Applying Systems Approach to the Process of Designing Information Systems

(HS-IDA-MD-01-303)

Ingvar Karlsson
Department of Computer Science
Högskolan i Skövde, PO Box 408
SE-54128 Skövde, SWEDEN

Final year project
on the study programme in computer science 2001
Supervisor: Anders Malmsjö

Applying Systems Approach

To the Process of Designing Information Systems

HS-IDA-MD-01-303

Submitted by Ingvar Karlsson to the University of Skövde as a dissertation towards the degree of M.Sc. by examination and dissertation in the department of Computer Science.

September 2001

I certify that all material in this dissertation which is not my own work has been identified and that no material is included for which a degree has already been conferred upon me.

……………………………………………..
Ingvar Karlsson

Abstract

Designing information systems is a complex task. The purpose of this work is to contribute to an improved understanding of the design conditions in order to alleviate the problems that occur due to complexity in the design process. To possibly increase the understanding of the conditions for the design of interactive information systems, this dissertation concerns applying systems approach to the design situation. This is done in order to obtain understanding, but also to be able to identify the consequences and possible benefits of doing so. A literature survey and two extensive interviews have been performed. The material has been analysed, and tentative models of the design situation and its components are presented. These models can be considered general to the design situation and consequences are deduced from them. The result of this work is manifested in the tentative models, which describe the design situation, the designer, the user, the customer and the design. The concepts of complexity and communication have also been thoroughly dealt with.

Keywords: systems approach, design, information systems

Table of Content

1 Introduction

”It’s a new dawn, everybody! It’s a new dawn!” singer Grace Slick of the Jefferson Airplane cried during a rock concert in California back in the sixties. She did not address the same topics as in this paper, but her words can be applied in a wider context. Ever since the transitional works of Kenneth Boulding and Ludvig von Bertalanffy were made public in the forties and fifties, there is a new dawn and a new paradigm within the field of human science, the science of system science. Germana (2000) considers the whole and the main ideas of system science, stating that:

> *(...) the whole idea of systems science is to develop a scientific paradigm, superordinate to the special sciences, which bring their first order models into a higher-order synthesis.* (p. 312)

As an illustration he also cites von Bertalanffy stating the aim to develop “unifying principles running *vertically* through the universe of the individual sciences”, (von Bertalanffy, 1955, p. 8). System science is a field of science in its own right but also a way of relating to science and scientific activities.

Scientific work done today, or work in many other areas, often includes the use of and interacting with an information system. This means interacting with computers, or interacting with an interface, often a graphical user interface. A starting point for the considerations of this paper is a statement by Mullet & Sano (1995), saying that “all graphical user interfaces (GUI’s) are communication systems” (p. xi). They are interfaces between humans and interactive systems and we communicate with the system through the interface. This means that there are certain demands or claims that can be placed on the interface and on the system behind it. For an acceptable work result applications must be easy to navigate, and there should be no unnecessary effort or time spent conquering a work process that should evolve quite naturally. But still after years of research, people get stuck or lost when browsing through applications. “I’m lost in the interface space”, a friend told me on the phone.

One purpose of this work is to study the appropriateness and the consequences of applying systems thinking and systems approach on the design of information systems, on the design situation. This is done to possibly obtain an understanding of the communicative preconditions belonging to information systems and their interfaces. This means trying to find the intersection between systems thinking, design, the designer and the user by addressing design from a holistic and systems theoretical perspective. Could the designer, the design and the user be considered and studied from a holistic view and seen as parts of a system? If so, important concepts to consider are communication, control, abstraction, hierarchy, variety, emergence, and feedback. This also means identifying principles, commonalties and reusable knowledge that together with the psychological and cognitive aspects that could be used when designing information systems to be as close as possible to what could be considered optimal. This is seen from a user perspective, but it is also a matter for the whole particular information system and its extension to a more effective work situation for an increased output of the work done.

To get a comprehensive view of this, the background of this work focus on two areas, system science and design of information systems. In search of the designer-design-user system, there is also complexity to be dealt with. The complexity of different perspectives, due to the designer's view on the design process with decision-making and problem solving connected to it, and the user interaction and the decision-making and problem solving belonging to that particular interaction. There is also an intrinsic complexity within each of these subsystems as such.

The aim of this dissertation is to identify the appropriateness and the possible benefits of applying systems approach on the design of information systems and to identify the consequences from this. To do so there are three objectives identified, to characterise the design situation, to apply systems approach on the design situation and an analysis of the possible effects or consequences of doing so. Based on this aim and these objectives, this dissertation is a search for a possible connection between systems thinking and information systems design for the benefit of design and human interaction with information systems. It is a search for the preconditions for a good design.

