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.

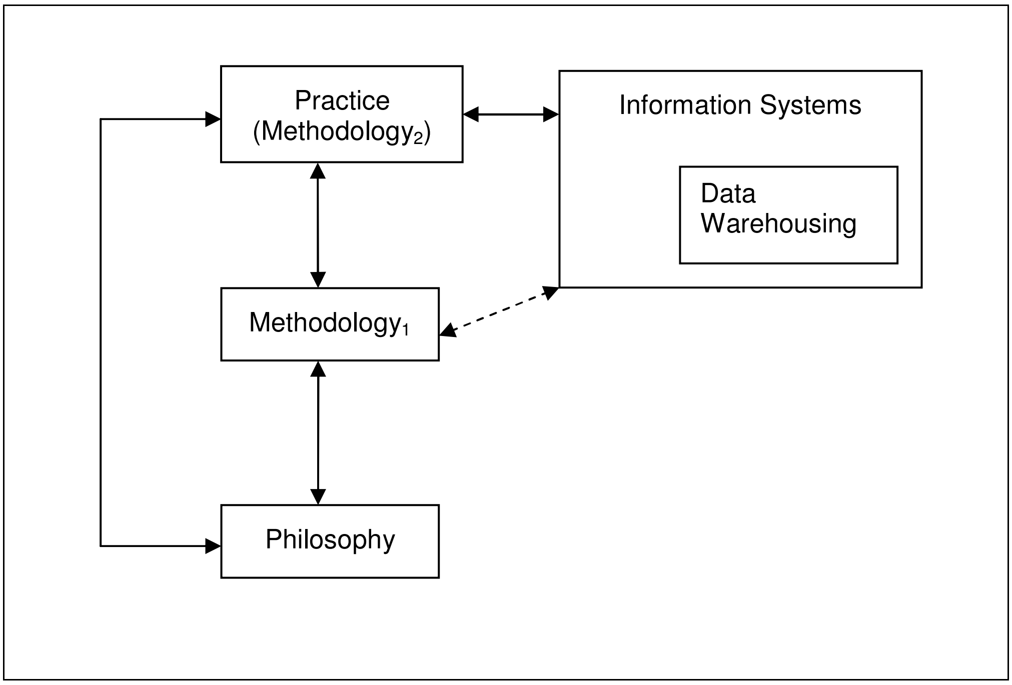

Figure 3.1 The relationship between philosophy, methodology$_1$, and practice

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.

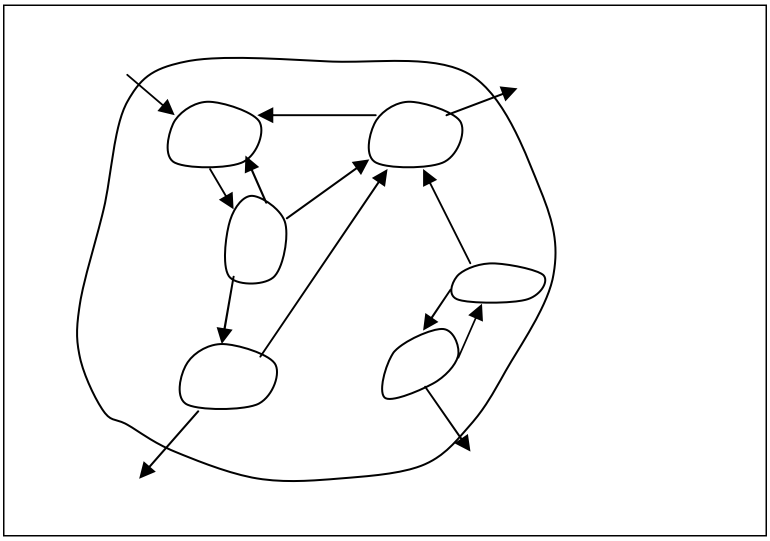

Figure 3.2 System (Kramer & De Smit, 1977:14)

