the data warehousing process, or the users completed pre-designed forms stating their requirements. The users are responsible for their requirements.	A partnership between IS and business was formed, where IS staff and business analysts worked together to determine the requirements. Prototyping was used to design a vehicle for discussion between IS designers and users.	The nature of decision making in the organisation was investigated (both currently and historically). Great effort was taken to ensure that all affected parties in the organisation are involved. Metaphors are used to verify communications.	Many different people were involved to ensure that the context of the data warehouse is understood. The main effort is to research consensus on the identity of the qualifying norm.
2	Who represented which levels of the hierarchy during the requirements specifications?	Limited participation of top management; strong subject orientation.	Strong business sponsor which is independent of a specific subject area.	Strong representation by the group initiating the data warehouse but care is taken to involve all the affected parties.	Many different levels should be represented to ensure better understanding of the essence of the organisation.
3	Do users know what they want? How do you go about assisting them?	No, users don't know, but we deliver typically what they ask us to do. It is their problem. Alternatively, an Inmon approach, where requirements are developed later in the project, after the technical implementation has been completed.	Not always, but the data warehousing team should help them to specify their different views, all of which are combined into user specifications on the basis of consensus.	Mostly yes. The group initiating the data warehouse has strong motivation for the development of the data warehouse. It is the task of the data warehousing team to be critical towards them in order to identify power struggles and negative intentions toward another group or individual in the organisation.	Mostly yes. The users know what they want to accomplish. The data warehousing team is also alert to everybody's objectives, i.e. whether they are ethically acceptable and in line with the essence of the organisation.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
4	How did you reach consensus on requirements?	The users are responsible for consensus; the IS department wants one voice from the users.	Different opinions give a better understanding of the functionality required by the data warehouse. This leads to the creation of different views relating to the data in the data warehouse.	It is accepted that boundary judgment is subjective. Team members are encouraged to share their values that led to their view of the data warehouse.	Requirements were tested against the qualifying norm in the organisation.
5	What is the role of the organisation's objectives in the requirements collection process?	The team don't know the objectives; they do not see it as of crucial importance to their task.	The organisation's objectives are crucial.	It depends on the scope of the data warehouse. The scope (or boundary) ought to be large enough to include the organisation's objectives.	They are important as long as organisational objective are in line with the essence of the organisation and without ethical conflict.
6	How do you keep your requirements documentation up to date?	This is done by filing user requests.	Clear joint ownership between the development team and the users.	Documentation is a priority for all the affected parties, since it defines the boundaries of the data warehouse. The data warehouse team uses an iterative process to keep the documentation up to date.	Documentation should clearly state what is regarded to be the qualifying norm and what aspects of the organisation should not be changed. It is best kept up to date by a joint effort between users and developers.
7	To what degree do existing systems determine the functionality of the data warehouse?	To a large degree, as only data available from the source systems, can be included.	User requirements are paramount when starting the process. Concessions are made for requirements that cannot be supported from existing data.	Changes to existing systems are strongly contemplated to assist user requirements, since existing systems might reinforce the oppressing structures targeted by the data warehouse.	If the existing systems are in conflict with the essence of the organisation, they need to be changed. However, there are many intrinsic restrictions in the organisation that are respected.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
8	Are you satisfied with the requirements documentation?	Yes.	Room for improvement.	Yes, but it can always be improved. It is continuously evaluated.	Yes, as long as it reflects the essence of the organisation as guiding aspect of the data warehouse.
9	Are the users satisfied with the requirements documentation?	The users never see the final documentation.	Yes, but it is an ongoing process.	Yes, because they are involved in the entire process.	Yes, as long as it reflects the essence of the organisation as guiding aspect of the data warehouse.
SECTION D: Data modelling					
1	Do users form part of the modelling team?	No, their inputs are represented by the requirements definition documentation.	Yes, users help to extend the model to represent as many views as true as possible.	Yes, since they are the key to understanding the underlying structures and the boundaries of the data warehouse.	Yes, users are helpful to identify and maintain the qualifying norm during the modelling process.
2	Do you use an ERD or star schema? Why?	Mostly ERD, but those who use star schemas do it for technical reasons, such as quick response time on queries.	Mostly star schemas, because users can understand them and are able to participate in the design process.	Mostly star schemas to allow the user to verify the process.	Star schemas, but the users want to see all the star schemas to form an image of the organisation as a whole.
3	Does the modelling team know the organisation's objectives?	Not necessarily.	Yes.	It depends on the boundary of the data warehouse, but they ought to.	Yes, they are especially aware of business ethics.
4	Do you view business processes different from department to department in the organisation?	Don't understand the question. After explanation: No.	Yes.	Yes, the data warehouse team will have a critical awareness of each function in the organisation.	Different business processes are used to further the essence of the organisation.
5	How often do you change the basic design of the data warehouse?	Not often.	Sometimes to incorporate new user views.	Keep on changing until desired goal is achieved.	Keep on changing in order to represent essence as disclosure continues.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
6	What is a model?	A true representation of the real world.	A vehicle for discussion about reality.	A metaphor would be used to explain the answer. Possible references to boundary judgments.	A model is used to describe something. The modalities are used to describe the essence of something.
7	How often do you talk to the users during the design process?	Not often, the requirements documentation represents their input.	Often, as an iterative process is used.	They are included in the design process. They are truly part of the process.	They are an integral part of the process.
8	Are you satisfied with the model used?	Yes.	Yes, it is an iterative process.	It is often reviewed in terms of strengths and weaknesses and is changed when required.	Yes, but one should be cautious of loosing sight of the essence of the organisation when building the model.
9	What is a data mart?	Inmon's approach.	Kimball's approach.	Kimball's approach.	Kimball's approach.
10	Why do you implement data marts this way?	Technical motivations.	User participation.	To level the playing field between users and "experts".	The data warehouse is divided into smaller parts without loosing the essence in any part.
11	What performance measures do you use?	Technical.	User satisfaction.	The problem situation is reviewed. If the problem is solved the performance is satisfactory.	The essence of the organisation should be incorporated in analytical decision making by using the data warehouse.
SECTION E: Data staging and data quality					

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	Who is responsible for data quality?	The source system owners as far as availability and accuracy are concerned and the IS team as far as compatibility is concerned.	A joint effort. The source systems should be in line with the organisa-tion's objectives and should therefore be willing to adapt to achieve objectives. The users should indicate which data definitions are most represent-tative of the organisation's practice.	High quality source data is part of a successful data warehouse. The data warehouse team ought to have a representative of the source system. Source systems that provide poor quality data need to be changed.	It is a joint effort of the source system owners and the data warehousing team, accepting restrictions caused by current responsibilities of employees with a strong focus on business ethics.
2	Does the overall objectives of the organisation influence data staging?	No.	Yes, very much.	Yes, depending on the boundary of the data warehouse. But it should.	Yes, assuming that the overall objectives of the organisation support the essence of the organisation and therefore the data warehouse.
3	How do you handle conflicting quality rules?	The source systems owners should issue instructions after having resolved conflict among themselves.	Through consensus.	The history of the data sources is investigated to expose the structures they support. Only after understan-ding the reasons for differences, can the problem be addressed.	Through consensus, with the essence or the organisation as guiding principle.
4	How much do you know of what keep the managers awake at night?	Not much.	Very much.	It depends on the boundary of the data warehouse, but since the data warehouse project is focussed on the total organisation, the answer should be "very much".	Very much, since the essence of the organisation is also the essence of the data warehouse.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
5	How do you measure success?	Check the number of data items. The user is responsible for supplying test cases.	Success criteria are built into each step and different people, such as the source system owner, the design team and the users are jointly responsible for supplying test cases.	Success in data quality indicates that the context and consequences of all the data is understood.	When the essence of the organisation is better reflected in analytical decision making.
6	Do you have contact with the users?	No, we implement the model.	Yes, sometimes.	Yes, very often.	Yes, very often.
7	What is the purpose of data staging?	Only a technical answer is given.	Technical answer and comments on system objectives are made.	To understand the underlying structures or data of the data warehouse in order to understand the problematic structures.	Technical answer, but reference to the essence of the organisation and responsibilities of different people.
8	Are there secondary benefits to the organisation?	Don't know.	Yes, better data consistency.	Yes, since the total organisation is viewed by the data warehouse team, the intervention should have some benefits to everyone.	Yes, sections of the organisation that are not in line with the essence of the organisation can be identified.
9	How does the data warehouse change the way people do their work?	Don't know.	The team members know how the organisation's objectives are achieved.	The team members know exactly what intervention is achieved by the data warehouse.	The analytical decisions also reflect ethical responsibility.
10	Who are your customers?	The application developers and the business users.	Similar to hard systems but also the customers of the organisation.	The answer would also reflect on who ought to be the customers.	Everyone affected by decisions made.
SECTION F: End-user applications					

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	When did you gather requirements for the end-user applications?	The users use standard access programs for which training was outsourced to the suppliers of these packages.	These requirements formed the foundation of the data warehouse design and were gathered at the beginning of the process and used throughout the lifecycle.	When the boundary judgements were made at the beginning of the project. It is however an iterative process.	At the beginning of the project when the norms were disclosed and the qualifying norm was identified.
2	What role does the organisation's objectives play in end-user applications?	Don't know, the end-user applications are done according to the specifications given by the users.	Very important role.	It depends on the scope (boundary) of the data warehouse, but it should be very important.	Important role, assuming that the overall objectives of the organisation support the essence of the organisation and therefore the data warehouse.
3	Do you develop end-user tools in-house?	Use very often standardised packages.	Yes, if standardised packages are used, contextual training is given.	Yes, to maximise the intended intervention.	Yes, since very few off the shelve packages allows one to model decisions around the essence of the organisation.
4	Are end-user applications part of the data warehouse?	No.	Yes.	Yes, they are central to the success of the data warehouse.	Yes.
5	Did you start with a proof of concept?	No. Our requirements are complete.	Yes. It eases user participation.	Yes, an iterative process holds great benefits.	Yes, it guides conversation around the qualifying norm.
6	What type of training do you give users?	Training is not individualised and sometimes outsourced.	Since the users were part of the design process, and since prototypes were used, they are familiar with the interface. They are trained in their own environment, using examples that correspond to their view of the data warehouse.	Through data warehouse training, the change intended by the development of the data warehouse is enforced.	Training is given to show how the new data warehouse incorporates the essence of the organisation in analytical decision making.
7	Do users change the way they do their daily work by using the data warehouse?	The data warehousing team does not know.	Yes.	Yes, that might have been the main objective of the data warehouse!	Yes, they are much more aware of the implications of their actions.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
8	Does everybody have access to all the information in the data warehouse?	No, the access levels are set by management and are of little importance to the data warehousing team.	No, but it is a contentious issue. The data warehousing team should ensure maximum flexibility in access levels.	No, but they ought to. All affected parties should have access to the information.	Yes, to a large extent and access is only restricted to protect the interest of people and not to hide information.
9	How many users do *ad hoc* queries that they design and implement themselves? Do you encourage this?	Not sure. The team does encourage it, because it means less work for them, as long as the users don't cause damage.	They know the answer and encourage users to make optimum use of the data warehouse in order to reach the objectives.	This indicates the empower-ment of the data warehouse users. Sometimes the data warehouse is designed to emancipate or to empower middle management. All the users ought to do *ad hoc* queries.	They are all motivated to use *ad hoc* queries, as long as they comply with ethical standards.
10	Did the usage of the data warehouse influence the career paths of certain managers?	Don't know.	Do know but not very important.	Do know. This might indicate the real objective of the data warehouse.	Yes, the careers of those sensitive to the intrinsic normativity are furthered.
11	Do you keep an audit trail of data warehouse usage?	Yes, to be able to send an account to each business unit.	Yes, to be able to improve service.	Yes, to determine to what extend the data warehouse is used as well as to clarify the boundary of the data warehouse.	Yes, to provide better service and to check ethical usage of the data warehouse.
12	How do you know when the data warehouse is successful?	When data quality improves and when the specifications are met.	When the organisation's objectives are better achieved.	When the intervention is achieved.	When the essence of the organisation is reflected in decision making.
13	Do you see the data warehouse a control mechanism that management uses to control how decisions are made?	No, or don't know.	No.	Sometimes, yes, but the data warehousing project is also used to expose the power structures in the organisation.	No, but the data warehouse is a tool to ensure that decisions made are ethically sensitive.
14	Do you know the data staging processes?	No, it's not the job of the team.	Yes, a holistic approach is followed.	Yes, it gives insights into the underlying structure of the organisation.	Yes, in order to understand the whole context of the data warehouse.

Table 5-1 Mapping of systems thinking methodologies[1&2] on data warehousing concepts

5.3 Data collection

Interviews were conducted in terms of the data collection method described in section 2.5.3.1. Semi-structured interviews were conducted using the questions in Table 5.1. The questions presented in Table 5.1 formed the basis of each interview, although additional questions were asked to clarify answers given. The answers presented in Table 5.1 were not given to the respondents. Interviews were mainly conducted in Afrikaans which is the home language of the respondents. All the interviews lasted between 60 and 80 minutes, and were recorded and transcribed.

Since most people enjoy talking about their work, the interviews had a conversational tone. It was made very clear at the beginning of each interview that there was no correct or incorrect answer and that the researcher aimed to learn from the respondents. The researcher also demonstrated some data warehousing knowledge early in the interview to establish a high standard of use of terminology. It was important to demonstrate some competence in the field in order to establish the researcher in the data warehousing paradigm.

All the case studies were completed before the data was analysed.

5.4 Data analysis

Interpretive pattern matching was used as method for data analysis. Answers to questions were carefully examined (interpreted) and compared to the pre-formulated answers in Table 5.1. Table 5.1 was used as a template to analyse the interview data in three iterations. During the first iteration an allocation was made of each answer in an applicable cell as explained below. This process was repeated for each case study. This mapping process of analysis was repeated two weeks later, without taking the first allocation into consideration. After this second allocation the two sets of tables were compared and different allocations of specific answers were investigated and corrected. A third iteration was conducted per question for all the case studies. Every question's answers were checked across all the case studies to ensure uniform allocation. All three iterations were repeated after any changes to the template (table 5.1) were made.

An analysis report is given for each of the three case studies. Each report consists of two tables. The first table assigns initials to the respondents, while the second table,

a copy of table 5.1, is used to map the answers given by specific respondents. An example is given here to aid the understanding of the case study reports.

Respondent Code	Position in the organisation	Experience in data warehousing
AB	Head of the data warehousing department (Information management department)	10 years
CD	Analysis and design manager	5 years

Table 5-2 Example of respondent profile table

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
SECTION A. Data warehouse adoption (Departmental head: OM)					
5	Who owns the data warehouse?	AB: I don't know.	CD	CD (later)[1]	

Table 5-3 Example of data collected table

Footnote:

[1] It is really the group of people who want the change who owns the data warehouse.

In this example two people were interviewed identified as AB and CD respectively. The question asked is numbered A5 (section A, question 5) and is quoted verbatim. The response "AB: I don't know" in the hard systems thinking column means that the answer given by AB was interpreted to be a hard systems thinking answer. The specific answer is not exactly the same as the answer provided in table 5.1 as a typical hard systems answer to question A5; therefore a brief summary is given of AB's specific answer namely that he does not know who owns the data warehouse.

The CD in the soft systems thinking column indicates that the answer provided by CD is very similar to the answer in the soft systems column provided in table 5.1. The answer in the critical systems column indicates the CD said something else later in

the interview, which may be mapped to critical systems thinking. An explanation of the mapping is required or his answer is too long to fit into the cell, therefore a footnote is used to present the answer given by CD. Since many of the answers were too long to quote, direct quotations are only used in crucial instances and where short answers were given.

The following additional aspects need to be considered when observing the case study results:

1. Confidentiality agreements were signed with the organisations preventing the disclosure of the identity of the organisation.
2. A background discussion is given for each of the organisations.
3. At least three interviews were conducted at each organisation and individual answers are mapped onto the table. The individual respondents are identified by initials identified at the beginning of each study.
4. Whenever a person expressed internal conflict, the answer was mapped to critical systems thinking accompanied by an explanatory footnote.
5. Similar interview and data analysis methods were used for each interview.

In order to facilitate easy reference to table 5.1 when reading the case study results, a removable copy of table 5.1 is provided at the back of this thesis.

5.4.1 Case study one: A large organisation in the financial sector

This first case study was performed on an organisation in the financial sector of South Africa.

5.4.1.1 Background

This is one of the largest organisations in the country's financial sector. It was formed some years ago as a merger of several smaller organisations and has a very large market share. As a result of the confidentiality agreement, limited figures will be reported.

The following should be taken into account when considering the answers given by the managers of the data warehousing department:

1. The data warehouse is seen as the base data store organised with an ERD model according to Inmon's definition. Managers (except the systems analysis and design manager) limit the boundary of the data warehouse to this central data repository.
2. The data warehouse is maintained and managed by the information management department, which is totally separated from the information technology (IT) department.
3. The size of the data in the data warehouse is about 3 Terabytes.
4. There are about 400 registered users of which 250 are active.
5. Each business unit is serviced by a member of the information technology department, called a business analyst.
6. The middle managers interviewed do not use the data warehouse themselves, but one intends using it in future.
7. The turnaround time for specific reports is about four days.
8. It is a strictly read-only data warehouse; all new data should go through the data staging process.
9. The base database has evolved over a period of 8 years. New developments are only done in terms of additional data marts (Inmon's approach) for specific business units.

From a disclosive systems thinking perspective, one needs to identify the intrinsic normativity of this organisation. This is typically done by asking: "What is the single most important value of the organisation?" After answering this question from the points of view of different customers, it is concluded that integrity or trustworthiness is the essence of this organisation.

5.4.1.2 Interpreted data

The main reason for selecting this organisation was the fact that they developed their own data warehouse with limited assistance from consultants. Their data warehouse has a large amount of data, which they believe influences design practices. The base data warehouse is well established and has already gone through one re-engineering phase.