1.1 Preview

The structure or the content of this dissertation will be as follows. In the second chapter, the background, the reader is introduced to the target areas and to important concepts within these. First the area of systems science will be accounted for together with systems theory, systems thinking, system design and the system approach. Important concepts, like system, decision making, cybernetics, abstraction and complexity, are presented to the reader for the benefit of increased understanding of the context of this work. The second part of the background will consider the area of design and human-computer interaction, where such concepts as the user, the designer and design are presented and accounted for. In chapter three the problem definition of this work will be presented and in chapter four possible methods to use will be presented. In chapter five, the materials, the performance and working process of this work will be presented. The materials chapter is a literature survey complemented with two extensive interviews in order to identify the nature of the design situation. A characterisation of the design situation is performed, systems approach is applied to the design situation and an analysis is made of the result of the work performed. The report ends with a result chapter and a brief discussion.

2 Background

An assumption that user interfaces can be regarded as communication systems, systems that transmit and transforms information, is a starting point of this dissertation. This background then considers the three-part-harmony of:

- the designer
- design
- the user

These concepts are studied from a perspective of systems science and systems thinking. In order to get a comprehensive view of this work with its presumption of a connection between system science and design, there are some initial concepts that need to be presented, and in this first part of the work they are accounted for. The system science aspects on the design process are to a large extent studied in van Gigch (1991). Van Gigch focuses on the design of organisations and information systems. One assumption or hypothesis of this work is that van Gigch's perspective on design and meta-design is general and also applicable to the process of a more concrete and practical design situation.

The reader should be aware of the fact that this dissertation focuses on two scientific areas. With the aim to combine two scientific disciplines there could evolve a reading situation where the necessity of reading depends on the reader's pre-knowledge. This could well be in line with Langefors' infological equation (Langefors, 1995), stating that communication and understanding depends on the pre-knowledge of the communicative parts. The reader familiar with the area of systems science or with information systems design, including aspects of human-computer interaction, could mainly focus their reading to the individually appropriate target area of the background material.

The two main areas of system science and information systems design, as presented in the following chapters, will be the basis for the understanding and the formulation of the problem definition of this dissertation.

2.1 Systems Science

A possible, but simple interpretation of the concept of system science claims that it is the field of scientific inquiry whose objects of study are systems, but Klir (1991) states that this is a useless definition unless the concept system is defined. Klir (1991) and Rosen (1986) make a close parallel between the concept of a system and the mathematical concept of a set, where S=(T, R). S is the system, T is a set of things within S and R is a relation defined on T. He exemplifies with a collection of books as a set, but when the books are organised in some way the collection becomes a system. A system is an organised set. The same set can play a role in different systems and the different relations of the set differentiate each system from the others. However complex a system may seem, some kind of organisation will always be found and such an organisation can be described by concepts and general laws independent of the actual domain.

According to Rosen (1986, in Klir (1991), system science is a science whose domain of inquiry consists of “systemhood” properties of systems and associated problems that come from the general notion of this. It means that the properties are independent of “thinghood”, or the set perspective of a system. The systemhood of system science differentiates it from classical thinghood oriented science and makes it disciplinary independent or a cross-disciplinary science.

Flood and Carson (1993) state that the field of systems science mainly concerns dealing with the complexity of our existence. Complexity can be considered an overall feature or property of society today, for instance when considering the field of information systems. Another important concept within systems science is *cybernetics*, the study of the control and communication in animal and machine (Wiener, 1964). Flood and Carson (1993) also state that system science is a way to deal with problem solving, planning and decision making, “to organise our thoughts and make sense of very complex issues” (Flood and Carson, p. 6). Today systems science can also be considered a meta-discipline and a meta-science to systems theory, cybernetics, systems approach, systems thinking etc. according to Xu (2000).

The founder of systems theory or systems science was the biologist Ludvig van Bertalanffy, who with the General Systems Theory state that homologies exist between scientific disciplines (Flood and Carson, 1993), meaning correspondence or sameness of relations. Bouldings (1956) version of General Systems Theory, a system of theoretical systems in a hierarchy of complexity, is another important early work.

Germana (2000) presents a short description of system science, claiming that its main idea is the notion of “ordered wholeness” or “organised complexity” (p. 311). It is a principle of organisation with a feedback to itself of the idea that “its organising principle and principle of organisation share a homological relationship” (p. 311).

The contribution of systems science to information systems is important due to the challenging nature of the information era. Systems concepts and principles are needed to deal with the complexity of the new ultra-large global communication systems (Xu, 2000).