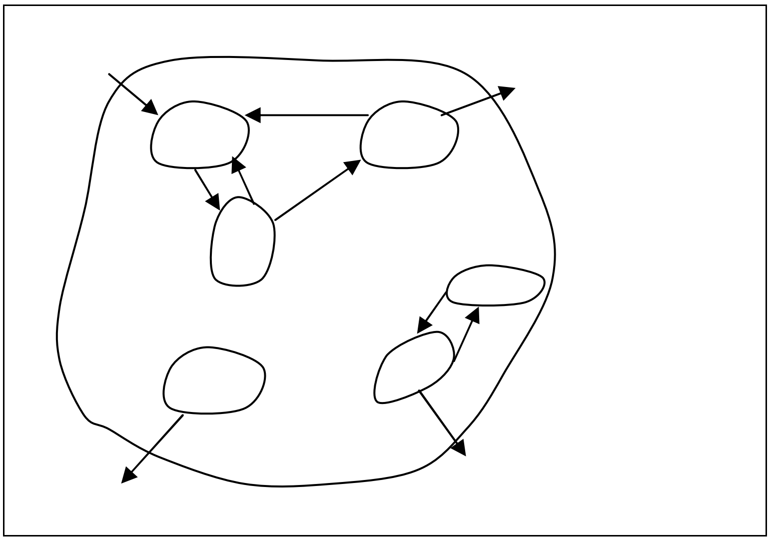

Figure 3.3 Aggregate (Kramer & De Smit, 1977:14)

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.