Table 5.4 contains a description of the people interviewed in terms of position in the organisation, as well as experience. Each person is allocated an identity code that is

used in table 5.5 to represent that person's answer. At the beginning of each section, the manager of that section in the organisation is indicated.

Respondent Code	Position in the organisation	Experience in data warehousing
OM	Head of the data warehousing department (Information management department).	10 years.
DM	Manager of systems analysis and design for the data warehouse.	5-6 years (18 years with the organisation).
WM	Data warehouse manager, responsible for the infrastructure and data staging.	4 years with this organisation and 3 years prior experience in data warehousing with other organisations.
IM	Information building manager, responsible for building data marts (Inmon style).	10 years, even before the department called their system a data warehouse.
SP	Data staging programmer.	6 years.

Table 5-4 Respondent profile of case study one

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
SECTION A. Data warehouse adoption (Departmental head: OM)					
1	What is a data warehouse?	DM gave a technical description. WM IM[1] SP	OM[2]		OM[3]

[1] "In short I would say it is a centralised location for data on different roll-ups….."

[2] "In theory, people should take the organisation's objectives into account when building a data warehouse, but in practice very few of them do."

[3] The goal of the organisation as presented by top management is "to be the best for the customers", which is in line with the essence of the organisation, but the goals expressed by the people in this Information Management department are centred around profitability and financial benefits for shareholders.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
2	Who decided the organisation needed a data warehouse?	DM: Don't know. WM: Result from mergers. OM[4] IM SP: Don't know.			
3	What is the root problem to be solved by the data warehouse?	SP	DM: Management Information for high level decision making. WM: Better results for the organisation. IM		
4	If any, what other solutions to the problem were considered?		DM: It was not even called a data warehouse, but the aim was similar. IM[5]		
5	Who owns the data warehouse?		IM: "The whole organisation." IM[6] OM gave the name of the organisation as answer	DM:"Business."	IM: "The whole organisation."
6	What is the impact of the data warehouse on other systems/ business?	IM[7]	OM[8]		
7	Is everything the data warehouse influences part of how you view the data warehouse?	WM: No, source systems can never be seen as part of the data warehouse, Data marts are only data. IM: No, data marts are not part of the data warehouse.	DM: "Yes."		DM: "Yes."
8	Do people form part of the data warehouse?	WM: No.	DM: "Yes." IM: "Yes."		

4 "It was difficult to convince the guys to get a data warehouse"

5 "We did not call it a data warehouse, we simply talked about the DB2-database"

6 The data marts belong to business, but the technical data store belongs to the information management department.

7 The impact is very limited, perhaps here and there a quality issue.

8 The source system's quality should improve according to the work done by the data warehousing team; there should be a closed feedback loop.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
9	How do you determine whether the data warehouse is successful?	WM[9]	DM: "When users are satisfied." OM[10]		
10	What are the main advantages of the data warehouse?	IM[11] SP OM[12]			
11	Which department is responsible for the development of the data warehouse?		DM WM IM OM[13]		
SECTION B: Data warehouse development methods (Departmental head: OM)					
1	Describe the lifecycle of the development of the data warehouse.	IM SP	DM[14] WM[15]		
2	Describe the relationships between people in the data warehousing team.		OM[16]		
3	What is the role of end-users in the development lifecycle of a data warehouse?	DM IM[17]			
4	What is the role of outside consultants?	WM[18]		WM[18]	
5	Explain how you divided the project into smaller projects.	OM: SDLC			

9 A target of 100 million more revenue for the total organisation was set and 92 million was achieved, which means that the data warehouse is successful.

10 "We asked about 300 guys in the organisation: do they know what we do? Are they satisfied with our work?"

11 It is to integrate data and to obtain one view of the customer to analyse.

12 "I think it is to integrate things and to have one view of a customer in order to analyse things with trends."

13 "The data warehouse is definitely separate from IT."

14 Get requirements, test requirements feasibility, extend base warehouse, develop data mart, deliver mart, using an iterative process.

15 "In most cases we start with a proof of concept… If they don't buy into in the benefit they will get – our work is worthless."

16 Managers differ greatly but this leads to the enrichment of the data warehousing department and a better mutual understanding.

17 "…That is what happens, you need to think on behalf of the users ."

18 One may use consultants for technical advice, but the responsibility stays with the internal staff.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
6	How did you specify performance objectives for each of these projects?	WM	DM[19]		
7	How is the project financed?		DM[20] IM WM OM[21]		DM[20] IM WM OM[21]
SECTION C: Requirements definition (Person responsible: DM)					
1	Describe the process of requirements collection.	DM: Business is responsible to draw up specifications.	OM[22]		
2	Who represented which levels of the hierarchy during the requirements specifications?		DM: Commu-nications are with business analysts, as well as the entire executive committee.		
3	Do users know what they want? How do you go about assisting them?	DM[23] IM[24] SP			
4	How did you reach consensus on requirements?	DM[25]			

19 "..their measures are more on the line of accuracy and user satisfaction ultimately."

20 Each business unit contributes a fixed amount per year irrespective of usage.

21 Contradictory to DM, each business unit is billed according to estimated usage.

22 Users need to be assisted to define their requirements, especially on a strategic level.

23 Business completes a fixed form, including aspects like the sources of the data they want, written in a combination of business and technical terms. The business analyst should assist the business unit.

24 "The users don't know what they want. He wants this MIS system, but he doesn't know what he wants. He wants me to figure out what he needs."

25 The form completed by the user is checked by a data warehouse systems analyst. He then goes back to the user indicating the technical feasibility of the requirements. The moment they get charged for specific requirement, the importance of that requirement is less. Business users are responsible for clearing conflicting requirements.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
5	Does the requirements collection team know the objectives of the organisation? What is the role of the organisation's objectives in the requirements collection process?		DM[26]		
6	How do you keep your requirements documentation up to date?	DM[27]			
7	To what degree do existing systems determine the functionality of the data warehouse?	WM			DM: Historic factors are a big influence that cannot be changed over night.
8	Are you satisfied with the requirements documentation?	DM: "Yes, it works well."	OM[28]	OM[28]	OM[28]
9	Are the users satisfied with the requirements documentation?	WM: "Some will always be unhappy."			
SECTION D: Data modelling (Person responsible: DM)					
1	Do users form part of the modelling team?	DM: "No." WM[29]			
2	Do you use an ERD or a star schema? Why?	DM[30] IM: Not sure.	WM[31]	DM[32]: In future. WM[31]	

26 "They actually do their business requirements from the strategy, and they divide that down to drivers."

27 It is the role of the data warehouse systems analyst to keep the requirements always up to date; it is signed off to the programmer.

28 Not quite satisfied with the current approach to user requests, because all the users are not on the same level of understanding the system.

29 Users are not able to understand ERDs. WM believes an Inmon approach is not the best approach and would like to change the model of the system to make it more user-friendly. It is however too expensive to change the system.

30 They use a combination of Inmon and Kimball, but from further explanation it is closer to an Inmon's approach. They have 400 tables and 24000 files.

31 WM would like to move away from Inmon to a Kimball approach to involve users.

32 An Inmon approach is used and *some users* have access to the data in the ERD directly, without a data mart. This is the case according to DM and this should only be allowed for *users at a certain level*.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
3	Does the modelling team know the organisation's objectives?	DM[33]	DM: "Yes."		
4	Do you view business processes different from department to department in the organisation?	DM[34]			
5	How often do you change the basic design of the data warehouse?	DM: Only to expand. SP			
6	What is a model?	IM	DM[35]		
7	How often do you talk to the users during the design process?	DM: "Not very often."			
8	Are you satisfied with the model used?	DM: "Yes." IM: "Yes."			
9	What is a data mart?	DM : Inmon. WM[36]: Inmon. IM: Inmon.			
10	Why do you implement data marts this way?	DM: Size of data.			
11	What performance measures do you use?	DM gave technical answer.			
SECTION E: Data staging and data quality (Person responsible: WM , programmer: SP)					

33 They should be able to work from business unit specifications.

34 "Sometimes in departments, sometimes across departments. We don't actually look at the cross department ones that much."

35 "A model is a representation of the ideal world, not the real world."

36 The star schemas used are copies from the ERD; they do not have a data warehouse bus.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	Who is responsible for data quality?	WM[37] IM: Source systems. SP	OM[38]		
2	Does the overall objective of the organisation influence the data staging?	SP	WM[39] WM[40] (later) WM[41](later)		
3	How do you handle conflicting quality rules?	WM[42] SP			
4	How much do you know of what keep the managers awake at night?	SP	WM: Expenses and income. OM[43]		
5	How do you measure success?	WM gave a technical response. SP			
6	Do you have contact with the users?	WM: "No." SP			
7	What is the purpose of data staging?	WM: Centralise data. SP			
8	Are there secondary benefits to the organisation?	WM: Possible to do outside consultation.			
9	How does the data warehouse change the way people do their work?	WM: Don't know.			

37 "Operational system owners are responsible for quality. It is your data; we get it from your systems. If you can not tell me what you want clean and what you want dirty, I cannot help you."

38 "I won't say it is only the production system owners – I think we have a role to play, since it is easier for us to put everything together."

39 If you don't have data staging, you don't have a data warehouse. The overall objective of the organisation is to make money, bring down costs and to increase income. Managers can limit financial risk by using the data warehouse.

40 The data warehouse can support all the strategic goals by supplying numbers.

41 There is a trade-off between speed and quality. Some people are happy with data that is not 100% correct as long as they receive it quickly.

42 Each source system has an owner. These owners are responsible for data quality of their systems. These source system owners are also seen as customers.

43 "Yes, I know a lot, because our vision is built on the strategic goals of Exco. In other words our strategic themes and targets."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
10	Who are your customers?	WM IM[44] OM[45] SP	DM[46]	DM[46]	DM[46]
SECTION F: End-user applications (Person responsible: IM)					
1	When did you gather requirements for the end-user applications?	DM[47]	IM[48]		
2	What role does the organisation objectives play in end-user applications?	IM[49]			
3	Do you develop end-user tools in-house?	DM: No. IM[47]: No.	OM[50]	OM[51]	
4	Are end-user applications part of the data warehouse?	IM: "No."	DM: "Yes."		DM: "Yes."
5	Did you start with a proof of concept?	DM: "No."			
6	What type of training do you give users?	IM[52] OM	DM: Training should be on the user's marts.	DM: Training should be on the user's marts	

44 "Any person who wants data from the data warehouse. It won't be the guy in the street."

45 "My customers are the business users and up, to the top."

46 "Business units and the man in the street; sometimes the business units are secondary to the clients in the street."

47 No end-user applications were written; off the shelf software is used. But user requirements are used to build data marts. The requirements are gathered as the need arise for more business unit data marts.

48 When fixed reports are written, the users are directly consulted without the use of an analyst. Users are part of the report design effort and it is very successful.

49 It is possible for business units to get end-user applications from outside parties, but it will not be supported by this department. There are only a few power users that are able to do *ad hoc* queries.

50 Other departments are serviced with data and each of them creates their own application for analysing the data. Later describer the tool used: "It is very flexible, I think it is going to be much more for top management."

51 "Yes exactly, we want to empower the guys with a tool such as Discover."

52 The training is provided by the software vendor. Users are only trained on parts of the product, because it is feared that they will do damage to the base design.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
7	Do users change the way they do their daily work by using the data warehouse?	WM: "No."	DM: Yes, also different perceptions. IM: Yes, believe so.	IM[53](later) OM[51]	
8	Does everybody have access to all the information in the data warehouse?	DM: "No." IM: Manager of business unit decides who gets access.			
9	How many users do *ad hoc* queries that they design and implement themselves? Do you encourage this?	WM: Need to spoon feed users. IM[54]	DM: 15 power users in one business unit. OM: Overall 40.	OM[55]	
10	Did the usage of the data warehouse influence the career paths of certain managers?		DM: "Yes." OM: "Yes."		
11	Do you keep an audit trail of data warehouse usage?	DM: "No." WM[56] IM[57]	DM would like to have an audit trail to improve service.	DM would like to have an audit trail to improve service.	
12	How do you know when the data warehouse is successful?		DM: When users are satisfied. IM		
13	Do you see the data warehouse a control mechanism that management uses to control how decisions are made?	DM: "No."	DM: "No." OM: "No."	IM[58] OM[59]	
14	Do you know the data staging processes?		DM has an overall knowledge. IM		

Table 5-5 Data collected during case study one

53 Ideally, all the users should do *ad hoc* queries through a web-based application; they should be able to do all their work this way.

54 Only a few after extensive training and support is given.

55 Want to empower the user to be able to take control of his situation.

56 WM wants an audit trail to be able to charge people for specific use of the data warehouse.

57 IM wants to know whose actions cause problems on the system.

58 It would be great if this can happen.

59 "In future it might be the case, mainly due to governmental regulations."

5.4.1.3 Conclusions

The senior manager stated the following: “In theory I think people should take the organisation’s objectives into account when building the data warehouse, but in practice very few of them do.” It is interesting to note how many more answers given by senior management (denoted by OM) can be mapped to soft systems thinking, compared to those given by middle management. The programmer interviewed (SP) gave almost all hard system thinking answers. Another interesting fact is the large amount of soft systems answers, which are not representative of current actions, but of how the respondents believe the work should be done.

The view of this particular data warehousing team of the data warehouse as a data store, limits their influence in the organisation. They are aware of many of the shortcomings in the usage of the data warehouse, but they view end-user applications as outside the boundary of the data warehouse and the scope of the data warehousing team.

It is clear that critical systems thinking are only practised to a limited extent. It is also clear that little effort is made to determine the intrinsic normativity of the organisation. One can argue that this organisation mainly follows a hard systems thinking approach, and that they experience many problems associated with this approach.

5.4.2 Case study two: An organisation in the health services industry

The second organisation investigated provides healthcare insurance management and administration services to a major mining group in South Africa.

5.4.2.1 Background

The organisation forms part of a chain of organisations, including hospitals, clinics, and pharmacies that provides healthcare to 50000 employees of a major mining group in South Africa. This organisation is responsible for the administration of health care insurance transactions, new product research and the supply of information to the other organisations in the chain. The information supplied to the other organisations consists of performance measurements, management accounting information and new business performance information.

The main motivations for studying this specific organisation are the following:

1. They utilise the services of data warehouse consultants during the development lifecycle.
2. They design and develop data warehouses for other companies in their group.
3. Since their data warehouse operation only started recently, they are currently working on all the phases of the data warehouse lifecycle. Interviews were conducted over a three month period.
4. Being in the healthcare industry, one would be able to separate the essence of the organisation from its financial objectives.
5. At present, the organisation is going through major changes and management expects significant cost saving measures from all the employees.
6. The operational information technology services of the organisation have been outsourced to an external organisation.

5.4.2.2 Interpreted data

Table 5.6 contains a description of the people interviewed in terms of position in the organisation as well as experience. Each person is allocated an identity code that is used in table 5.7 to represent that person's answer. At the beginning of each section, the manager of that section in the organisation is indicated.

Respondent Code	Position in the organisation	Experience in data warehousing
IM	Chief information officer (member of the executive committee of organisation).	Two years prior experience in management information, as well as a qualified medical practitioner with applicable specialisation fields.
WM	Data warehouse manager.	Six months in this organisation and 5 years as data warehouse consultant.
SA	Systems analyst and designer.	One year experience and formal training in data warehousing as part of a four year degree in computer science.

TS	Person responsible for data staging and data warehouse repository management.	Eighteen months data warehousing, as well as prior programming experience.

Table 5-6 Respondent profile of case study two

It should be noted that this organisation is still in the initial phases of their data warehousing project. They delivered working proofs of concept, but still need to complete their first project. This is not a result of poor project planning, as they are relatively on target with their project dates.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
SECTION A. Data warehouse adoption (Departmental head: IM)					
1	What is a data warehouse?		IM[60] SA WM[61] TS[62]		IM[63] WM[64]
2	Who decided the organisation needed a data warehouse?	TS: "The chief information officer." SA	IM[65] WM		
3	What is the root problem to be solved by the data warehouse?		IM[66] TS and SA both stated business objectives. WM[66]		
4	If any, what other solutions to the problem were considered?	SA gave technical explanation.	IM[67] TS[68]		

60 "A data warehouse contains reliable integrated information used in decision making."
61 "A data warehouse is a collection of business data used for decision making."
62 "A data warehouse is a large collection of data that is easy to access in a suitable format."
63 "The data warehouses in the chain (group of companies) are representative of very different industries e.g. finances and health and therefore very difficult to compare."
64 WM referred to "patient care" as an objective of the organisation, but did not refer to it again in answering any question.
65 Previously, the IT department, but it did not work. A data warehouse will never work if the motivation does not come from top management. The data warehouse is now developed in the Information Management department.
66 "The root problem to be solved is the provision of fast reliable information for decision making."
67 A manual system was used prior to the data warehouse to provide management with information.
68 "The organisation used to print out paper reports. This caused problems, since some of the people wanted to do further analysis, but not everybody received these reports."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
5	Who owns the data warehouse?	TS: "The chief information officer."	SA[69]	IM[70]: Business owns the data warehouse. WM	
6	What is the impact of the data warehouse on other systems/ business?	TS[71]	WM: Better quality. IM: Better quality.	SA[72] TS[71]	
7	Is everything the data warehouse influences part of how you view the data warehouse?		SA: "Yes." WM: "Mostly." IM TS		SA: "Yes." WM: "Mostly." IM TS
8	Do people form part of the data warehouse?		IM: "Yes." SA: "Yes." WM: "Yes." TS: "Yes."		
9	How do you determine whether the data warehouse is successful?		IM: If it is used. TS: If it is used.	SA[73] WM[74]	
10	What are the main advantages of the data warehouse?		IM[75] SA: To support decisions. WM: Good management information. TS		
11	Which department is responsible for the development of the data warehouse?		IM[76] SA WM TS		
SECTION B: Data warehouse development methods (Departmental head: WM)					

69 There is a lot of conflict between the business users and the development department; the business users don't always accept their responsibilities of ownership.