2.2 Systems Theory

Within the field of science, systems theory can be considered a new discipline and according to van Gigch (1991), it was initiated in 1954 as an area of investigating concepts, methods and knowledge within the field of systems and systems thinking. System theory developed from a need for an alternative to the analytical-mechanistic approaches of the traditional science paradigm. It takes on a holistic approach to systems and searches for generality among different disciplines. It is a transdisciplinary study of abstract organisation. It also encourages the use of mathematical models and promotes the unification of the whole scientific field. According to Avison and Fitzgerald (1997), systems theory has had a widespread influence on information system work, suggesting that whatever methodology adapted, ”the system analyst ought to look at the organisation as a whole and also be aware of externalities beyond the obvious boundaries of the system” (p. 41). Systems theory also suggests that a multidisciplinary development team is more likely to understand the organisation and to suggest proper solutions to its problems.

Within the systems movement there is the conviction that the traditional scientific method has to be modified to satisfy the requirements of the social science domain. Traditional science, dealing with closed, separable and reducible systems in an analytic-mechanistic way, are no longer considered appropriate. System science has the view of open non-separable and irreducible biological-behavioural wholes (van Gigch, 1991). System theory has, as a part of systems science, evolved to become a basis for information systems when applied in information systems research. Due to research findings, system science concepts have continuously been adopted by the field of information systems (Xu, 2000).

2.2.1 System

Considering systems science and systems approach, the concept of a system is of utterly importance. A system is something that takes input and transforms it via throughput to an output. Flood and Carson (1991) gives the following short characterisation of a system:

- A system is an assembly of elements related in an organised whole.
- An element is a representation of some phenomena of the material or social world.
- A relationship concerns influence and control.
- Elements or relationships have attributes of quality or property.

Van Gigch (1991) has a similar view of a system, claiming that “a system is an assembly or set of related elements” (p. 30). These elements could be *concepts*, *objects* or *subjects* and a system could be made up of all of them. A system has subsystems and a superordinate system. Ackoff (1981) states that a system is a set of interdependent elements where the behaviour of each element has an effect on the whole. A system can not be divided into independent parts.

A system has a boundary and an important consideration is how and where to place this boundary, to make a proper or correct and useful limitation in relation to the environment. Avison and Fitzgerald (1997) state that

> *We define a boundary of a system when we describe it. This may not correspond to any physical or cultural division.* (p. 39)

A system is also a representation of levels in a hierarchical structure. The system and its subsystems can be understood by analysis when greater detail is needed. A holistic view is looking upon a system and its components as a whole, with the notion that a system cannot fully be understood without this view.

The core of system science is related to considering a system as something more than the simple sum of its parts and therefore also something that is greater than the sum of its parts. It deals with new emergent and complex properties. "A system is a set of elements standing in interaction"(von Bertalanffy, 1955, p. 9) in a way so that the characteristics of the whole system are not possible to explain or deduce from the characteristics of its isolated parts. The core of a system is considered by Germana (2000), p 312, and considered to be:

> *...the overall patterns or whole interrelationships which emerge from the ongoing interactions among its interdependent parts.*

O´Connor and McDermott (1997) have a similar perspective, when they claim that a system maintains itself through the *interaction* of its parts. They state that the relationships and the influences between the parts are of greater importance, rather than just the number or the size of the parts. According to them, there are two ways to look at a complex system. It could be something that have many different parts and something that has a dynamic complexity. This means that elements can relate to each other in many different ways. Each part can have several possible states, possibly represented in a state vector, whose parts can be combined in a huge amount of different ways. (x represents a state: $x = [x_1, x_2, x_3, \ldots x_n]$, where x_i (i = 1 to n). A sequence of states makes a state trajectory).

Understanding is not a matter of studying the number of possible and separate bits, but the many possible ways of combining them.

2.2.2 System Domains

Hard and soft systems

Considering real world phenomena or systems defined by human interaction, these systems are typically appreciated as poorly structured or “messy” and therefore system boundaries could be very hard to identify. In this perspective the term system could be divided in two different methodologies, systemic, which is about holistic thinking, and systematic which refers to a step-by-step procedure. These two concepts are exposed in literature as hard and soft system methodologies (Flood and Carson, 1993).

With a hard system, it is considered possible to get to know the structure of the system. The structure is the way elements can relate to each other, providing the supporting framework in which processes occur. Throughout the literature problems related to the concept of hard systems, systems related to traditional science, are dealt with or solved by *analytical* and *reductionist* thinking. See for instance Ackoff (1973), Flood and Carson (1993), van Gigch (1991).