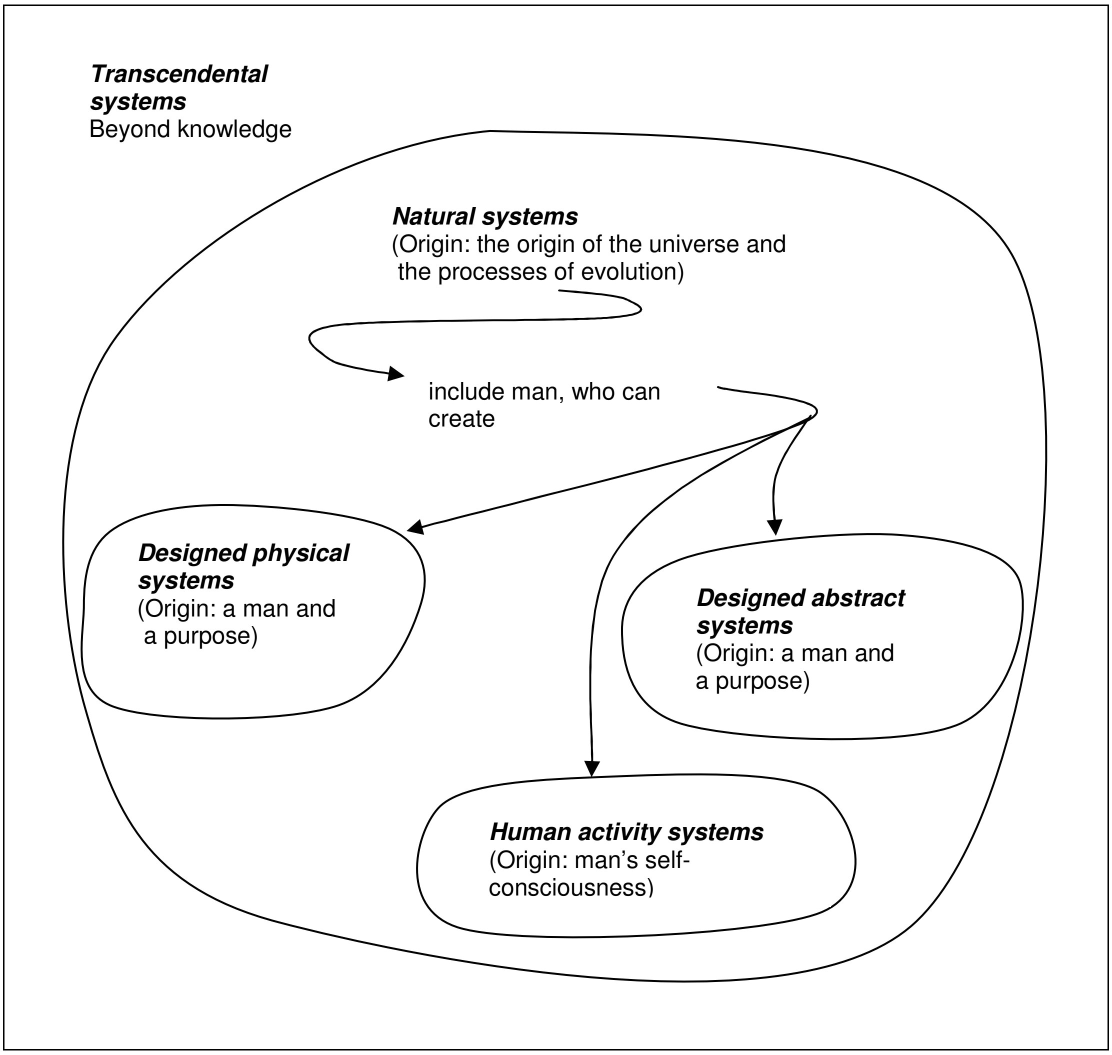

Figure 3.4 Five classes of systems (Checkland, 1981:112)

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 multistaged. 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.

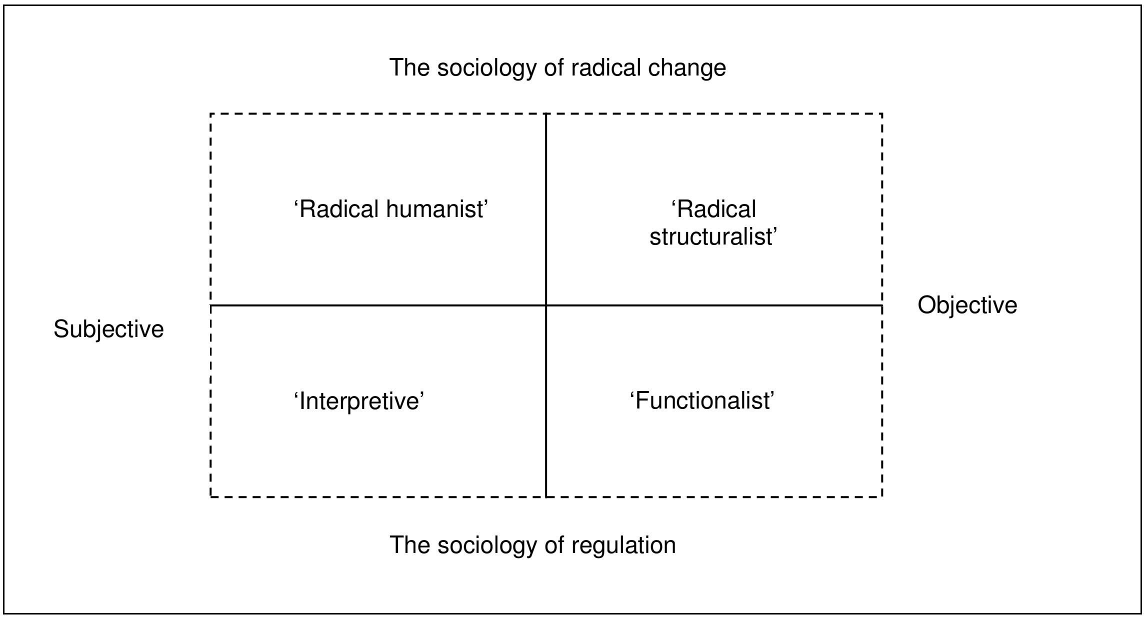

Figure 3.5 Four paradigms for the analysis of social theory (Burrell & Morgan, 1979:22)

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.