70 One needs to have a business sponsor who is willing to take full ownership of the data warehouse.

71 "The other information systems people might feel threatened because the data warehouse team is taking their data and their knowledge so they might feel we are taking their jobs."

72 It depends on how good relationships between IS and the data warehouse team are; the result can be very positive, but the communication is not always open enough.

73 If it is used. At the moment, it is regarded as successful if successful measures for cost saving is provided.

74 The data warehouse team should not determine whether the data warehouse is successful, business should. It is always difficult to determine the value of good information.

75 Fast accurate information. We want to study the diversity within the organisation.

76 The data warehouse is developed in a separate department for management information. IM is the manager of this department and is a member of the executive committee of the organisation. One needs collaboration with IT services.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	Describe the lifecycle of the development of the data warehouse.		SA explained an iterative requirements-driven method. IM WM[77] WM[78] TS explained an iterative process.		
2	Describe the relationships between people in the data warehousing team.		TS: Good relations with minimal conflict (solved by consensus).	WM[79] SA[80] IM: Conflict between more technical and more business oriented team members.	
3	What is the role of end-users in the development lifecycle of a data warehouse?	TS[81]	SA[82] WM[82] IM described the role of users in every phase.	SA[82] WM[82]	
4	What is the role of outside consultants?		SA[83] WM[84] TS[85]	IM[86]	

77 They use an iterative SDLC with strong emphasis on feasibility study strongly based on the SDLC process described by Kimball.

78 "You can not understand the business quickly and one is not able to build a prototype before understanding the business, therefore I'm sceptical of people stating that one can make a prototype in six weeks."

79 There is conflict between technical and non-technical team members, but it is handled through open communication.

80 There is a lot of internal conflict but it is seldom expressed openly.

81 "End-users should only be part of the requirements analysis and the end-user application development phases."

82 User should be part of entire process to solve difficulties, for example quality issues.

83 Their role should be that of facilitator. It is very important for them to understand the business issues. Not enough information is given to them.

84 It is very important that consultants study the organisation's objectives first, for them to be useful.

85 "The outside consultants do not understand the meaning of the data. They incorporate their misconceptions into their designs, … the data warehouse team must then redo the work because they (the consultants) don't know anything about the business."

86 "One can easily loose control of the situation. The consultants deliver results and leave. They do not always keep the specific business problems in mind."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
5	Explain how you divided the project into smaller projects.	WM[87] TS[88]	SA[89] IM: "According to business processes." TS[88]		
6	How did you specify performance objectives for each of these projects?		SA: User satisfaction. IM TS		
7	How is the project financed?	SA: don't know.	IM[90] TS	WM[91]	IM[90] TS
SECTION C: Requirements definition (People responsible: SA and WM)					
1	Describe the process of requirements collection.	TS[92]	IM[93] SA[94] WM[95]		
2	Who represented which levels of the hierarchy during the requirements specifications?		IM[94] SA[94] WM[94]		

87 A project is broken up according to the availability of the data in three groups; those where the data is immediately available, those where the data is difficult to obtain, and those where external data is required.

88 The business processes are so interrelated that it is difficult to design a data warehouse for a single business process.

89 Collect overall requirements before selecting one business process. Keep overall requirements in mind in the modelling phase.

90 One should keep track of the data warehouse time spent on all the different projects. Each business unit should share in the total cost according to the time spent on their project.

91 A return on investment (ROI) should be calculated, but it is difficult to determine how to do it. "The data warehouse project manager should not compute the ROI, the managers should."

92 TS does not know the process very well, he/she was not a part of the process. When asked whether he/she read the requirements specification, TS replied negatively.

93 Users need facilitation to determine their exact needs. This is done through facilitated sessions led by IM.

94 Facilitated sessions are held with top management followed by interviews with heads of departments. The entire data warehousing team spent time with the operational systems' data capturers in order to form a better understanding of data with regard to the operation of the organisation.

95 "We will do anything to understand the needs of management in terms of the availability of management information."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
3	Do users know what they want? How do you go about assisting them?	TS[96]:"No"	SA[97] WM[98] IM	SA[99]	
4	How did you reach consensus on requirements?	IM[100]	WM[101]		
5	Does the requirements collection team know the objectives of the organisation? What is the role of organisation's objectives in the requirements collection process?		SA[99]: "Yes." IM TS: "Yes."	SA[99]	WM[102]
6	How do you keep your requirements documentation up to date?		SA: Versioning, include users. WM IM		
7	To what degree do existing systems determine the functionality of the data warehouse?	SA: To a large extent. WM[87] IM[87] TS[103]			
8	Are you satisfied with the requirements documentation?		SA[104] WM IM: It is used also to manage the user's expectations.		

96 One works from sketchy requirements and after the project is completed, the users will be able to identify the shortcomings of the project.

97 "They know in high level abstract terms, but someone should help them to get practical requirements."

98 "Users are not able to articulate their needs; one should ask the right questions. … Most data warehouse consultants think that it is the user's problem to decide what they want, but this is incorrect. You need to understand the entire project before you start."

99 SA reported frequently on specific cost saving objective of management. SA's work is currently dominated by this objective.

100 Somebody on the executive committee of the business unit should make the decision; it cannot be made for them.

101 One needs more than one opinion; a prototype is a good idea.

102 The requirements collection process should yield a data warehouse that provides a better service for everybody, from patient to shareholder.

103 "The users want the data staging team to perform miracles and to produce something from nothing."

104 If more information is needed, the users are asked, which indicates an open line of communication.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
9	Are the users satisfied with the requirements documentation?		SA: "Yes." WM: "Yes." IM		
SECTION D: Data modelling (People responsible: SA and WM)					
1	Do users form part of the modelling team?	SA[105] WM[105] IM: They don't understand the model. TS: They should definitely not.	SA[106] WM[107]	WM[107]	
2	Do you use an ERD or a star schema? Why?	WM[108] SA: Star, it is easy to understand (for the data warehousing team). IM TS		WM[107]	
3	Does the modelling team know the organisation's objectives?		IM[109] WM TS	SA[99]	SA[110]
4	Do you view business processes different from department to departments in the organisation?		SA: Some-times. WM: "Yes." IM: "Yes." TS: "Yes."		
5	How often do you change the basic design of the data warehouse?	WM: Change indicates poor requirements analysis. SA: Mainly for growth. TS			

105 Users are not involved currently.

106 "They should be part of the team, but one should select a user who is really interested to help."

107 "They will be able to identify missing attributes, therefore we should include users. Users will not be able to understand ERDs, but this is not a problem, since mainly star schemas are used, which are easier to understand."

108 Star schemas, since it is easy to get the data out. WM thinks other methods may also work, but the star schema works best. Most systems built on ERDs are older than the introduction of dimensional modelling by Kimball in *ca.*1997.

109 The person responsible for requirements analysis should understand the business rules of the data warehouse environment.

110 SA argues that the essence of the organisation is patient care, but that keeping patient care in mind when modelling, will not change the final model.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
6	What is a model?	SA[111] TS[112]	IM		
7	How often do you talk to the users during the design process?	TS[113]	IM[114] SA[106] WM	IM[114]	IM[114]
8	Are you satisfied with the model used?		SA: "Yes." WM: "Yes." TS: "Yes."		
9	What is a data mart?	TS[115]	SA[116] WM[116] IM: It is a subsystem of a data warehouse.	SA[116] WM[116]	SA[116] WM116
10	Why do you implement data marts this way?	SA: Trained to do so. WM: It works well. IM: It is not very important how a data mart is viewed. TS: "Who knows?"			
11	What performance measures do you use?	SA[117] WM[117] IM[118]			
SECTION E: Data staging and data quality (People responsible: TS and WM)					

111 It is a representation of a business process.

112 A model is a logical design of something actual and physical. Most people should arrive at the same model for the same situation.

113 "No, it is too late to talk to users during the design phase, but who knows?"

114 "Very often, to clear any misunderstanding and to enhance your understanding of their business."

115 It is a smaller data warehouse. When asked whether people form part of a data mart TS answered negatively.

116 A group of fact tables with their dimensions that models a single business process.

117 One should be able to source requirements.

118 It is very difficult to determine the success of the star schema before data staging takes place.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	Who is responsible for data quality?	SA: Mainly source system owners. TS: Source data capturers.	IM[119] WM[120]		
2	Does the overall objective of the organisation influence the data staging?		WM: "Yes." IM[121] TS: Very important.	SA[122]	
3	How do you handle conflicting quality rules?	TS[123]	IM[124] SA WM[125]	IM[124] TS[123]	
4	How much do you know of what keep the managers awake at night?	TS: "I can guess, but it is all about money."	IM gave detail. SA WM gave detail.	SA[99]	
5	How do you measure success?		WM[126] TS	WM[126]	WM[126]
6	Do you have contact with the users?	TS[127]: Limited contact.	SA[128] WM: "Yes."	SA[128] WM: "Yes."	SA[128] WM: "Yes."
7	What is the purpose of data staging?	SA[129] TS[130]	WM: To gather data to support decisions.		

119 "The data warehouse team is jointly responsible for data quality. It is our job to identify quality problems in the source systems and to give feedback to the source systems to rectify problems."

120 "It is a joint effort between source systems and data warehousing team.. but there should be a strategically managed feedback loop from us to the source systems."

121 The people responsible for data staging should know the organisation's objective, but it is rather difficult for the technical staff to internalise these objectives.

122 "If one is part of an organisation, all your actions are influenced by the main objective of the organisation, which in our case is to minimise expenses."

123 Some conflicts are never resolved. (TS gave an example of such a conflict.)

124 It is very important to understand the minor differences in the data and to be able to explain these. Consensus is important for the final decision on which data element is correct.

125 One needs standards that everybody accepts. These standards should determine data quality. Metadata should be used to indicate ownership. One needs a holistic approach.

126 "The data warehouse is successful when managers make better decisions."

127 "It is difficult to say who the business users are… some of them – yes, the others- no."

128 The staging team should have contact with end-users, but one should not overwhelm users with too many people.

129 The aim of data staging is to extract data from the source system and to solve problems in the data.

130 "The aim of data staging is to get everything into the data warehouse."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
8	Are there secondary benefits to the organisation?	IM: It is also a backup copy of all the data. TS did not understand the question.	SA: "Yes, improved data quality of source systems." WM		
9	How does the data warehouse change the way people do their work?		IM SA[131] WM[132]		
10	Who are your customers?	IM[133] TS: "The chief information officer and the end-users."	SA[134] WM: Also the patient.	SA[134] WM: Also the patient.	SA[134] WM: Also the patient.
SECTION F: End-user applications (People responsible: IM and WM)					
1	When did you gather requirements for the end-user applications?		WM: At the beginning of the project. TS[135]	SA[136]	
2	What role does the organisation objectives play in end-user applications?		IM: It is of major importance. SA: It is crucial for success. WM TS		
3	Do you develop end-user tools in-house?	IM: No. SA: No. TS	WM[137]	WM[137]	WM[137]
4	Are end-user applications part of the data warehouse?	IM: No, it depends on how a data warehouse is viewed.	SA: "Yes." WM: "Yes." TS: "Yes."	SA: "Yes." WM: "Yes." TS: "Yes."	SA: "Yes." WM: "Yes." TS: "Yes."

131 "All the managers are not always aware of what they can do with the data warehouse. A business sponsor is needed to show them the advantages of the data warehouse and exactly how to use it."

132 "It gives them information they did not have before."

133 The business users in the first instance, but the value chain inside the organisation is always kept in mind.

134 SA highlighted the fact that although the organisation's customers are not their direct customers, they are beneficiaries of the data warehouse.

135 "Some time at the beginning of the project; there is no point in delivering wrong things."

136 It is very difficult to know exactly when to gather these requirements. The end-users do not understand the practical implications of the project at the beginning and requirements gathered later on may have serious implications on the design.

137 You should do whatever is needed to cater for different users' requirements.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
5	Did you start with a proof of concept?	TS[138]	SA: "Yes." WM[139]: "Yes." IM: "Yes."	SA: "Yes." WM[139]: "Yes." IM: "Yes."	SA: "Yes." WM[139]: "Yes." IM: "Yes."
6	What type of training do you give users?	TS[140]	IM[141] WM[142]		
7	Do users change the way they do their daily work by using the data warehouse?		IM: "Yes." SA: "Yes." WM: "Yes." TS[143]		
8	Does everybody have access to all the information in the data warehouse?	TS: "No, it is too dangerous…It should be limited to a need to know basis only."	IM[144] WM[145]	IM[144] WM[145]	IM[144]
9	How many users do *ad hoc* queries that they design and implement themselves? Do you encourage this?	TS: "Not many."	IM: *Ad hoc* queries are very important. SA[146] WM[142]		
10	Did the usage of the data warehouse influence the career paths of certain managers?		WM IM TS: "Possibly, yes."	SA[147]	
11	Do you keep an audit trail of data warehouse usage?		IM: One should keep an audit trail to improve service. WM[148] TS	IM: One should keep an audit trail to improve service. WM[148] TS	

138 "A proof of concept was developed, but the users did not use it. The proof of concept helped to develop the technical skills of the data warehousing team."
139 "It takes time to understand the business, so one can not deliver a prototype quickly."
140 "One needs somebody with a lot of patience."
141 It is very important to give users training to make sure they use the data warehouse.
142 "One should start by explaining fixed reports and as user confidence grows, introduce *ad hoc* queries."
143 "Yes, if is incorporated with a portal".
144 Everybody should have equal access, but it does not realise in practice. It depends on the management style of the business unit. There may also be physical restrictions, for example network availability that prevents widespread access.
145 Everybody should get the advantage of using the data warehouse.
146 "The data warehouse can still be successful even if the users do not use *ad hoc* queries."
147 "Yes, positive for those using the data warehouse and negative for those who don't."
148 One should know which *ad hoc* queries to change into fixed reports to improve the service.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
12	How do you know when the data warehouse is successful?		IM: When it is used. SA: When it is used. WM: When management makes better decisions. TS: When the users requests additions.		
13	Do you see the data warehouse a control mechanism that management uses to control how decisions are made?		IM: "No." SA: "No." WM[149]	WM[149] TS: It is possible.	WM[149]
14	Do you know the data staging processes?		SA: Yes, all team members should. WM: "Yes." IM has technical knowledge.		

Table 5-7 Data collected during case study two

In addition to the interviews conducted, operational documentation was studied and a data warehouse project planning meeting was attended. Information gathered from these sources includes the following:

1. The chief information officer (IM) explained the role of this organisation within the chain of organisations in great detail to the researcher without being asked. Explanatory documentation was provided to "give the researcher a holistic view" of the organisation.
2. The first question on their planning documentation used in business analysis of other business units, enquires about the unit's strategic objectives.
3. The chief information officer (IM) gave background on all the projects to all the data warehouse team members during the project planning meeting attended.

In addition to the questions tabled above, questions were asked to explore the role the essence of the organisation played in the practices of the team members. IM, SA and WM gave similar answers confirming their awareness of patient care being the

[149] "The entire organisation, from patient to shareholder, should benefit from the data warehouse. As many people as possible should use it."

essence of their organisation, but they are of the opinion that their models and practices would not be different, even if they actively take patient care into consideration during their daily activities. TS answered that in his/her opinion, the hospitals in the mining group do not have patient care solely as highest priority, while their essence includes an economic element as well, in so far as they want the miners fit to continue with their mining activities as soon as possible. TS stated that the miners are very distant from his/her thoughts when data staging tasks are being performed. This statement indicates clearly a hard systems thinking approach.

5.4.2.3 Conclusions

The researcher was well informed by the chief information officer (IM) before the first interviews were conducted. It is clear that this person shows respect for the objectives of the organisation while dealing with external parties.

It is interesting to note the consensus of the answers of IM, WM and SA. Some people, by nature, are more suspicious than other. It is clear that SA is more suspicious of the intentions of others than the other respondents. When the researcher attended the project plan meeting, internal conflict among members of the data warehousing team was detected. It is interesting to note that TS reported that the data warehousing team has little internal conflict, while the others identified TS as a source of conflict.

The technical warehouse team member (TS) primarily followed a hard systems approach, as specific questions on practical detail revealed. However, the influence of the rest of the team on TS was noticeable, since many of the more general questions were answered from a soft systems point of view.

The team members, who leaned towards soft systems thinking, did not follow a soft systems approach throughout. Users were excluded from the data modelling process, mainly because they would not understand the models, but everyone said that star schemas are used because they are easy to understand.

Everyone interviewed had mixed feelings towards the role of outside consultants. On the one hand the consultants provided technical skills that were not present in the organisation, but on the other hand team members had to redo a large part of the work done by the consultants, because the latter did not understand the business.

It is clear that patient care, which is the essence of this chain of companies, does not play a major role in the practices of the data warehousing team. However, it is difficult to understand each person's personal attitude towards the patients, in this case the miners. IM had been a medical practitioner before and in general discussion did show compassion towards the miners, but did not refer directly to patient care when detailed questions were asked. One may finally conclude that, although the healthcare institution's essence lends itself to a disclosive systems approach, soft systems thinking was predominant, with even some evidence of a hard systems approach.

This case study proved to be extremely helpful in the development of the final framework, since it was apparent that the team members' answers to general questions differ from their answers to specific questions. Sometimes they were thinking of a data warehouse as a system, incorporating people, while at other times, it was seen as a data store. The framework should assist practitioners to extend this broader view to all data warehousing practices.

5.4.3 Case study three: A data warehouse consulting firm

The third case study was conducted at a data warehouse consulting firm, which is also the exclusive distributor in South Africa of a well-known internationally developed integrated data warehousing software package.

5.4.3.1 Background

For the past four years, the organisation has built a reputation as one of the best data warehousing consulting firms in the country. Their clients are major corporations in South Africa, ranging from financial to telecommunication institutions, most of which use the integrated data warehousing tool distributed by this organisation. They recently underwent a relaunch to separate their business activities from the specific tool they market. At present, their consultation service encompasses much more than just the technical assistance related to the usage of the software tool. The overall success of their client's data warehouse is of the utmost importance to them.