Soft systems are difficult to comprehend through structure and they are also hard to quantify. It is possible and necessary to study them from different perspectives using contrasting or conflicting theories. According to Flood and Carson (1993), this means that a holistic view and inductive thinking is a necessity when interacting with problems within the soft system domain. Within the soft systems view, systems are living and undergo change when interacting with the environment (van Gigch, 1991). Soft systems thinking states the need for *induction* and *synthesis* within an informal reasoning process encouraging intuition and judgement. The weight of evidence comes from a few observations with a small chance of replication. Predictions are based on weaker evidence than explanations.

Open and closed systems

Flood (1990) defines a system as an abstract organising structure that could have many different interpretations, some of which connect systems to processes of the real world and others to processes of consciousness. He states that the main idea is of a whole characterised by interactive parts. A system could be viewed upon with systemic metaphors and, according to Flood (1990), there are a number of them, important for the development of system thinking. According to Flood and Carson (1993), an important characteristic of a system is that it has a feedback relationship with its environment, sharing input and output. A system also has a boundary and could be divided into closed and open systems. The importance of this difference is fundamental to systems theory (van Gigch, 1991).

Open systems exchange matter, energy or information with its environment. In van Gigch (1991) open systems are systems that has an environment, there are other systems relating to it, exchanging matter/energy and information with it and communicating with it. The final state of an open system may be reached from several different initial conditions due to the interaction with the environment. This is the property of equifinality. An open system is of a homeostatic nature and, according Flood and Carson (1993), self-regulating, survival and adaptability are important concepts.

Closed systems are systems that can be distinguished from their environment, that has no environment and no outside systems with which it interacts. The system and its surroundings are made up of and made clear by defining a boundary around the system. If this boundary is absolute and no external relationships exist, Flood and Carson (1993) consider this a theoretical construct of a closed system.

Living and non-living systems

A living system has biological and behavioural characteristics and in Miller (1995) the concept is defined. All living systems are concrete systems and they are also open systems with input, throughput and output. Living systems has subsystems and process matter, energy and information and are considered to comprise more than just a minimum of complexity.

Non-living systems are closed systems, but feedback could provide them with properties relating them to the equilibrium state of a living system. Closed systems that moves towards an equilibrium state depend on the systems initial conditions (van Gigch, 1991). If the initial conditions change, the closed systems final state changes and the system moves towards maximum entropy. Non-living systems with an appropriate feedback could also strive for equilibrium due to external constraints on the system. This could generate behaviour similar to that of a living system.

2.2.3 The Whole System

Van Gigch (1991) gives the following definition of what could be considered the whole system:

> *The whole system comprises all the systems deemed to affect or to be affected by the problem at hand, regardless of the formal organisation to which they belong. By exclusion, the environment is made up of all the systems not included in the whole system* (p. 44).

The whole system is then characterised by the following:

- A problem is defined in relation to superordinate systems
- The objectives are viewed in relation to larger systems or the whole system
- Optimum design involves planning, evaluation and implementation of new alternatives.

In a system hierarchy the system levels indicate what systems are embodied in other systems and are thus used for establishing system boundaries. Van Gigch (1991) makes the following distinction between the system levels:

- The Subsystem level is where each element of the total system operates with its own purpose and objectives.
- The Total system level is where the subsystems are aggregated into a single system working towards a common goal.
- The Whole system level is all the other systems that are affected by or affects the total system.

The Environment comprises of all systems over which a decision-maker does not exercise control.

2.3 Systems Thinking

Within system science, systems thinking can be considered a way of looking at reality. Its guiding principle says that it is not possible to understand the elements of a system until the whole, of which they are a part, is understood. According to Flood (1990), systems thinking is a term reserved for general discussions concerning any matter of systems without considering any position or rationality. The term in itself is neutral to this. The concept of systems thinking, according to Flood & Carson (1993), is connected to holism as considered within systems theory and formalised systems thinking leads to systems theory, helping to develop thinking and theory in other disciplines. It helps to promote management effectiveness and it improves the effectiveness of problem management. In a feedback loop all these promotes systems thinking. Flood and Carson (1993) also states that humans deal with complex situations in a piecemeal manner due to limited cognitive ability. We cannot perceive or process more than a certain amount of information at a time. There is also the need for holism in mans interaction with the world, since the outcomes of our behaviour rarely are what we expect due to our neglect of the nature of complexity. This implies that man needs systems thinking externalised in methodologies and methods to deal with the complexity of our reality. Analysis and decomposition cannot be used to understand systems (Ackoff, 1981). Systems are understood by synthesis and holism which is the basis for systems thinking and thus applied in the systems approach.