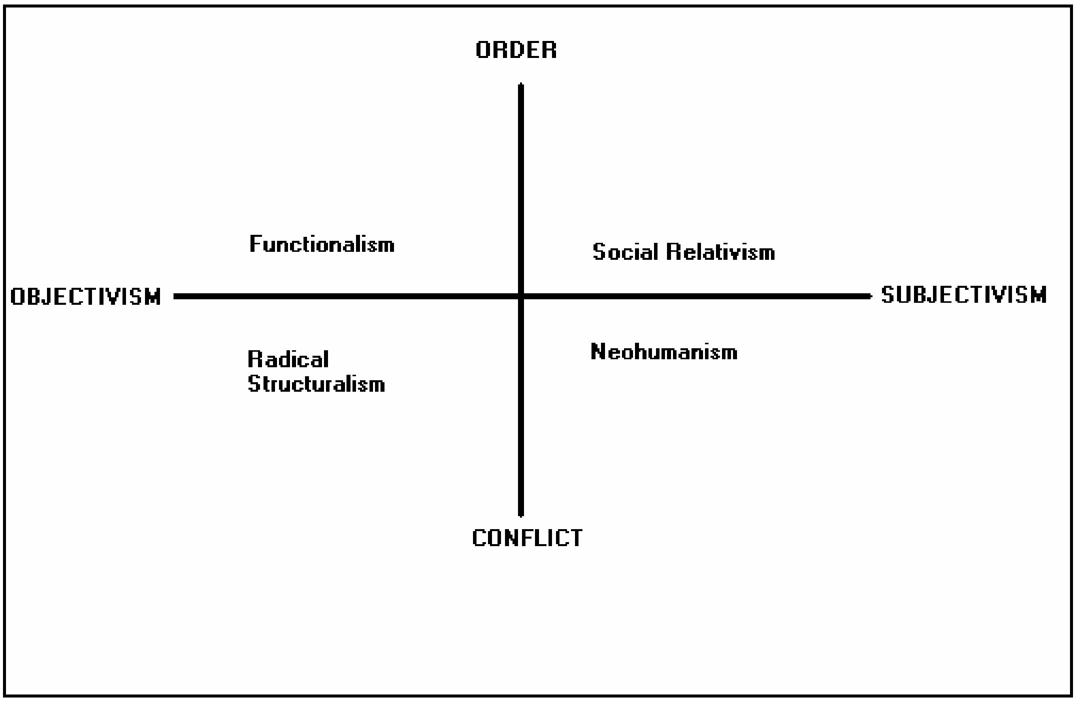

Figure 3.6 Information systems development paradigms (Hirschheim & Klein, 1989:1202)

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) methodology₁	Soft (interpretive) methodology₁	Emancipatory (critical) methodology₁
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.