The main motivations for studying this specific organisation are the following:

1. As a consulting firm, it would be interesting to know how much of their clients' objectives they know.
2. They are able to reflect in a wider sense on practices.
3. They are able to describe what they view as best practice.
4. This case study will aid the researcher to develop guidelines for the use of external consultants for data warehousing development in organisations.

5.4.3.2 Interpreted data

Table 5.8 contains a description of the people interviewed in terms of position in the organisation, as well as experience. Each person is allocated an identity code that is used in table 5.9 to represent that person's answer.

Respondent Code	Position in the organisation	Experience in data warehousing
MC	Manager of the organisation; also does consultation work.	6 years.
SC	Senior consultant.	7 years.
DC	Data warehouse consultant.	5 years.

Table 5-8 Respondent profile of case study three

This case study differs from the previous case studies, as it mainly reflects on ideal practices expressed by the respondents. These respondents have seen many organisations attempting data warehousing and using a wide variety of methods. They reported that, although they have witnessed many different methods of implementing each aspect of a data warehouse, they developed strong ideas of practices that would lead to successful data warehouses.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
SECTION A. Data warehouse adoption					
1	What is a data warehouse?	SC[150]	DC[151] MC[152]		
2	Who decided the organisation needed a data warehouse?		DC[153] SC MC		
3	What is the root problem to be solved by the data warehouse?	DC: Integration problems.	DC: Business information. MC: Difficult to generalise.	SC[154]	
4	If any, what other solutions to the problem were considered?	DC: Don't know.	SC[155] MC		
5	Who owns the data warehouse?		SC[156] MC	DC: Business, not IT.	
6	What is the impact of the data warehouse on other systems/ business?		DC[157] MC[158]	SC[159]	

150 A data warehouse is a special kind of data store, and data warehousing is everything required to create a data warehouse.

151 "A data warehouse is a collection of the most important information in an organisation modelled around key performance areas - to be used in decision making."

152 A data warehouse is a system (of which people form a part) and data warehousing is the process of creating a data warehouse.

153 The project should be driven from the highest level of the organisation, ideally the CEO.

154 "You cannot start a data warehouse project hoping that the business managers will utilise the data warehouse. The organisation must have a specific problem they need to fix with the data warehouse."

155 Management identified a problem to be solved. IT should come up with the technical solution to management's problem in the form of a data warehouse.

156 "Management owns the business data in the data warehouse and the IT department owns the architecture and the access tools."

157 "Management can see information of different aspects of the business. It is all put together in a meaningful way."

158 "The data warehouse has a large impact on decision making systems."

159 Some people who become power users, take the opportunity to learn as much of the business as possible. "A generation of people emerges that really understands business, and who has the technical skills to use the data optimally. They are tasked to provide information to the rest of the organisation. The rest of the people will become dependent on them, they will be the most powerful people in the organisation."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
7	Is everything the data warehouse influences part of how you view the data warehouse?		DC: "Yes." SC[160] MC	SC[160]	DC: "Yes." MC
8	Do people form part of the data warehouse?	SC[161]	DC: "Yes." MC: "Yes."		
9	How do you determine whether the data warehouse is successful?		DC[162] MC[163]	SC[164]	
10	What are the main advantages of the data warehouse?		DC[165] SC	MC[166]	
11	Which department is responsible for the development of the data warehouse?	DC[167]	MC[168] SC[169]		
SECTION B: Data warehouse development methods					
1	Describe the lifecycle of the development of the data warehouse.		DC: Iterative process using SDLC. SC MC		

160 No, the data warehouse influences the marketing strategy of the organisation, and marketing is not part of the data warehouse. The source systems are however part of the data warehousing project.

161 People form part of data warehousing (everything that's needed to built a data warehouse), but people are not part of a data warehouse.

162 "If all the reports in the organisation come from the data warehouse and all the users are satisfied with the reports and the quality of the data."

163 "Switch it off and see how many people are dissatisfied. It is difficult to determine the value of the data warehouse before it has been implemented."

164 "The data warehouse is successful when the key business question is answered."

165 "It provides quick and easy access to the data by business users."

166 "The main advantage is to empower business users with quick reliable information."

167 "Mostly the IT department, but they need input from the business users."

168 "IT and business should work together, but unfortunately, many times mostly the IT department."

169 Although IT teams are used to build data warehouses, it should be dedicated teams only working on the data warehouse, but there should be business users that are actively involved.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
2	Describe the relationships between people in the data warehousing team.		MC: Use consensus to solve conflict.	DC[170] SC[171]	SC[171]
3	What is the role of end-users in the development lifecycle of a data warehouse?		DC[172] SC[173] MC gave a description of the role of the user in every phase.		
4	What is the role of outside consultants?		DC[174] MC[175]	SC[176] MC[177]	
5	Explain how you divided the project into smaller projects.	DC[178] SC gave technical answer.	MC: Study whole organisation and then prioritise.		
6	How did you specify performance objectives for each of these projects?		DC: User Satisfaction. MC[179]		SC[180]

170 "There are conflicts present, mostly between technical and business users. Some of these result from differences in personalities. Many conflicts are a result of clashes between Inmon's and Kimball's approaches."

171 "Most conflict on a data warehousing team results from the project leader not identifying clear roles and responsibilities."

172 "It should be interactive, but it helps if there is a business user (somebody that is technical but understands the business) on the data warehousing team."

173 One needs a business user on the team to aid in prototyping.

174 The consultants cannot work alone on the project; they need a strong business driver. The aim of the consultants should be to transfer knowledge to the organisation.

175 "Consultants who do not know the business objectives are not able to contribute to the organisation. As consultants, we want to help the organisation to help themselves."

176 "The first thing a consultant does, is to understand the business problem that the data warehouse aims to solve. …It is not a case of "Here is a warehouse we developed for you", but rather: "Here is the warehouse we developed together." There is a joint ownership of the project between the consultant and the organisation."

177 "We want to know who are involved and from where the data warehouse is driven. Only after we are sure that we understand how the data warehouse supports their objectives, can we help them with prioritisation."

178 Start with one key performance indicator. DC did not state the fact that the whole organisation's requirements should be gathered first. When asked if the organisation's overall objectives are important to start off with, he/she answered that it might help to read the pamphlets that are handed out.

179 "Yes, … one can subdivide the performance measures of the total data warehouse into performance measures of separate data marts." (This answer was provided in response to a follow-up question.)

180 It is difficult to specify performance objectives for different phases of the project, because of the nature of the project. It works best if one has a relative small data warehousing team that shares the responsibilities in the different phases. They need to have an overall view of the project.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
7	How is the project financed?	DC: Don't know.	SC: Initially organisation-wide and later on per project. MC: Jointly.		SC: Initially organisation-wide and later on per project. MC: Jointly.
SECTION C: Requirements definition					
1	Describe the process of requirements collection.		DC: Iterative. SC[181] MC	SC[181]	
2	Who represented which levels of the hierarchy during the requirements specifications?		DC[182] SC MC[183]		
3	Do users know what they want? How do you go about assisting them?		DC[184] MC[185]	SC[186]	
4	How did you reach consensus on requirements?		SC[187] DC[188] MC		
5	Does the requirements collection team know the objectives of the organisation? What is the role of organisation's objectives in the requirements collection process?		DC: Yes, very important. MC	SC: "They should understand the business problem."	

181 "You need to ask the correct questions to understand the key business problem."

182 One needs to talk to the clerks who produced the reports manually, as well as their superiors. One should talk to people on all management levels, always keeping business objectives in mind.

183 Need a chief information officer from business to serve as interface between business and data warehousing team.

184 They have a broad view, but they need some guidance. Prototypes help to show them what is possible.

185 The users don't know, but one should ask the right questions.

186 "They know what their biggest business problem is. They need help to identify how a data warehouse can help them."

187 Consensus is very important. There are simple techniques to reach consensus on a rational way by using measures. There is always a lot of politics in an organisation regarding the data warehouse, but it is overcome by using different methods aimed at reaching consensus.

188 "One needs to set priorities to the requirements. These priorities should be similar to business priorities."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
6	How do you keep your requirements documentation up to date?		DC[189] SC MC[190]		
7	To what degree do existing systems determine the functionality of the data warehouse?	DC[191]	MC[192]	DC[191] SC[193]	
8	Are you satisfied with the requirements documentation?		DC[189] SC	MC[194]: No.	
9	Are the users satisfied with the requirements documentation?		DC[189] SC	MC[194]: No.	
SECTION D: Data modelling					
1	Do users form part of the modelling team?		DC: One needs a business analyst. SC MC		
2	Do you use an ERD or a star schema? Why?		DC: Star, easy to understand. SC: User understand-ability. MC: Easy to change.		
3	Does the modelling team know the organisation's objectives?		DC: It helps if they know it. SC: They should. MC: Yes.		

189 "It is an iterative process…. The users have access to the requirements, but they don't look at it often, they rather ask the development team when they want information."

190 "It is very important that everybody has access to the specification documentation. It should always be up to date."

191 To a very large extent, if the quality of the source systems is poor, you need to fix those problems first.

192 It is important to listen to the requirements without knowing the limitations of the source system. After gathering the requirements, the source systems are studied and a report is given to the organisation on the limits the source data imposes. This is used as part of the prioritisation process.

193 "One needs to do a gap analysis between the aim of the data warehouse and the available source system data. This analysis will give an indication of what must be changed to solve the business problem addressed by the data warehouse."

194 "The processes of keeping the requirements up to date do not function well enough and the users do not look at the requirements often enough."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
4	Do you view business processes different from department to department in the organisation?		DC: Sometimes. SC: Yes definitely. MC: Yes.		
5	How often do you change the basic design of the data warehouse?		DC[195] SC[196]		
6	What is a model?		SC[197] MC[198]		
7	How often do you talk to the users during the design process?		DC: Very often. SC[199]	SC[199]	
8	Are you satisfied with the model used?		DC: "Yes." SC: "Yes."		
9	What is a data mart?	DC[200]	DC[200] SC: Represents a business process.	DC[200] SC: Represents a business process.	DC[200] SC: Represents a business process.
10	Why do you implement data marts this way?		SC: One needs a holistic approach. MC		
11	What performance measures do you use?	DC[201]	SC MC		
SECTION E: Data staging and data quality					

195 "The design changes as the organisation changes."

196 After the initial model has been finalised, the data warehouse is on an anatomic level and the specification investigation was done well, all the changes will focus on growth. The initial modelling is however an iterative process where the model changes often.

197 "It is a visual representation when you aim to do something. It also shows how a business user views the business."

198 "A model is a representation of how something is supposed to be. It is a perception of a certain individual, … more perceptions enrich the model."

199 "There should be a business user on the data warehousing team."

200 Part of the data warehouse that can be linked to a specific department's questions. Not a copy of the data. (This is a mixture between a Kimball and an Inmon approach)

201 One should check whether the business requirements are represented in the model.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
1	Who is responsible for data quality?	DC: Source system data capturers.	DC[202] SC[203] MC[204]		
2	Does the overall objective of the organisation influence data staging?	DC: "It is not crucial, as long as the documentation is up to date."	MC: Will be able to do a better job.	SC[205]	
3	How do you handle conflicting quality rules?		DC[202] SC: By consensus. MC[204]	MC[206]	
4	How much do you know of what keep the managers awake at night?	DC: Not much.	MC[207]: Not enough.	SC: Very much.	MC[207]
5	How do you measure success?	DC gave a technical answer. SC[208]			
6	Do you have contact with the users?	DC: Limited contact.	MC and SC: It helps to have a small team doing all the phases.	MC and SC: It helps to have a small team doing all the phases.	MC and SC: It helps to have a small team doing all the phases.
7	What is the purpose of data staging?	DC gave a technical answer. SC MC			
8	Are there secondary benefits to the organisation?	DC	SC: Solves quality issues. MC		

202 "One needs a person on the team that is full-time occupied with reconciliation of data warehouse data quality with source system data quality."

203 "The business users need to identify data quality issues, but the IT department should implement them."

204 Data quality should not be such a big problem, because all the information systems in the organisations should aid the overall objectives.

205 It would help a lot if everybody knew the key business problem. Everyone should buy into the solution of that problem.

206 "Language creates barriers; different people do not mean the same thing when using the same words."

207 "The client organisations do not always trust consultants with their detailed problems. This prevents the consultant from understanding their business in full, which has a negative effect on the consultant's success rate. I could add more value of I knew more of their business."

208 The data staging programmer can do very good work, but if the design is poor the data warehouse objectives will not be satisfied.

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
9	How does the data warehouse change the way people do their work?	DC: Don't know.	SC MC		
10	Who are your customers?	DC: Business users only. SC: Business Sponsor.	MC[209]		
SECTION F: End-user applications					
1	When did you gather requirements for the end-user applications?		DC: At the beginning of the project. SC MC		
2	What role does the organisation objectives play in end-user applications?		DC: Very important role. SC MC	SC[210]	
3	Do you develop end-user tools in-house?	DC: No. SC: No.	MC[211]	DC[212]	
4	Are end-user applications part of the data warehouse?		DC: "Yes." SC: "Yes." MC: "Yes."	DC: "Yes." SC: "Yes." MC: "Yes."	DC: "Yes." SC: "Yes." MC: "Yes."
5	Did you start with a proof of concept?		SC: "Yes." MC: "Yes."	DC[212]	
6	What type of training do you give users?			DC[213] SC MC[214]	

209 There are two types of customers: the business users and the customers of the client organisation.

210 "The end-user applications need to be designed in such a way that will enable the users to solve the critical business problem."

211 The tools are not preventing the users from doing *ad hoc* queries. A tool can be used well or poorly.

212 DC reminded the researcher that these consultants also do marketing for their own product. They show the users how their product can solve their problems.

213 "We give users training on sample data at a neutral site. If we use their own data, their attention is taken up by their own business problems and we do not succeed in providing them with proper training."

214 "Ideally one should first train the users on sample data to use the tool and then train them on their own data. It is very expensive for us to do that, because we have to set up individualised training for each organisation."

	Question to data warehousing team member	Hard systems thinking	Soft systems thinking	Critical systems thinking	Disclosive systems thinking
7	Do users change the way they do their daily work by using the data warehouse?	DC: It frees up some of their time.	SC[215] MC: More effective.		
8	Does everybody have access to all the information in the data warehouse?		MC: "Every body should have the same level of access, but it doesn't work like that in practice."	MC: "Every body should have the same level of access, but it doesn't work like that in practice."	
9	How many users do *ad hoc* queries that they design and implement themselves? Do you encourage this?	SC: Very few.	DC[216] MC[217]		
10	Did the usage of the data warehouse influence the career paths of certain managers?	DC: Don't know.		SC[159] MC[218]	
11	Do you keep an audit trail of data warehouse usage?		SA: To improve service. MC		
12	How do you know when the data warehouse is successful?		DC: When it is used. SC: When it is used to make decisions. MC		
13	Do you see the data warehouse a control mechanism that management uses to control how decisions are made?		DC: "No." SC: "No." MC: "No."	SC: Might be a good idea.	
14	Do you know the data staging processes?		DC: "Yes." SC: "Yes." MC: "Yes."		

Table 5-9 Data collected during case study three

215 "The data warehouse is a supporting tool for users. They don't change their job. They have a tool to support their managerial functions. They do their daily work better."

216 People start mainly with fixed reports, but as their knowledge of the data warehouse grows, they start doing more *ad hoc* queries.

217 Ideally 50% of all usage should be managers doing their own *ad hoc* queries, but we are not there yet.

218 "If a specific manager chooses a part of the work in the organisation which is in line with the business objectives it could fast-track his career."

5.4.3.3 Conclusions

The interview with DC was conducted first during this case study. Half way through the interview, DC was asked whether the answers given are a true reflection of reality, or whether DC was providing the correct textbook answers. DC answered that the answers are how it should work ideally. This proved to be central to most of the answers provided by all three respondents. As consultants, they see different organisations dealing with problems in different ways, and they developed fixed ideas on how they would want organisations to handle specific situations.

It is clear that MC has a broader approach to a data warehouse. MC views a data warehouse as a system. SC however, refers to data warehousing as the broader approach to developing a data warehouse and views the data warehouse as a data store organised in a specific manner.

SC stated that a data warehouse aimed to be a general tool for managers of an organisation, will not be utilised. SC argued that a data warehouse should address a well-defined need in the organisation. There should be a specific problem of major importance, for which information on a different level than that available in the source systems, is required. This shared problem should motivate everybody involved in the project to perform to the best of his/her ability. Such a view has a very strong critical systems characteristic. SC also expressed empowerment of business users as an effect of the data warehousing project, but not as the overriding aim of the data warehouse. The researcher interprets the answers given by SC as more towards critical systems thinking than the other respondent, but not overwhelmingly critical.

Although MC stated that the consultants discuss data warehouse aspects frequently from a client's objectives viewpoint, DC has a typical hard systems approach to data staging.

The overall importance of the client's objectives was central to most answers given by the more senior consultants interviewed. They agreed that data warehouse consultants who do not understand their client's organisation's objectives, cannot be successful.

The respondents of this case study provided more critical systems thinking answers than any of the other respondents. Although very few hard systems answers were given, most of them were given by the junior consultant with the least experience.

5.4.4 Research difficulties

Since the research methods used in this study are untested it is necessary to highlight the difficulties posed by the selected method. The quotes provided in this section to highlight problems are direct translations from Afrikaans. Many respondents spoke in incomplete sentences and no attempt was made to rectify this during translation.

One of the first problems encountered was to choose between full quotations and summaries in the footnotes of the data representation tables. Although one does not want to lose any information by summarizing the data, some of the answers are too long to quote and the key aspect is spread out in the answer. The answer of respondent IM of case study 1 given for question F9 can be used as an example of this problem:

Question: "How many users do ad hoc queries that they design and implement themselves? Do you encourage this?"

IM's response: "At this stage they have one guy who is really clued-up and our agreement with them is that if we say to the users: "Right, you have to give us one or two power users, then those guys must do proper courses at Oracle since they are the guys that are going to do your *ad hocs*," and if they want to come, if they want to do certain *ad hocs* and they can see for example they don't have enough data, we will add the data for them, but we will no longer be responsible for creating reports for them. We will create initial reports for them and thereafter these guys should do it. If they encounter problems we will help them."

The researcher summarized this answer as:

"Only a few, after extensive training and support is given."

Respondents did not always understand the question and asked whether the researcher could give them examples. It is very difficult to formulate examples without leading the respondent. In most cases the researcher repeated the question using an alternative formulation. If the respondent still did not understand the question, the conversation was gently moved forward to the next question.

One of the biggest problems was the hermeneutic interaction between a specific answer of a person and his/her other answers. Sometimes a person for example gives a typical soft systems answer to a question which appears to be contradictory to other hard systems thinking answers given by that person. The dilemma then arises whether to take the answer on face value or to ask clarification questions. It is very difficult not to categorise given answers intuitively while you listen to them. It is as if one starts to use the answers to support a specific systems thinking methodology$_{1\&2}$ one associates with a person. When a conflicting answer is given one is tempted to reason that the person did not formulate his/her thoughts correctly. If a clarification question is asked it is very difficult not to influence the respondent. From a data analysis point of view these follow-up questions also creates difficulties. One might speculate whether follow-up questions should have been asked for every question, and if it had been done whether it would have influenced the outcomes of the analysis.

Quite often respondents only answered “yes” or “no”. Although the questions were formulated to avoid these simple answers some respondents manage to avoid longer answers. It did not even helped to ask them about their motivation in a simple “why do you say that?” type of question. The researcher used such short answers as being meaningful themselves by concentrating on what was not answered. For example if the qualifying norm of patient care was guiding the actions of the data stager in case study two, he/she might in stead of just answering “No” have said “No, it is not good for the patient.”

Such an example also highlights the problem of similarity of answers between different methodologies$_{1\&2}$. Different ontological viewpoints do not always lead to different practices in data warehousing. As an example one might consider end-user involvement during the more technical phases of the development lifecycle. A hard systems thinking approach limits end-user involvement to the first and last stages. The other three systems thinking methodologies$_{1\&2}$ encourage end-user involvement in all the phases of the development lifecycle of the data warehouse. The motivation

for this differs however. It was extremely difficult to understand the specific motivations of different respondents without asking leading questions or giving alternatives. The problem with giving alternatives is that the respondent might choose the "most impressive" option. It was therefore concluded that if the respondent had a strong critical or disclosive motivation they would have mentioned it spontaneously as indicated in the previous paragraph. It might be interesting to train a group of data warehouse practitioners in systems thinking methodologies$_{1\&2}$ before asking them about the applicability of these methodologies$_{1\&2}$ in data warehousing. The framework developed in chapter 6 can serve as a tool in such a research project.

Another difficulty is the fact that answers differed substantially from the template answers given in table 5.1. The literature review according to the philosophy, methodology and practice structure helped in the allocation of these answers. It is easier to allocate such answers to a specific methodology$_{1\&2}$ when one understands the philosophical underpinning of a methodology$_{1\&2}$. It did however result in changes to table 5.1 to include these alternative answers.

Such changes to table 5.1 create new difficulties in the analysis of the interview data. The researcher decided that any changes to table 5.1 have a serious impact and required all the analysis to be redone. It was therefore important to first complete one iteration for all the case studies in order to evaluate all the answers before finalizing the template table.

In hindsight some of these problems would have be avoided if a pilot case study was done before the actual three case studies. It would have highlighted problematic questions before the actual interviews and follow-up questions could have been formulated prior to the research activity for such questions. It is important when doing such a pilot study that the researcher completes the process of analysis on the pilot data before embarking on the actual case studies. The difficulty with following this approach of a pilot study is finding a willing respondent for the study. It was already difficult to find three organisations that were willing to participate in the research.

5.5 Research conclusions

The aim of the case studies reported in this chapter was to understand data warehousing practices from a systems thinking methodology$_{1\&2}$ perspective. Since this part of the research had a strong interpretive nature, the intended outcome was to understand motivations rather than to determine clear answers to questions. One cannot for instance count the number of hard systems or critical systems answers to compute statistical measures in order to formulate research findings.

Although specific conclusions were drawn after each case study analysis table, more general conclusions can be derived when considering the combined results of the three case studies.

When the report tables of the case studies are viewed in terms of completed columns, one can easily see the most influential systems thinking methodology$_{1\&2}$. The completed tables indicated that soft systems methodologies$_{1\&2}$ are most often used in data warehousing practices. One should however be careful not to lose sight of the fact that many critical and disclosive answers have a similarity to the soft systems answers. The critical and disclosive answers in table 5.1 include a specific motivation for the answer which was not stressed in the soft systems approach. If the specific motivation was not given, the given answer was only allocated to the soft systems approach.

Although some actions (especially in case study one) reflected hard systems thinking, the problems with such an approach in data warehousing also came to the fore. When a predominantly hard systems approach is used, the boundaries of the data warehouse narrow to such an extent that the data warehousing team creates an artefact rather than a solution to a problem. The data warehousing team focuses on specification rather than on problem solving. All the respondents in managerial positions reflected on the disadvantages of such an approach to data warehousing.

Case studies two and three also reflected some critical systems thinking actions. No negative consequences of these critical actions were observed as in the case of hard systems thinking. The impression was created that if more direct questions were asked such as: “Which of the following two options would you prefer…” followed by the soft and the critical answers, more critical answers would have been selected than revealed by the open ended approach followed. The aim, however, was to

obtain the spontaneous reaction of the team members, which were better achieved by the open question approach. Considering the objective of the study namely to understand current data warehousing practices, it would have been counterproductive to ask multiple choice questions. Respondents would have chosen the ideal answer which would not necessarily have reflected their current practices. The respondents would have been confronted with options they have never considered themselves.

The reader is reminded that the respondents are not knowledgeable on system thinking methodologies$_{1\&2}$. This fact should also be taken into account when considering the worth of critical and disclosive systems thinking in data warehousing. It is the position of the researcher that critical and disclosive systems thinking can not simply be disregarded since the respondents answers did not reflect these methodologies$_{1\&2}$.

A similar argument may be used for disclosive systems. The fact that very few disclosive systems answers were formulated does not indicate that disclosive systems thinking cannot enhance data warehousing quality. It may indicate that people are more motivated by monetary objectives than by furthering the intrinsic normativity of the organisation. One can only speculate whether a strong awareness of the normativity of the organisation would have yielded better results in terms of data warehousing quality.

On a more technical note, it is interesting to note that everybody interviewed in case studies two and three gave similar answers to question B1 on the phases of the life cycle of a data warehouse. This indicates the movement towards the methods described in Kimball *et al*. (1998). This monograph is becoming an industry standard in South Africa. The methods used in case study 1 reflect ideas from Inmon (1996). The reason for this might be that their data warehouse is older. Some of the respondents commented on a possible shift towards the methods described in Kimball *et al*. (1998). This motivated the researcher to use the life cycle presented by Kimball *et al*. (1998) as basis for the framework presented in chapter 6.

5.6 Chapter summary

The aim of this chapter is to map data warehousing practices to systems thinking methodologies$_{1\&2}$. In order to do such a mapping, one should work in both directions; from systems thinking to data warehousing practices and then from data warehousing practices to systems thinking. Table 5.1 represents the first of these directions. Data warehousing practices were identified from a systems thinking methodology$_{1\&2}$ point of view, thus providing a mapping from systems thinking methodology$_{1\&2}$ to data warehousing practices.

In the second part of the chapter, table 5.1 was used to evaluate the data warehousing practices in terms of the different systems thinking methodologies$_{1\&2}$. This was done by starting at the practices reported by the respondents. The tables representing the respondents' answers represent the mapping backwards from data warehousing practices to systems thinking methodologies$_{1\&2}$.

When studying the tables compiled from the case study data, it is clear that different organisations follow different systems thinking methodologies$_{1\&2}$. The first organisation follows a typical hard systems approach, the second and third more of a soft systems approach. The third organisation, although following mainly a soft systems approach, did show some critical systems thinking characteristics. It is clear that none of the organisations' practices could be mapped exclusively to a specific systems thinking methodology$_{1\&2}$. When investigating the use of disclosive systems thinking in data warehousing practices, it became clear that data warehousing teams are mainly motivated by the financial aspects of an organisation, and that the intrinsic normative principles, such as patient care, do not have a formative influence on data warehousing practices.

Case studies two and three afforded the researcher the opportunity of gaining insight into the use of external consultants in data warehouse development projects. It was evident that the success of consultants is dependent on their ability to share in the ownership of the organisation's objectives. Therefore, any framework on data warehousing practices in South Africa should provide specific guidelines as to the role of external consultants.

The researcher used the results of these case studies to develop a framework for the explicit use of systems thinking methodologies$_{1\&2}$ in data warehousing practices.

This framework is presented in the next chapter, and represents the reconstruction part of the critical social research methodology for this study. The presentation of the framework includes specific references to answers given by the case study respondents.

CHAPTER 6 FRAMEWORK

6.1 Introduction

This chapter introduces a framework for the explicit use of specific systems thinking methodologies$_{1\&2}$ in data warehousing practices. The aim of the framework is to improve data warehousing practices by providing methods based upon such systems thinking ideas. The framework also represents the reconstruction part of the critical social research methodology for this study described in chapter 2, section 2.5.2.

The framework represents research that combined three resources, namely a literature study on systems thinking methodologies$_{1\&2}$ (presented in chapter 3), a literature study on data warehousing concepts and success factors (presented in chapter 4) and case study research conducted to understand to what extent current data warehousing practices reflect systems thinking methodologies$_{1\&2}$ (presented in chapter 5). The framework should thus not be read in isolation from the mapping between specific systems thinking methodologies$_{1\&2}$ and data warehousing practices given in section 5.2.

This chapter represents a specialisation of the practice layer in the philosophy, methodology$_1$, and practice model used in throughout this thesis.

The framework presented in this chapter constitutes three different frameworks. Although one basis figure is used, it is viewed through three different lenses resulting in frameworks for soft, critical and disclosive systems respectively. Although the case study results indicated some hard systems practices used by industry professionals, respondents in managerial positions highlighted the problems resulting from these hard systems thinking practices. The researcher therefore chose to focus on the other systems thinking methodologies$_{1\&2}$ investigated.

The chapter begins with a description of a data warehouse as a system in section 6.2. In section 6.3, the framework is then introduced gradually, according to the different aspects of a system proposed by Churchman (1968), to aid the explanation. Although the work of Churchman (1968) can be categorised as soft systems thinking, critical systems thinkers such as Ulrich (1987) acknowledges the critical aspects in Churchman's work. Each section of the framework is initially presented from a soft

systems view where after it is viewed through the lenses of critical and disclosive systems thinking respectively.

An important aspect in the application of the three methodologies$_{1\&2}$ in data warehousing practices is that although different methodologies may lead to similar practices, the practitioners' motivations for choosing such practices are rooted in different ontological views.

The discussion of each section of the framework concludes with references to the answers of the respondents of the various case studies to illuminate the guidelines given in that section. The analysis of the case study data given in chapter 5 indicated mostly soft systems motivations for practices. It was argued in section 5.5 that although fewer critical and disclosive systems answers were given, the use of these metodologies$_{1\&2}$ may still be able to improve data warehousing quality.

The discussion in section 6.4 compares this framework to the existing frameworks of Wixom and Watson (2001) and Kimball *et al.* (1998). The chapter (and the thesis) concludes with a summary of the research study presented and a critical evaluation of the scientific progress made by this research study.

The purpose of the complete framework given in figure 6.1 is to guide the reader in building a holistic view from the subsections presented in this chapter. The division of the framework into parts is done from a soft systems perspective, following a hermeneutic method, and not from a hard systems perspective where the total is simply seen as the sum of the parts.

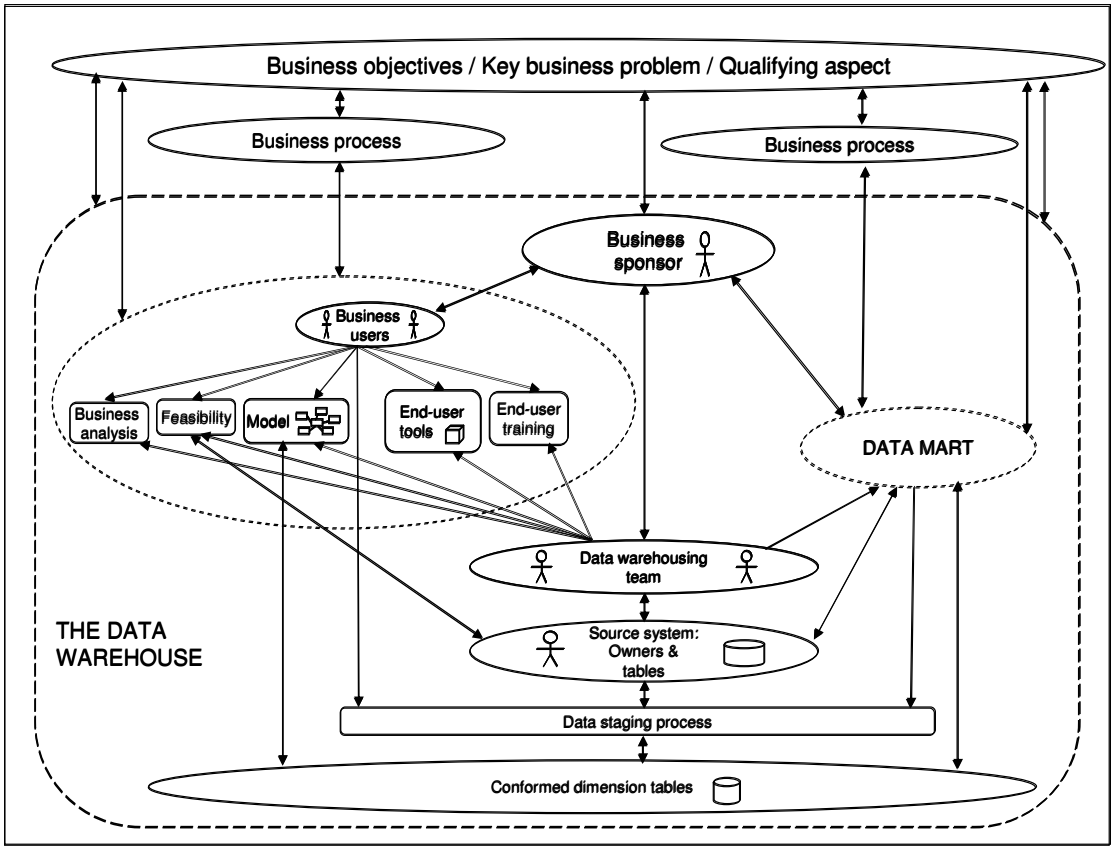


Figure 6.1 A data warehousing framework

6.2 The data warehouse is a system

As a soft system, the data warehouse should be defined in terms of its purpose and not its components. *A data warehouse therefore, is a tool to provide management information for decision making in order to achieve the overall business objectives.* The data warehousing framework (presented in figure 6.1) is not a true reflection of reality; it simply represents a view of a data warehouse to aid discussion of this tool.

The property of providing management with accurate information which is easy to access, is viewed as an emergent property of the total system (the data warehouse). The components of the system work together to realise this purpose, rather than being the summation of the individual properties of the parts of the data warehouse.

The stated purpose of the data warehouse can be viewed from a *critical systems thinking perspective* by focussing the business objectives on a single critical problem area in the organisation. In a typical critical systems environment, this problem area will be associated with intervention or emancipation, while in *disclosive systems thinking,* the qualifying aspect of the organisation would be central to the business objectives. The reader is reminded that the qualifying aspect of the organisation refers to the intrinsic meaning of that organisation such as patient care in a hospital.

The view of a data warehouse as a system was supported by all the case study respondents, when answering question A1 (section A, question 1 of table 5.1). Question D6 of the same table explored the acceptance of different views of a model. In this case, the respondents of case study three followed a soft systems approach, while the other two case study respondents gave mixed answers. The data warehouse is shown in figure 6.1 by the large dotted-line rounded rectangle.

6.3 Data warehousing according to the systems approach

This section describes the data warehouse framework presented in figure 6.1, according to the systems approach of Churchman (1968) discussed in chapter 3, section 3.2.4. In order to aid the explanation of the framework, a simplified version of figure 6.1 is associated which each of the system characteristics.

It should be noted that one cannot include all the business users in the process. Therefore, the business users indicated in this framework is a representative group of two to four persons.

6.3.1 The objectives of the data warehouse

Figure 6.2 indicates the relationship between the data warehouse and the organisation's objectives. The data warehouse is a subsystem of the overall system formed by the organisation. When viewed through the lens of *soft systems thinking*: the organisation's objectives (i.e. the strategic objectives of the organisation), are achieved by employing the various subsystems in the organisation, including the data warehouse.

To ensure that the data warehouse achieves the objectives of the organisation, role players from the executive committee of the organisation should form part of the data warehouse. The business sponsor (described by Kimball *et al.* (1998), referred to in section 4.5.1) fulfils this role. The business sponsor should be somebody who serves on the executive committee of the organisation and who believes that the data warehouse can assist in achieving the overall objectives of the organisation. The business sponsor should also be an influential person, able to motivate the rest of the executive committee to allocate enough resources to the data warehousing project.