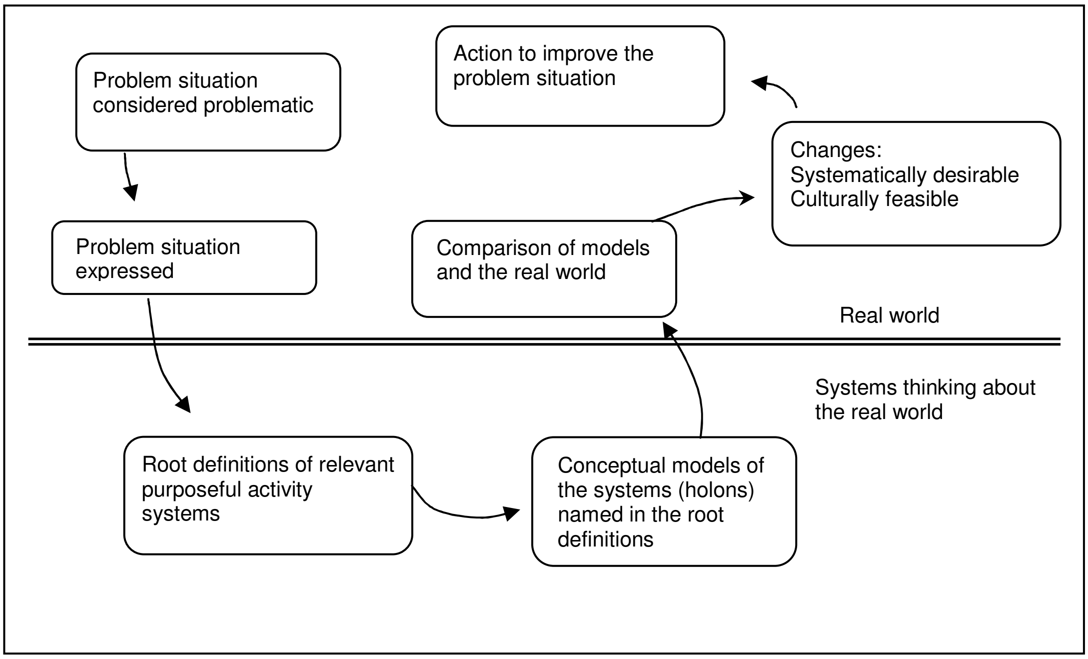

Figure 3.7 Seven stages of the SSM (Checkland, 1995:11)

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).

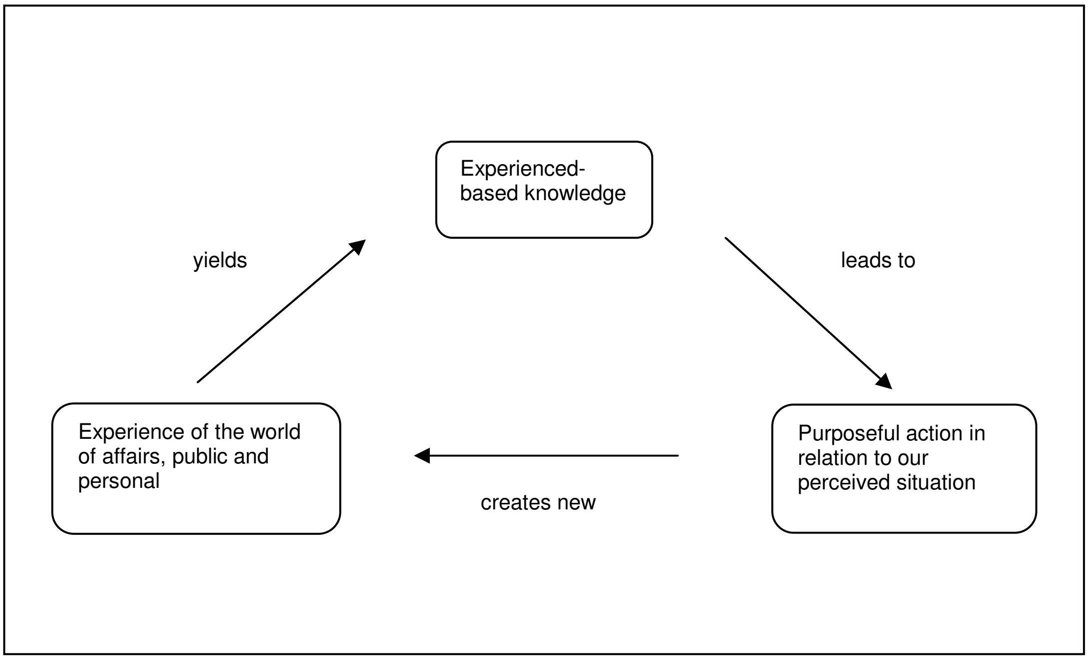

Figure 3.8 The experience-action cycle (Checkland & Scholes, 1999:3)

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).

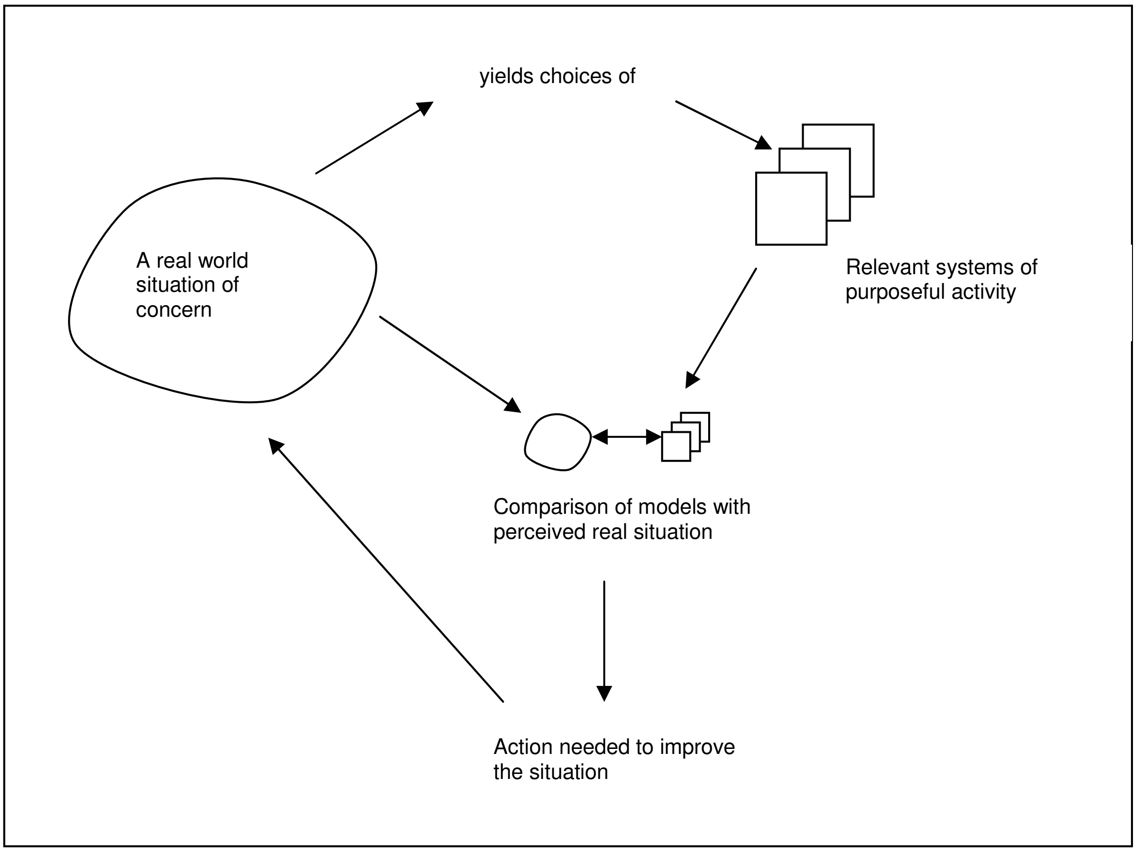

Figure 3.9 The basic shape of SSM (Checkland & Scholes, 1999:7)

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.