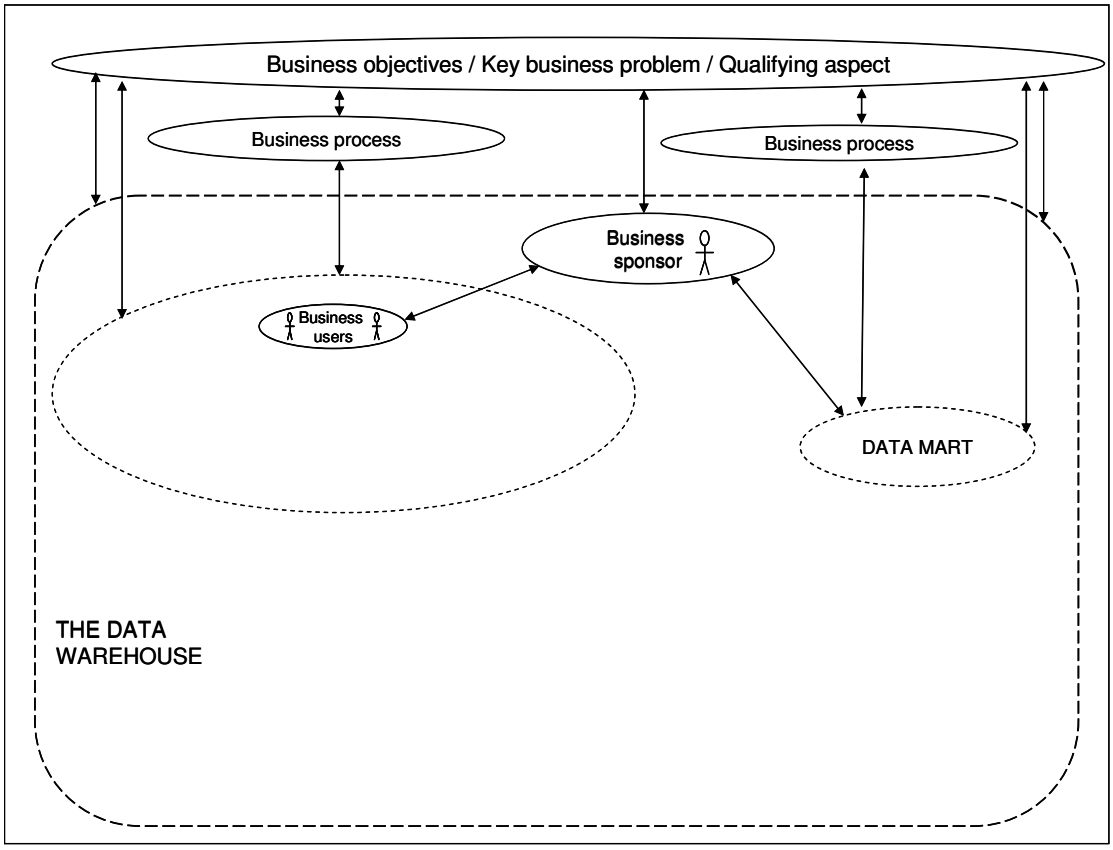


Figure 6.2 Data warehouse objectives

The most important role of the business sponsor is to ensure that the organisation's objectives are taken into account in all the activities of the data warehousing project, including the more technical activities, such as data staging.

Organisations need to divide their activities into smaller areas to provide effective management. Churchman (1968:40) as discussed in section 3.2.4.4 advocates the division of organisations into business processes, rather than traditional departments.

The division of the data warehouse into data marts should follow a similar pattern. The main reason for this is the realisation of overall business objectives of the organisation by supporting the objectives of its subsystems. Business users from each of the business processes form an integral part of each data mart.

When these practices are viewed through the lens of *critical systems thinking*, one should be aware of the underlying political agendas of the role players. The business sponsor should be chosen as somebody whose own personal objectives are compatible with the real objectives of the organisation. The business sponsor should facilitate the underlying structures in the organisation that should be addressed through the data warehousing project. One should also take care that the position of the business sponsor in the organisational hierarchy does not influence the effectiveness of the data warehousing project. This implies that decisions should still be reached by consensus and not be determined by the business sponsor's rank in the organisation.

When these practices are viewed through the lens of *disclosive systems thinking,* the objectives of the organisation should promote its intrinsic normativity. All the actions of the business sponsor, as well as those of business users from the different business processes, should be focussed on achieving this main objective of the organisation as a whole. One should ask: "What is the benefit of the data warehouse?" And even more important: "What benefit does the organisation bring to society?" Answers to these questions will lead to the disclosure of the intrinsic normativity of the organisation. The business sponsor should play a facilitation role in the process of disclosure of the qualifying aspect of the organisation and the supporting role of the data warehouse to this aspect of the organisation.

The role of business objectives was covered by a number of questions during the case studies. Question A3 (section A, question 3 in table 5.1), probed into the relationship between the overall data warehouse objectives and the organisation's objectives. All three case studies' respondents accentuated this relationship. Questions C5 and D3 investigated the relationship between the organisation's objectives and requirements analysis and data modelling respectively. Once again, most of the respondents agreed that the organisation's objectives are important in these phases. However, questions E2 an E4 on the relationship between the organisation's objectives and data staging revealed mixed results. Senior personnel of the organisations agreed that a thorough knowledge of objectives should form part

of the traits of a data stager. Technical staff members on the other hand, acknowledged that they do not know the organisation's objectives but believe they should.

The viewpoint represented by this framework stresses the importance of data staging team members fully understanding the organisation's objectives. It will aid in solving data quality conflicts, and it will make them more aware of requirements that are contradictory to the overall objectives of the organisation.

Most of the respondents agreed with the division of a data warehouse in terms of data marts that should correspond to business processes (refer to questions D4, D9 and D10).

From the answers to question E10 on the identity of data warehouse customers, it became apparent that a complete systems approach by the respondents has not been followed intuitively. Very few referred to the organisation's customers as the customers of the data warehouse.

When a true systems approach is used, i.e. where the business objectives are truly accepted and incorporated in the data warehouse objectives, the customers of the organisation will also be the customers of the data warehouse.

6.3.2 The environment of the data warehouse

Churchman (1968:35) describes the environment of a system as the factors outside the system that influence the system. These are the factors the system cannot control, but which has control over the system. In a data warehouse system, some people view the source systems as part of the data warehouse resources and others as part of the environment. This point is debated here in terms of data warehousing literature and case study results.

Figure 6.3 depicts aspects that are discussed in terms of the environment of the data warehouse. From a *soft systems thinking* perspective, there are four parties to consider when debating the environment of a system:

1. The organisation's management and their objectives
2. The business sponsor

3. The business users
4. The source systems owners responsible for the source systems

There is consensus that the organisation's objectives are initially part of the environment of the system. These objectives led to the initiation of the project. After extensive analysis of the data warehouse data, the management of the organisation might alter their objectives. Although the data warehouse, used as a tool in decision making, caused the change, it is not viewed as controlling the business objectives.

One might argue whether the business sponsor is not in the same position as the organisation's objectives. It is clear from the role of the business sponsor that he/she represents the data warehouse on the organisation's executive committee and all the proposals made to this committee by him/her is influenced by the data warehouse. The business sponsor is viewed as part of the data warehouse system and not of its environment.

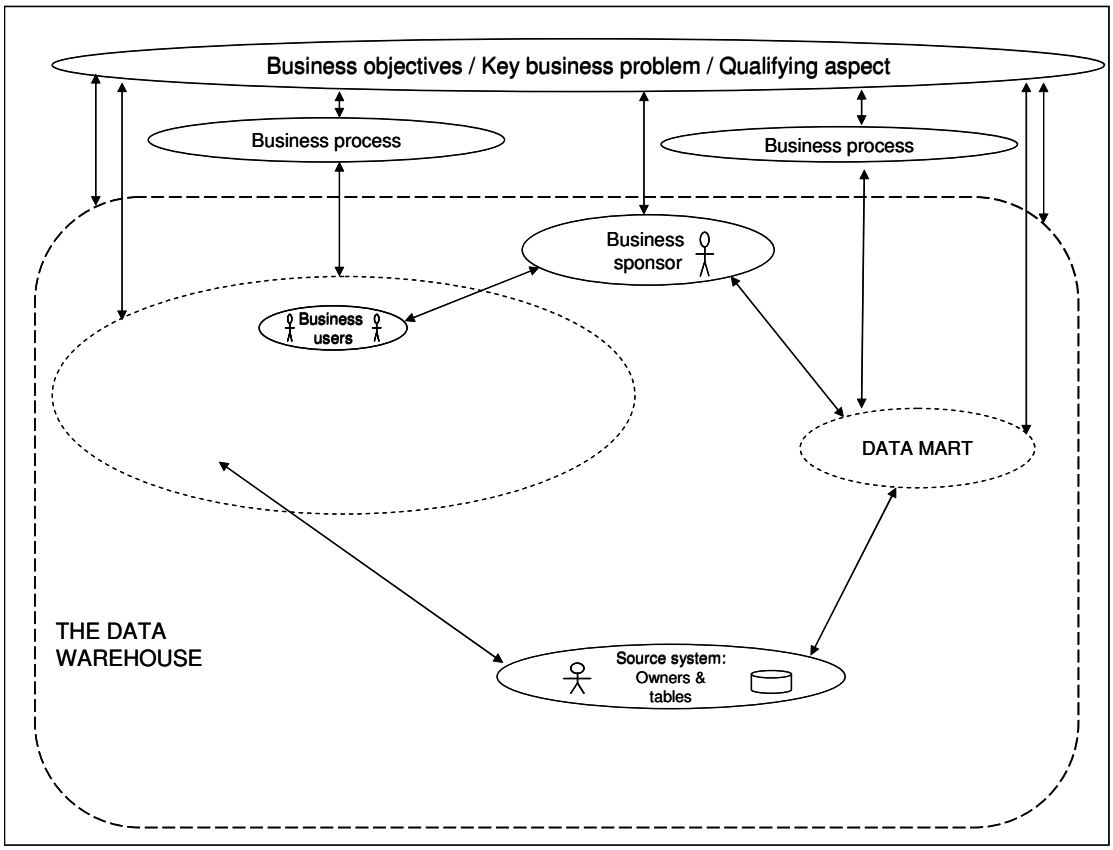


Figure 6.3 Aspects regarding the data warehouse environment

A similar argument can be used to show that the business users are part of the data warehouse as well. Question F7 of table 5.1 probed into the effect the data warehouse had on the business users. Only one respondent answered negatively, while all the others agreed that the data warehouse changed the way they do their work. In the second and third case studies, most respondents also answered that the end-user applications are part of the data warehouse (question F4). In response to question A5, most respondents agreed to at least a joint, if not sole, ownership of the data warehouse by the business users. It is concluded that the business users are part of the data warehouse system and not of its environment.

In the organisations represented by case studies one and two, the data warehouse was developed by a group of people outside the information systems department (question A11). The consultants of case study three reported that the development typically takes place in the information systems department by a specialised team. In response to question A6 on the influence of the data warehouse on other systems in the organisation, many respondents in case studies two and three reported on major quality advantages, if a feedback loop exists between the data warehouse and the source system. Kimball *et al.* (1998:329) also indicated such a feedback loop.

It is therefore concluded that the source systems and their owners are indeed part of the data warehouse. It is nevertheless of critical importance that data warehouse development is separated from operational systems development. This view is based on the data models used and will be discussed as part of the components of the system.

From a *critical and disclosive systems* perspective, the source systems and their owners will be more readily incorporated in the system. Critical systems thinking will change anything in the organisation to achieve the required intervention, while a disclosive systems approach will change anything (including the source system) that is opposed to the intrinsic normativity of the organisation.

6.3.3 The resources of the data warehouse

Churchman (1968:39) states: “Resources are the general reservoir out of which the specifics of the system can be shaped.” Resources are part of the system and it can be people, as well as physical instruments.

Figure 6.4 shows the resources of the data warehouse framework. Churchman's (1968:38) view that the potential of people also forms part of the system is strongly supported by this data warehouse framework.

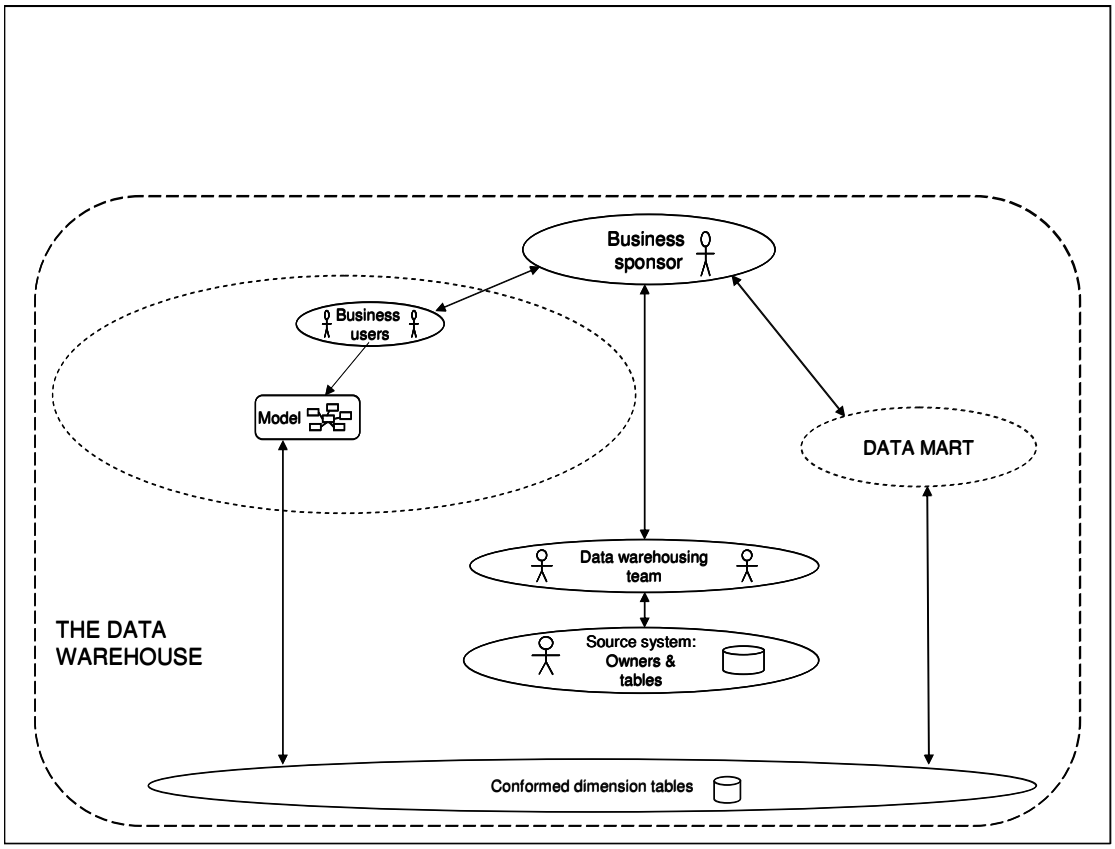


Figure 6.4 Resources of the data warehouse

The data warehouse system has the following resources:

1. *The business sponsor.* He/she provides insight into business problems and forms the gateway to the organisational resources.
2. *The business users*. Business users are the most important resource of information about the objectives of the system.
3. *The data warehouse team.* The team includes people to assist in all components of the systems as discussed in the next section. External consultants may form part of this group. It is of the utmost importance for the data warehousing team to understand the organisation's objectives.
4. *The source systems and their owners*. They are the main source of data for the data warehouse. The source system owners also provide input to quality

assurance activities during the data staging process (also discussed in the next section).

5. *The conformed dimension tables.* These are loaded from the source systems and form the data warehouse bus. This is similar to Kimball *et al.'s* (1998) view presented in section 4.5.3 and illustrated in figure 4.6. Each data mart does not contain a copy of the data, as it is stored on a shared location. The modelling process and the interaction with the conformed dimensions are discussed in the next section.
6. *Software tools and hardware*. Software and hardware are used throughout the data warehouse to manipulate and store the data. The main data store is the conformed dimensions. Each data mart contains fact tables with links to the dimension tables. All tables are physically stored on one or many computers. One might see the combination of fact and dimension tables as a presentation server congruent with Kimball *et al.* (1998:329). This data warehousing process is metadata-driven and metadata is also used to store information about the role players i.e. resources in the data warehouse.

It is important to identify the different worldviews of the people involved in the data warehouse. The respondents of case study two, when reacting to question B2 of table 5.1, reported conflict amongst the data warehousing team members as a result of different world views.

The business users are typically associated with a single business process and therefore a single data mart. The business sponsor, being a member of the executive committee, has an interest in all the data marts. The data warehousing team also has influence in all the data marts. Every data mart should not have its own data warehousing team, since it will be very difficult for such an isolated team to incorporate the overall objectives of the data warehouse and the organisation in their activities. Source system input is required in all the data marts, and specific source systems may provide input to more than one data mart.

From a *soft systems thinking* perspective, the organisation's objectives, supported by the data warehouse objectives, are the common factor that enables the different role players to work together. Soft systems thinking advocates an awareness of internal political aspirations and advises a method to resolve conflict and achieve consensus. The respondents of case study three stated that there is a variety of methods for reaching consensus, even in hostile situations (refer to question B2, respondent MC).

The above views were supported by the respondents of case studies two and three. Most respondents agreed (question A8) that people are part of a data warehouse and that the data warehouse is jointly owned by business and technical staff (question A5). Responding to user involvement (question C2), most participants agreed that senior management of business units should be involved in requirements specification. The organisation reported on in case study one, draws a much tighter boundary around their data warehouse. They view a data warehouse mainly as an organised data store. They also admit that many of their problems result from this view of a data warehouse.

The resources can once again be viewed through critical and disclosive systems thinking lenses. A *critical systems* perspective would accentuate the different agendas of the different role players. It is necessary to state for each of the role players what benefits they may gain from participating in the data warehouse. It is also important to highlight the differences in the real objectives of these role players. The technical staff's worldview, for instance, differs substantially from that of the business users (case study three, question B2). While soft systems thinking advocates the role of consensus to settle these differences, critical systems thinking admits that differences are difficult to identify and not always possible to be solved by consensus. Data quality and the influence of the data warehouse on the source systems were discussed in section 5.2.1.3.