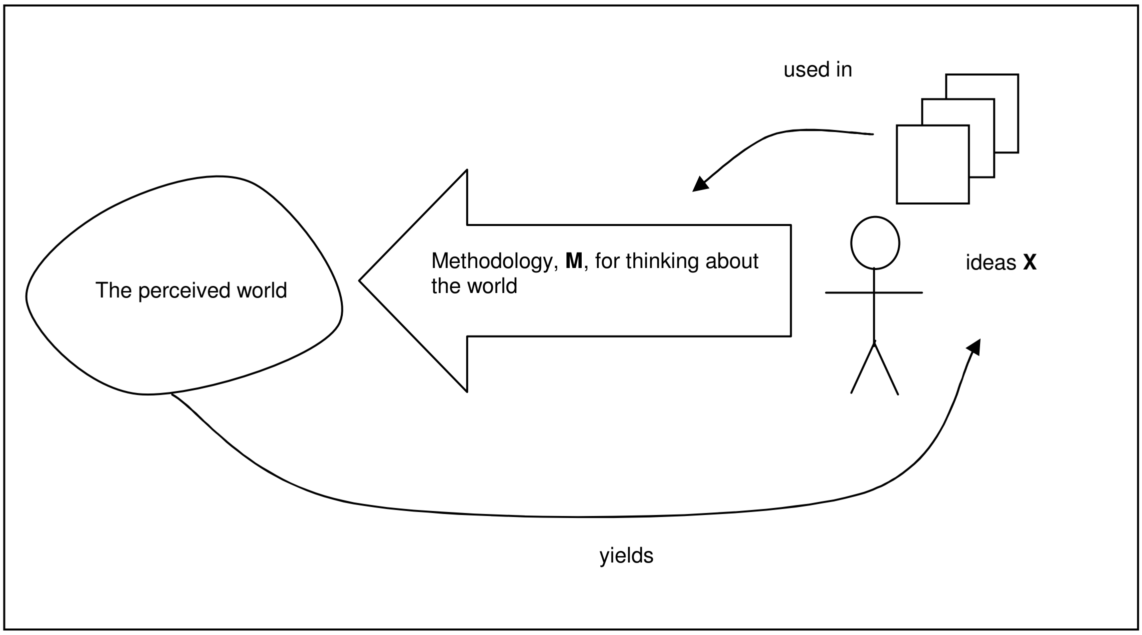

Figure 3.10 The world interpreted by ideas of the world (Checkland & Scholes, 1999:21)

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.