Disclosive systems thinking is very similar to the soft systems approach, but the unifying factor would be the qualifying aspect of the organisation, as opposed to its quantifiable business objectives.

6.3.4 Components of the data warehouse

Churchman (1968:40) describes the components of the system as the different activities the system has to perform. The bold parts in figure 6.5 indicate the components of the data warehouse. These components form the development lifecycle of the data warehouse.

Most of the respondents agreed on the order of activities of the lifecycle (question B1). With reference to the data warehouse team, all but one of the respondents of

case studies two and three agreed on extended business user participation (question B3). They also agreed that consultants can only be beneficial when knowing and understanding the business objectives (question B4). Most of the respondents agreed with the division of the data warehouse into data marts according to the business processes (question B5) of the organisation.

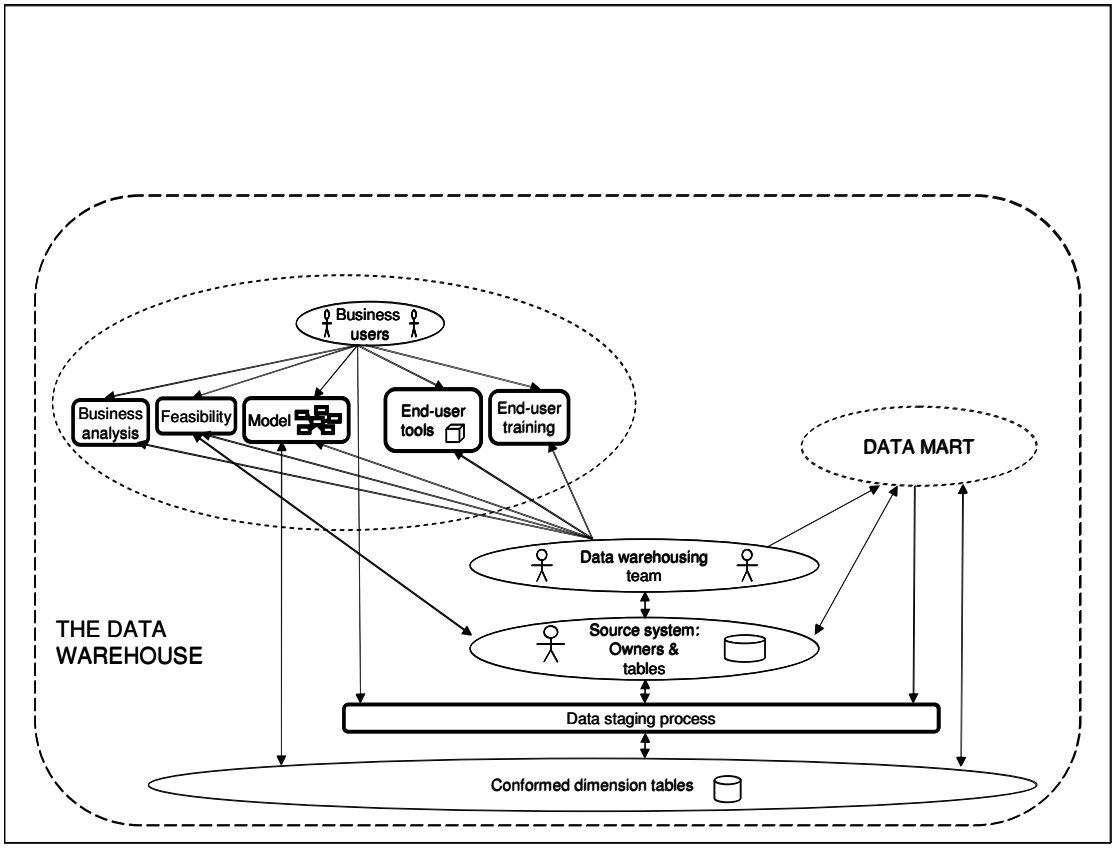


Figure 6.5 Components of the data warehouse

The organisation as a whole should be studied first, before identifying data marts. The performance measures of the data marts should be linked to the performance measures of the business processes.

6.3.4.1 Business analysis

From a *soft systems thinking* perspective, the first phase of data warehousing is to gain a complete understanding of the business. In this phase, the business users play a pivotal role, as indicated by all respondents to questions C1 and C2. There was also general consensus that users are unable to articulate their needs in

technical terms and need facilitation (question C3). The organisation reported on in case study one, using a hard system approach, often finds that users are able to express their needs only after completion of their data mart.

Critical systems thinking accentuates the view of one key problem area that needs to be resolved by the data warehouse (refer to case study three, respondent SC's answer to question A3). Consultants would typically take this approach, since it is easier to measure their success in terms of the solution to one such identified problem. The decision making structures as described in section 5.2.1.3 will be investigated during this phase. Ulrich's (1987) boundary judgements as described in section 3.5.3.2 will also be done during this phase.

A *disclosive systems thinking* perspective is similar to soft systems thinking, but with an added focus on the intrinsic normativity of the organisation. The entire organisation will be investigated in order to disclose the intrinsic meaning of the particular organisation. The lists of aspects given by Dooyeweerd, described in section 3.3.1.3 may aid this process.

The requirements documentation should be available to all role players, while procedures for updating the requirements must also be at hand (question C6). A computerised system if proposed for this function.

6.3.4.2 Feasibility study

A feasibility study should reveal how much of the data required by the business analysis, is available in the source systems. In this regard, the business users and the source system owners are important role players, since the business users understand what is required, and the source system owners know what is available. The availability of source data influences the prioritisation within the data warehousing project (question C7).

From a *critical systems* point of view, the data warehouse system would expect changes to be made to the source systems to accommodate the data warehouse objectives. From a *disclosive systems* perspective, the data warehouse team would be sensitive to the fact that historic and other factors beyond their control might influence the source systems. They would therefore accept shortcomings in the

source systems, provided they are not in direct conflict with the intrinsic normativity of the organisation.

6.3.4.3 Data modelling

Data modelling is the process of designing a star schema, to represent the views of the business users and the data warehousing team of the data required in the data mart. The responses to questions D1, D2 and D7 in case studies two and three indicated that users do not normally participate in data modelling, but it could be very advantageous if they would. The respondents reported that most users would understand the technicalities of star schema design.

There is interaction between the modelling team and the data warehouse bus of conformed dimensions. The modelling team designs dimensions to represent the user's needs. These dimensions must be compared with the existing dimensions of the data warehouse bus. The existing dimensions then need to be extended to contain any additional information required by the data mart.

From a *critical systems thinking* perspective, the users would want to be involved in all the phases of the data warehouse lifecycle, ensuring that their critical problem is correctly understood and solved by the data warehouse team.

A *disclosive systems* approach is similar to that of soft systems described above. The model is viewed as a tool for supporting the qualifying aspect of the organisation.

6.3.4.4 Data staging

Data staging involves the extraction, transformation and loading of source data from the source systems into the conformed fact and dimension tables of the data warehouse. The process may also update the source tables to improve source system data quality, since data quality is of the utmost importance to data staging. Firstly, it should be determined who is responsible for data quality. The respondents of case studies two and three indicated a joint responsibility (question E1); whereas respondent SC of case study three assigned the responsibility directly to the business users. Although this is a technical process, business users should be involved to ensure that data anomalies are resolved.

By taking ownership of data quality, the business users will be able to verify data values in the data warehouse, and this would enhance confidence in the data warehouse data. If the data warehouse users have confidence in the data warehouse data, they will use the data warehouse in support of their decisions, which is the most important success criterion of all.

The challenge is not to lose sight of the organisation's objectives in the data staging process. These objectives can only be reached if the data warehouse data is of high quality from a business user's perspective.

Critical systems thinking will highlight conflicting interests of source system owners and owners of the rest of the data warehouse system. The underlying motivations of these conflicts need to be exposed and resolved before the data in the data warehouse can be trusted.

Although the practices of *disclosive systems thinking* are very similar to the soft systems approach described above, conflicts between different source systems will be investigated in terms of the qualifying aspect of the organisation.

6.3.4.5 End-user tools

End-user tools are programs used by business users to access the information in the data warehouse. All respondents reported that these tools are very seldom developed in-house, and that they use standardised packages from large vendors (question F3). This increases the responsibility of selecting a tool that is acceptable to the business users. If the tool is too complicated to be used for the analysis required by the business users, the data warehouse will not be used and therefore be unsuccessful. A proof of concept can be applied to test the value of a specific tool. The business users should take actively part in the tool selection process.

Since *critical systems methodologies*$_2$ such as TSI discussed in section 3.5.3.1 provides methods for comparing different methods, the critical systems thinker will be able to critically evaluate different end-user tools in order to select the most appropriate tool for the specific needs of the organisation.

Since *disclosive systems thinking* views the data warehouse as a support tool to further the qualifying aspect in the organisation, different tools will be compared

according to their ability to enable the business users to apply the analytical aspects of the data warehouse in support of the qualifying aspect of the organisation.

Almost all respondents agreed that end-user requirements need to be collected during the business analysis phase of the data warehouse development lifecycle (question F1). This is in contrast with the methods proposed by Inmon (1996) described in section 4.3.

6.3.4.6 End-user training

From a *soft systems* perspective, the data warehouse is only successful if it is used by the business users. By engaging them in all the development phases, acceptance of the data warehouse by the end-users is established. As stated earlier, the business users involved are only a representative group of between two and four users and not the entire user community. The rest of the users need to be trained to use the data warehouse. It would be ideal if the users that were part of the data warehousing project could do the training of all the other users. The respondents of case study three indicated (as a response to question F6) that end-users need to be trained on neutral data before using the data warehouse data, since they get distracted from the functionality of the end-user tool by organisational information in the data.

Although most respondents reported (question F9) that users do not use the *ad hoc* query capabilities of the tools, follow-up training could rectify this problem.

It is proposed that business users involved in the data warehouse train the other business users and that follow-up training be given after a period of six months of data warehouse usage to ensure business users utilise the data warehouse to its full capacity.

From a *critical systems* approach, business users need to be empowered through training to use the data warehouse to its fullest extent. This view underlines the standpoint taken in the previous paragraph.

Although the *disclosive systems* perspective is similar to that of soft systems thinking presented above, the focus in training would be to enable the users to use the

analytic powers of the data warehouse to understand and further the qualifying aspect of the organisation as a whole.

6.3.5 Management of the system

The management of the system is responsible for setting the objectives of the system, defining the environment, managing the utilisation of resources and dividing the system into components. In data warehouse terms, the management of the system needs to do all of the above, focussed on overall quality assurance and metadata management. The performance of the system should be constantly checked to ensure that the business objectives are achieved.

The management of the data warehousing team should involve all stakeholders in the data warehouse, as depicted in figure 6.6. The group of business users shown in figure 6.6 is a representative group of business users. The data warehousing team comprises people trained in data warehousing and responsible for each of the components discussed in the previous section. This team may include external consultants, provided they share ownership of the organisation's business objectives and therefore of the data warehouse. The respondents of case study three reported advantages of having a small data warehousing team, with team members involved in all phases of the project (question B6). The business sponsor, representative of the executive committee, should be a person highly motivated towards the data warehouse and its success. The source system's owners are technical people from the information systems department concerned with the operational information systems of the organisation.

The data warehousing team should include a project manager responsible for the co-ordination of all activities of the different role players. It is important to select an experienced person who is in touch with the business objectives and familiar with the key problem areas of the organisation.

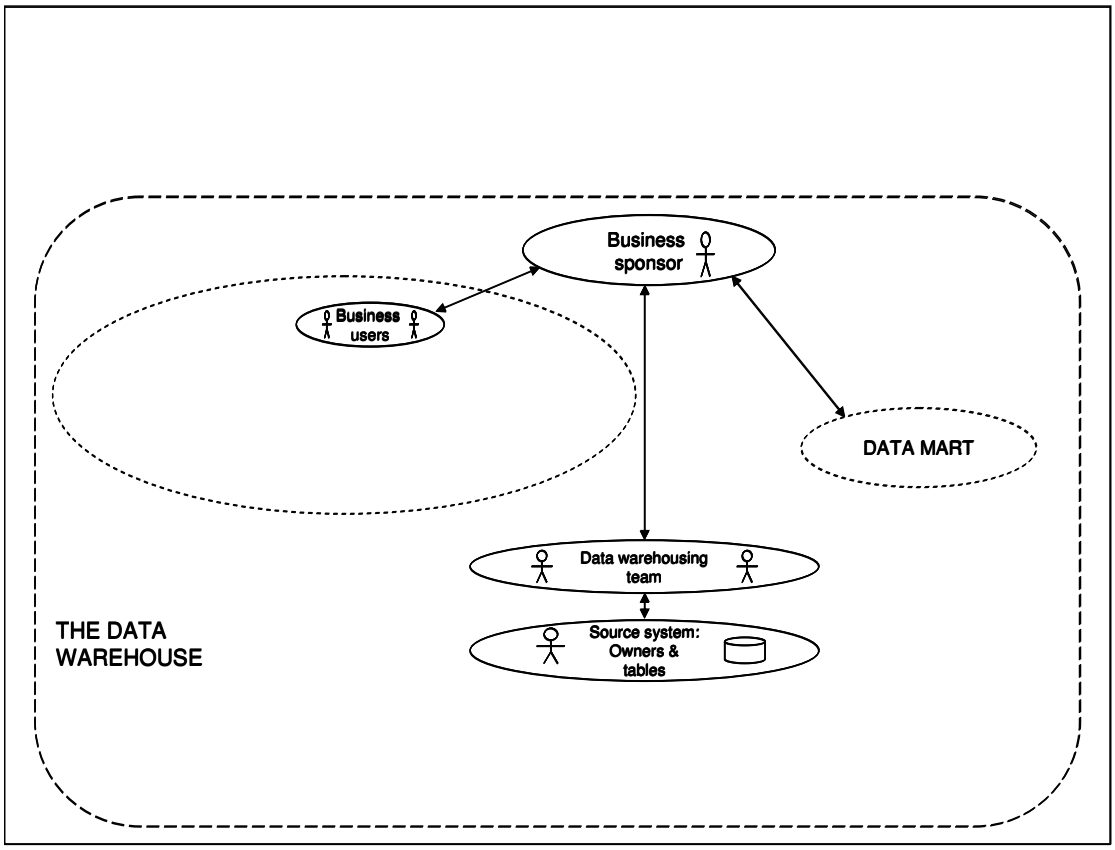


Figure 6.6 Role players in the data warehouse

The role players responsible for data integrity should decide on success factors and parameters for determining the success of the data warehouse. Most of the respondents stated that the data warehouse is only successful if it is used to improve decision making (question F12). The project manager along with the other team members should design measures to monitor the usage of the data warehouse. The monitoring team can also identify areas where service could be improved (question F11).

The role players in the data warehouse should decide on different levels of access assigned to end-users. Although the researcher and some of the respondents believe that every user should have full access to all the data in the data warehouse, the majority of the respondents argued that it is not practical and that executive committees want multi-level restrictions on data warehouse access (question F8).

The project leader should ensure a high standard of technical skills relevant to the data warehouse system. This includes a detailed plan for keeping metadata updated

and easily accessible. The project leader and his/her team should also ensure that the overall objectives of the organisation and therefore the data warehouse are taken into account during each activity of the data warehouse system. The respondents in case study three reported that conflict can be eliminated if the responsibilities of all the role players are clearly defined (question B2).

From a *critical systems* perspective, the data warehouse will solve a specific problem and management activities will focus on aspects required to achieve this single objective. The data warehouse team will also focus on the underlying structures of the identified problem. Ulrich's (1987) ideas of "ought to" questions in boundary judgements would be central in the identification of role players in the data warehousing project. The critical systems thinking project leader will be aware of different agendas and motivations and will attempt to expose conflicting views to the main objective of the data warehouse.

From a *disclosive systems* point of view, the project leader will ensure that every role player is assigned definite responsibilities for achieving the intrinsic normativity of the organisation. The ethical values of the data warehouse team will also be defined clearly, and the project leader will hold them responsible for adhering to these.

6.3.6 The relationships between the components and role players in the system

Figure 6.7 contains the complete framework with numbers assigned to each of the connecting lines. The meaning of each line is described briefly in table 6.1, thereby completing the discussion on the framework. The explanations of the various connections contained in table 6.1 are applicable to all the discussed systems thinking methodologies$_{1\&2}$ unless otherwise indicated.