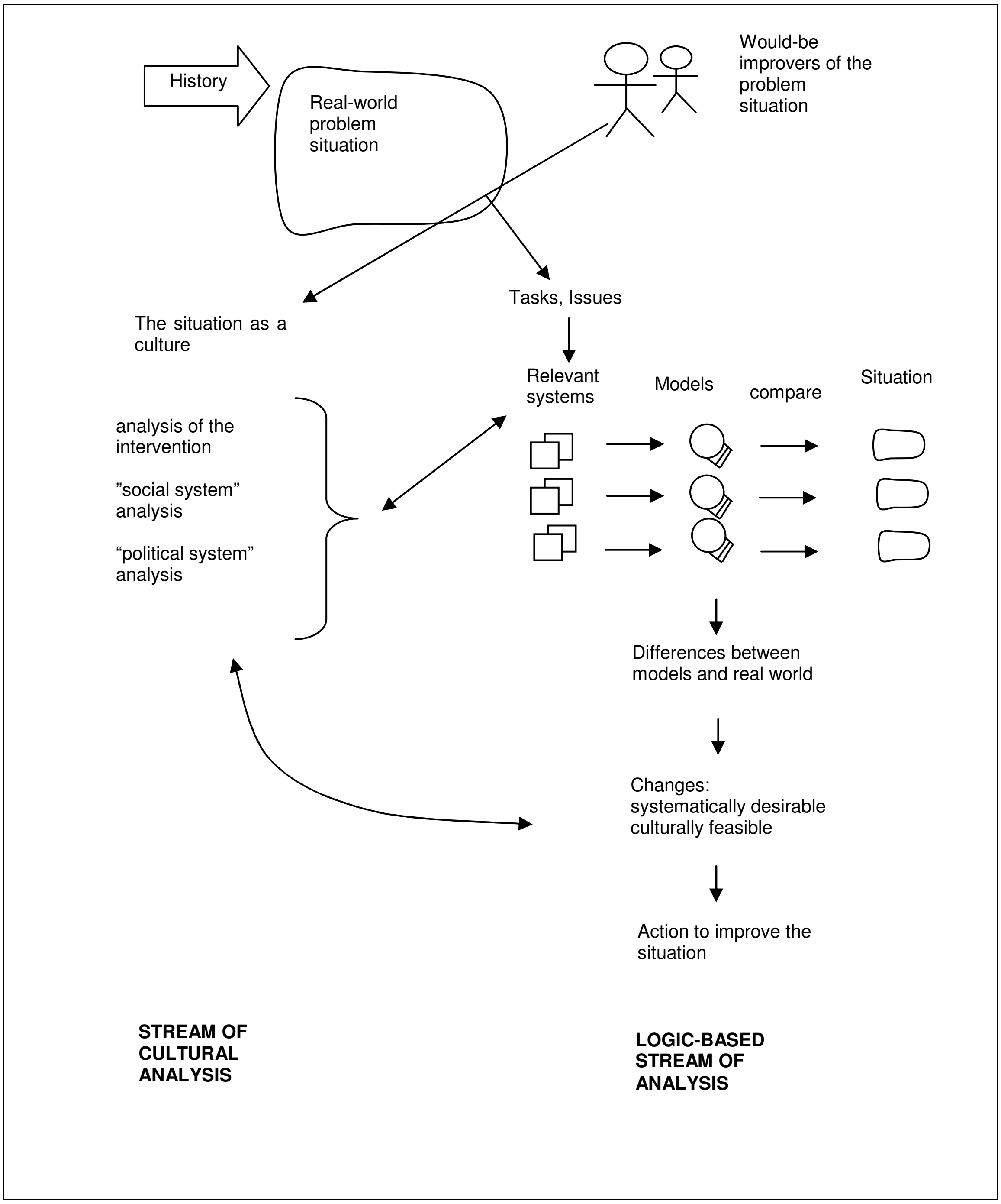

Figure 3.11 The SSM as enquiring process (Checkland & Scholes, 1999:30)

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.

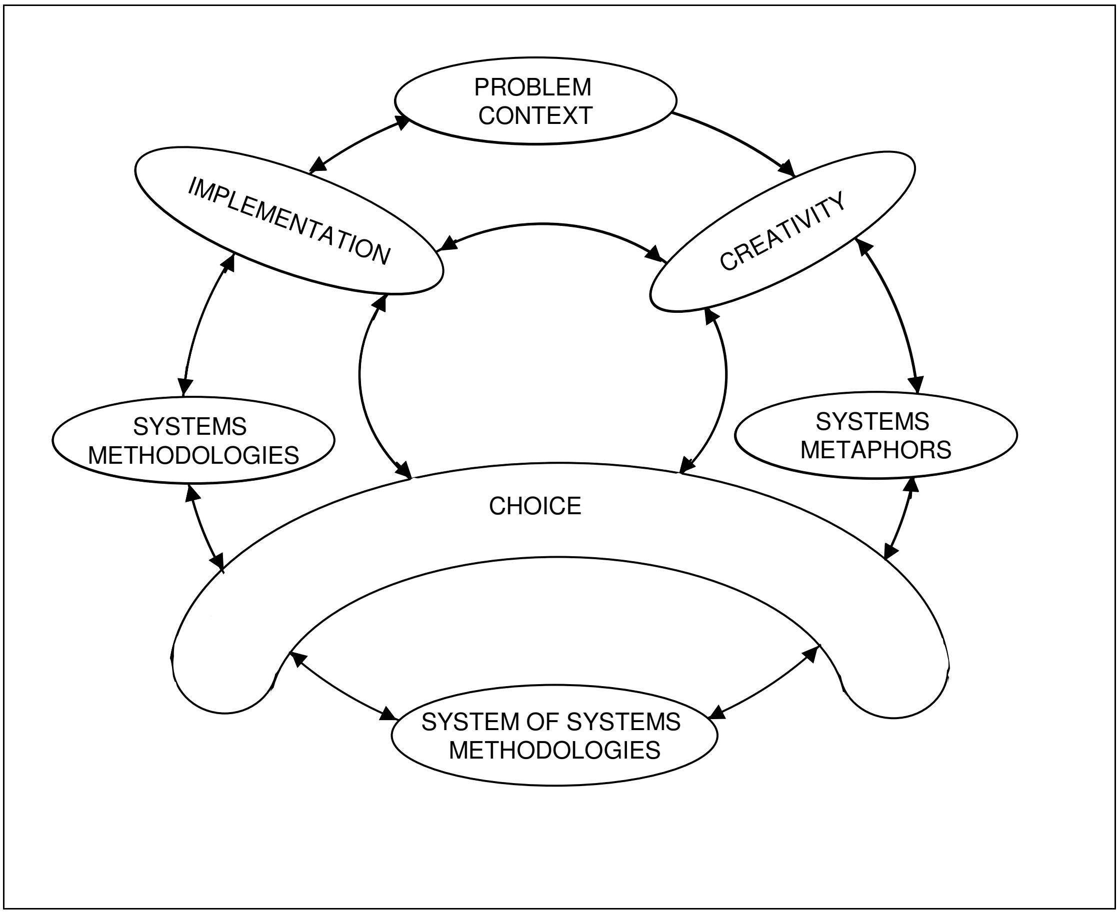

Figure 3.12 The process of the TSI (Flood & Jackson, 1991b:330)

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.