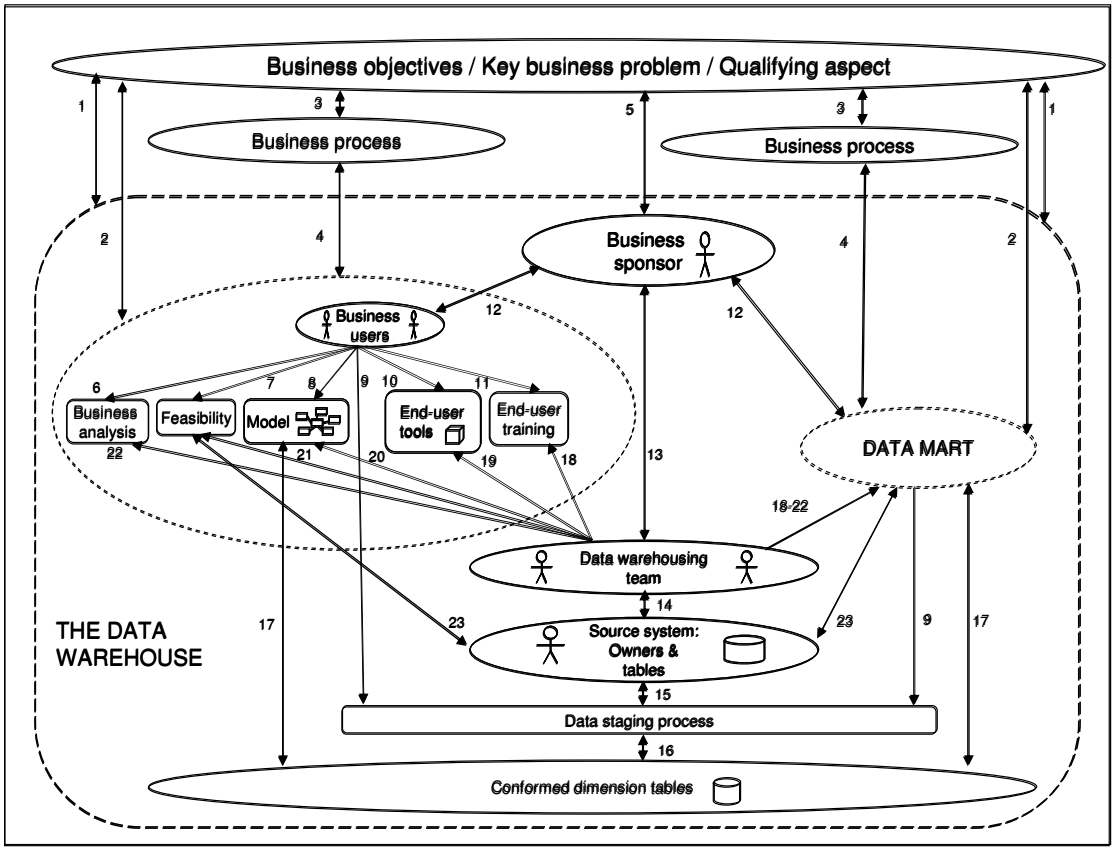


Figure 6.7 The complete data warehouse framework

Connection number	Explanation
1	From a *soft systems* perspective the overall business objectives influence the whole data warehouse system, but the systems objectives may also be altered as a result of the data warehousing project. From a *critical systems* perspective the key business problem will direct the data warehousing process. From a *disclosive systems* perspective the qualifying aspect and disclosure thereof will direct the data warehousing process.
2	The overall business objectives, key business problem or qualifying aspect (depending on the prevalent systems thinking methodology$_{1\&2}$) influence each data mart and all components of the warehouse system. The investigation of a business process may also lead to the altering of the overall business objectives or key business process or the formulation of the qualifying aspect of the organisation.
3	The overall business objectives, key business problem or qualifying aspect (depending on the prevalent systems thinking methodology$_{1\&2}$) influence the business processes in the organisation.
4	Each data mart represents a business process in the organisation.
5	The overall business objectives, key business problem or qualifying aspect (depending on the prevalent systems thinking methodology$_{1\&2}$) are promoted by the business sponsor in the data warehouse system.
6	Business users are involved in business analysis.

7	Business users are involved in the feasibility study.
8	Business users are involved in the modelling of the data in terms of star schemas.
9	Business users are involved in data staging.
10	Business users are involved in the selection and implementation of end-user tools.
11	Business users are involved in end-user training.
12	Business users are in frequent contact with the business sponsor and vice versa.
13	Data warehousing team members are in frequent contact with the business sponsor and vice versa.
14	Data warehousing team members are in frequent contact with the source systems owners and vice versa. Data quality and availability issues are frequently discussed.
15	Source system owners are involved in the data staging process supplying data, but also accepting improved data or additional data resulting from data mining efforts.
16	Conformed dimension tables are updated as a result of data staging. It is however possible to send updated table data back through the staging area to the source tables.
17	The design of a data mart influences the group of conformed dimension tables in that tables are added or changed. Current dimension tables could also influence the design of a specific data mart.
18	The data warehousing team is involved in end-user training.
19	The data warehousing team is involved in end-user tool selection.
20	The data warehousing team is involved in data modelling.
21	The data warehousing team is involved in the feasibility study.
22	The data warehousing team is involved in business analysis.
23	The source system owner assists in the feasibility study; it is also possible that data capturing standards in the source system changes as a result of the feasibility study.

Table 6-1 An explanation of the connections on the framework

6.4 Comparison of the framework with existing models

The framework presented in this chapter differs from the models presented by Wixom and Watson (2001:17) and Kimball *et al.* (1998:329). The main differences are highlighted in this section.

6.4.1 The framework compared to the Wixom and Watson (2001) model

The model presented by Wixom and Watson (2001: 20) is repeated in figure 6.8 to aid explanation. This model was proposed by Wixom and Watson (2001) as a basis for data warehousing research and not explicitly as a model for data warehousing methods. It does however indicate a perspective of role players in the data warehouse development activity.

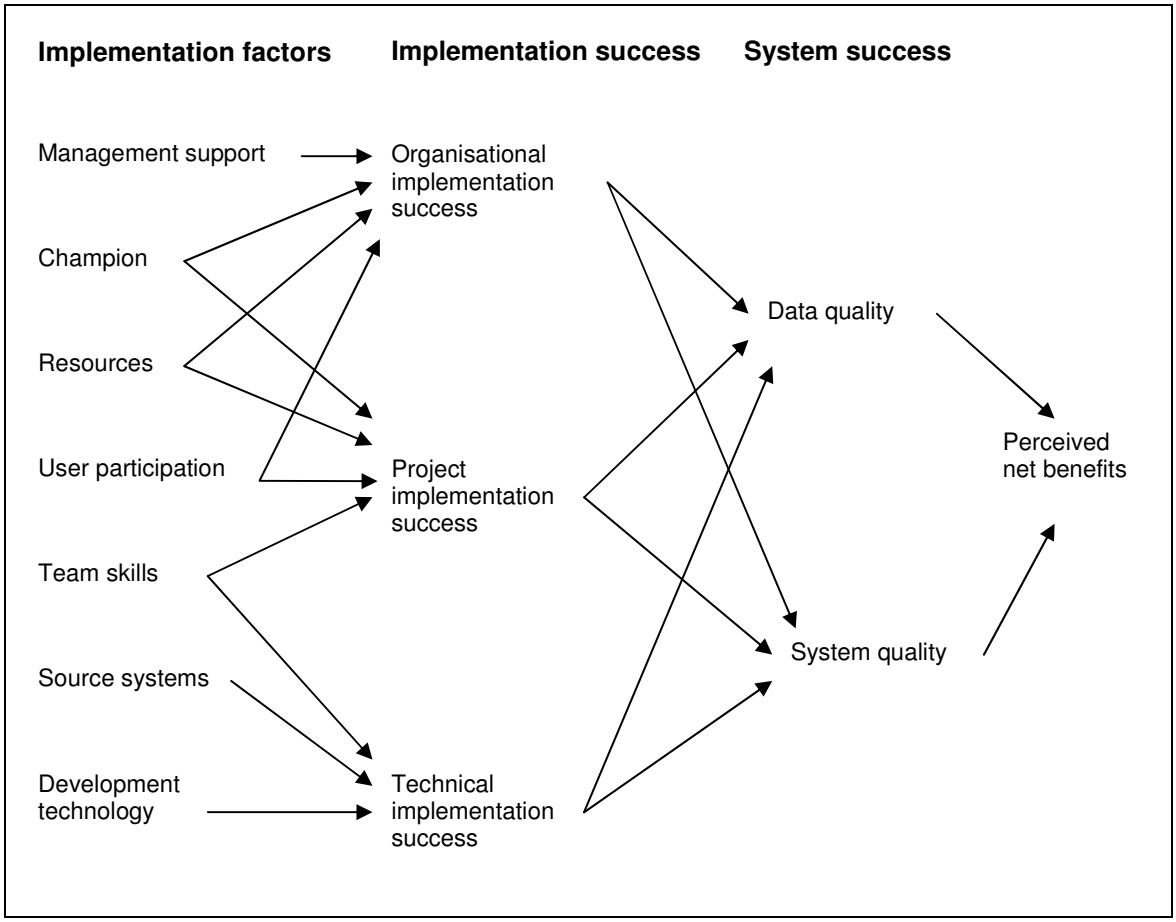


Figure 6.8 The data warehouse research model of Wixom and Watson (2001:20)

The following differences are evident when comparing the Wixom and Watson model (2001) with the framework presented in this chapter:

- In the Wixom and Watson model, management support does not extend to project and technical success. Even if the "champion" is part of the management team, he/she is not involved in the technical success of the project. In the framework presented in this chapter, the business sponsor (representing management support) and the business users are involved in everything related to the data warehousing team's activities. Both the data warehousing team and the business users have direct access to the business sponsor.
- From the Wixom and Watson model, it is not clear why resources do not extend to technical implementation success.
- Wixom and Watson do not indicate the influence of the organisation's objectives on the process.
- According to Wixom and Watson, the users are not involved in technical implementation success.

6.4.2 The framework compared to the model of Kimball et al. (1998)

Kimball *et al.* (1998) played an influential role in the researcher's view of data warehousing practices. Kimball *et al.* (1998) can be viewed as a soft systems response to the hard systems approach introduced by Inmon (1996). They do not link their data warehouse views to any methodological$_1$ viewpoint, nor do they provide a single illustrated framework indicating the role players in the data warehouse system. They also do not explicitly involve the users in the data warehousing team but do advocate user participation in data modelling when stating that users are able to understand star schemas.

Kimball *et al.* (1998) use two illustrations to indicate the data warehousing process and the technical data warehouse architecture (refer to figure 4.3 and figure 4.1 respectively). Neither the organisation's objectives nor data warehouse role players are included in either of these illustrations. When studying the complete monograph, it is clear that Kimball *et al.* (1998) advocate similar role players to those indicated in the framework presented in this chapter.

Another important difference to the work of Kimball *et al.* (1998) is the participation of users in technical phases, such as data staging. Kimball and co-authors do not include a business user on the data warehousing team, nor do they refer to any contact with end-users during data staging.

In conclusion, Kimball *et al.* (1998) display some evidence of using soft systems ideas in data warehousing practices, but do not follow an explicit soft systems approach, where role players, worldviews, objectives and management are identified explicitly. These notions of soft systems thinking were part of the initial motivation of the researcher to make explicit the link between data warehousing practices and systems thinking methodologies$_{1\&2}$.

6.5 Summary

The aim of this thesis was to develop a framework for the explicit use of specific systems methodologies$_1$ in data-driven decision support system development practices. Data warehousing was chosen to represent data-driven decision support systems.

The research was done according to a pluralistic approach of combining interpretive and critical social research practices. The combination of different research practices was based on a study of research philosophy, methodology$_1$ and practices in general, as well as applied to information systems research specifically.

The concluding framework presented in this chapter is a combination of information gained from literature studies and interpretive case studies. The framework presented here is not, as in pure interpretive research, a theory describing current practices of data warehousing practices. It should rather be viewed as a framework to guide the practices of data warehousing professionals. This view represents the critical research or intervention aspect of the research.

The literature study presented in chapter 3 gave a discussion on systems in terms of philosophy, methodology$_1$, and practice. This philosophy-based approach was required since systems thinkers do not give guidance to data warehousing practitioners, and the researcher had to understand the philosophical foundation of

systems methodologies$_{1\&2}$ before applying specific systems thinking methodologies$_1$ to data warehousing.

Another source of information was data warehousing literature. A literature study on data warehousing and data warehousing success factors was presented in chapter 4.

The researcher required practical information about current data warehousing practices to gain understanding of the role systems thinking can play to improve data warehousing success. Three interpretive case studies were conducted to collect data on current data warehousing practices. Pattern-matching was used to analyse the collected data according to systems thinking methodologies$_{1\&2}$. The analysis indicated that, although the first organisation followed mainly a hard systems thinking approach, they were able to express soft ideals. The second organisation followed a soft systems thinking approach to some extent, but not all data warehouse team members bought into the organisation's objectives as a motivational factor for their activities. The third organisation, being a consulting firm, reported mainly on ideal practices. They supplied information on how they believe data warehousing practices should be performed to be successful. Aspects of critical systems thinking were clearly evident from their soft system thinking answers. They gave very few hard systems thinking answers. The researcher concluded that hard systems thinking is not advantageous to data warehousing practices.

The combination of literature studies and case study data lead to the development of a framework for the explicit use of specific systems thinking methodologies$_{1\&2}$ in data warehousing practices. The framework presented in this chapter focussed mainly on a soft systems approach but can easily be extended to include critical and disclosive systems thinking perspectives.

The framework was discussed with the people who participated in the case studies. They were satisfied that the framework proposed practical solutions that may lead to increased data warehousing success in organisations. The manager of the data warehousing department of case study one's organisation identified three benefits of this research initiative:

- Table 5.5 indicated that the manager is more inclined towards soft systems thinking than the other team members. Based on the insights into the motivation of individual team members provided by table 5.5, the manager is able to identify specific problem areas.

- The completed framework serves as a communication tool to explain the role of the data warehouse in the organisation to top management, and to motivate top management to allocated organisational resources to the data warehouse.
- The framework will be used to illustrate the holistic nature of the data warehouse as a system to the data warehousing team members.

6.6 Further research

The researcher aims to test the acceptance of the framework in industry to complete the intervention aspect of the research. More organisations will be targeted, as well as industry literature, popular web sites and data warehousing periodicals.

This application of disclosive systems thinking can be extended to other problem situations to assist in the development of a general methodology$_2$ for the application of the disclosive systems thinking methodology$_1$.

The thesis concludes with an evaluation of the research that produced the framework presented in this chapter.

6.7 Evaluation

As a conclusion to the thesis, the research is evaluated according to the following criteria for evaluating a theory for scientific progress as proposed by Introna (1992:5.31):

a. Does the theory raise problems previously not perceived, e.g. problems of an increasing depth, and does it display an ever-increasing fertility in new problems?

This research highlights the relationship between philosophy, methodology$_1$, and practices. It applies knowledge gained by the exploration of these relationships to data warehousing practices. The study opens up research into the application of these relationships in other information systems disciplines. It also furthers the development of specific systems thinking methodologies$_2$, specifically disclosive systems thinking.

b. Does the theory anticipate novel facts and auxiliary theories?

A new way of addressing problems in information system development is proposed. Problems are to be addressed from a philosophy, methodology$_2$, and practice framework. This perspective may lead to an increased awareness of the advantages of systems thinking and different systems thinking methodologies$_{1\&2}$ in information systems development. Other researchers may also explore the direct relationship between philosophy and information systems development practices.

c. Is the theory more precise in its assertions and in the facts it explains than previous theories?

From a data warehousing perspective, the answer to this question is in the affirmative. The proposed framework for data warehousing success differs from existing frameworks in that it provides a solid philosophical and methodological$_1$ foundation. Other existing frameworks only base data warehousing success on past experience, i.e. the practice level of the philosophy, methodlogy$_1$, and practice model.

d. Has the theory unified or connected various hitherto unrelated problems, or concepts?

Although hard, soft, and critical systems thinking methodologies$_{1\&2}$ have been linked to information systems development, they have not been linked to data warehouse development methods before. Disclosive systems thinking has not been linked to any information systems development methods prior to this study.

e. Does the theory have positive and negative heuristic power?

Introna (1992:1.118) states: “Positive heuristic power indicates which research paths should be pursued and negative heuristic power indicates which research paths should be avoided. Without heuristic power, a research program would collapse into *ad hoc*-ness.”

Chapter 2 explored different perspectives of the problem situation as reported in this thesis. From a negative heuristic power point of view, it was indicated that the research problem did not purely fit into either interpretive or critical research methodology. From a positive heuristic power perspective, it was

indicated that a pluralistic approach using case studies, pattern matching, and intervention, can produce a scientifically sound solution to the problem.

This solution can be extended to other research problems of a similar nature. One may generalise the research problem as a problem where the respondents in the problem situation are not familiar with the aspects under investigation. Chapter 2 raised two similar research problems, namely a study of adjustment problems in children and a study on the extent to which parents use pedagogical principles unknowingly in the upbringing of their children.

f. Has the theory produced a new perspective on existing problems and thus created a new understanding of these existing problems?

This study produced a systems thinking perspective on data warehouse development methods. Failure of data warehousing projects can now be understood from a holistic point of view. The work of Kimball *et al.* (1998) is now viewed from a soft systems perspective, whereas previously, it was viewed only from a data warehouse industry point of view.

g. Has the theory produced unconventional ideas, ideas that radically challenge current conceptions?

The answer is in the affirmative. Data warehousing professionals did not previously seek solutions to their problems in philosophical ideas. Any model that links philosophy and methodology$_1$ to data warehousing practice is foreign to the data warehouse practitioner. An in-depth literature search did not yield any literature exploring relationships as presented in this thesis.

The use of pattern matching as performed in chapter 5 is also unconventional in information systems research. Although it is difficult to search extensively for similar applications, none were found.

From the above evaluation, it is clear that the research presented in this thesis satisfies the criteria laid down by Introna (1992) and therefore represents scientific progress.

6.8 Research conclusion

The aim of the research was to develop a framework for the specific use of systems thinking methodologies$_{1\&2}$ in data warehousing practices. This research objective was divided into sub-objectives in chapter 1 (section 1.4). In order to reach the first sub-objective, namely to understand data warehousing practices from a systems thinking point of view, literature studies were conducted on systems thinking and data warehousing. The aim of the case studies was to explore the systems thinking nature of current data warehousing practices. Analysis of the case study data indicated that most data warehousing practices in the organisations studied can be related to soft systems thinking. There were practices that could be related to hard systems thinking, but management expressed dissatisfaction with these. Some practices on the other hand could be related to critical systems thinking. The case study data also indicated that respondents might have preferred practices related to critical or disclosive systems thinking, had they been knowledgeable regarding these methodologies$_{1\&2}$. This perception will be tested in a follow-up study. Although very few disclosive systems answers were given, managers in case study two reported that patient care should be important in all their actions.

In reaching the second objective a framework was developed for the use of specific systems thinking methodologis$_{1\&2}$ in data warehousing practices. The framework was depicted on a single figure that was viewed through three different lenses for soft, critical, and disclosive systems respectively.

The researcher repeatedly came to the conclusion that to evaluate the motivation of the practitioner for preferring certain practices, one needs to understand the methodological$_1$ and philosophical underpinning of such practices.

It also became clear that different systems thinking methodological$_{1\&2}$ viewpoints may lead to similar practices, although the underlying motivation for these practices is based on different ontological (philosophical) views.

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