According to Flood and Carson (1993), the philosopher and systems thinker C. W. Churchman stated the need for ethics and morality in systems design. Churchman’s work was an important inspiration when P B Checkland founded the term Soft Systems Thinking. Related to the Soft System Thinking is Ackoff’s (1981) contribution of interactive planning and problem solving. P B Checkland redefined systems as an abstract organisation structure rather than a real world entity. Checkland has four concepts considered essential in systems thinking

(Flood and Carson, 1993). The concepts are *communication* and *control*, as identified in the field of cybernetics, *hierarchy*, the system represented in a hierarchical structure, and *emergence* or the emergent properties which means that the system as a whole consists of more than the sum of its parts. S. Beer created his Viable Systems Model as an evaluative or diagnostic tool for systems or organisations (Beer, 1994).

O´Connor & McDermott (1997) have a slightly different perspective to this concept. They have studied it from a feedback perspective and state that “Systems Thinking is thinking in loops rather than in straight lines” (p. 26) and that all parts of a system are connected directly or indirectly. A change in one part effects all other parts, and these parts return an effect back to the original part which respond to this new influence. The influence comes back to the original part in a modified way, it is making a loop, a feedback loop. Feedback is the output of a system re-entering as its input, or the return of information to influence the next step. Our experience is made up of feedback loops, the return of effects of actions influencing the system. “Thinking in terms of feedback is thinking in circles” (O´Connor & McDermott, 1997, p. 27). Related to systems thinking there are some important concepts presented in the following pages.

2.3.1 Methodologies

Man needs systems thinking externalised in methodologies and methods to deal with the complexity of our reality. System methodologies are *systematic* in the way a problem is taken care of and *systemic* when a holistic thinking is used, when dealing with the problem situation. A methodology follows the systemic or systematic guidelines that could be related to a certain philosophy. It has associated rules and sets a strategy for things to be done. Each problem solution has essential and different characteristics and needs an appropriate methodology for dealing with main difficulties (Flood and Carson, 1993).

One of the main objectives in hard system methodologies is to select an efficient mean to achieve the goals or objectives in the problem-solving situation. Soft system methodologies were developed due to insufficient means-end analysis within the existing hard system methodologies. An essential feature is backtracking and iteration and this methodology consist of both real world and systems thinking activities. The real world involves the people in the problem situations. Systems thinking include these people. Its main purpose is to handle the possible plurality of viewpoints and to generate a meaningful debate (Flood and Carson, 1993).

How could a system-based methodology relating to a certain problem context be identified? Flood and Carson (1993) state that if a holistic and unified analysis is made, it is clear that each methodology will help us to deal with some issues and not others. There is no universal methodology. A methodology appropriate to difficulties within the problem situation is to be chosen. But these are relative matters, so this is also in itself a problematic situation.

2.3.2 Cybernetics

Feedback is an important concept within systems thinking and it is also the most important mechanism within cybernetics. Cybernetics is a discipline focusing on how a system functions regardless of system type, and showing that the same basic principles work in all systems. The basic principle is self-regulation through feedback (Wiener, 1965). Feedback means that power can be controlled. Feedback is something that allows self-regulation and in 1948 Norbert Wiener, a professor of mathematics at MIT (Massachusetts Institute of Technology) published his book “Cybernetics, the science of communication and control in animal and machine”. This was a major contribution within the field of systems thinking.

According to Flood and Carson (1993), cybernetics deals with adaptation, regulation and control, and important concepts in doing so are:

- negative feedback
- positive feedback
- variety

Negative feedback is about control and ensures a stabilising effect within a system since the outcome of initial influence feeds back on itself. *Positive feedback* leads to unconstrained and unstable growth, structural changes and eventual collapse of

the system. Wiener (1964) claims that cybernetic control is control based on work done, not work intended, and this controlling mechanism is feedback.
Feedback is created from sensors that have a signalling function showing that something is done. This mechanism controls the tendency towards disorder (entropy) and changes the normal direction of entropy (disorder or disorganisation), and reaching a state of homeostasis (the state of dynamic equilibrium of a system maintained through negative feedback as long as this is stronger than the non-equilibrium state of positive feedback).

A systems *variety* is the set of all possible states within the system. When interacting with or controlling a system, it is most important that the controlling system has a variety equal or superior to the controlled system. The controller must be capable of mastering at least as many system-states as the system that is under control. Variety itself depends on the number of settings or values. Acquisition of control means coping with the systems variety as the controller is being able to match the actions of a system. This is Ashbys Law of Requisite Variety and according to van Gigch (1991) and Flood and Carson (1993) this law refers to the information processing capability of the controller of a system compared to the information within the system on which control is exercised. It is also referred to as a guideline in understanding a situation, or to better deal with it. In order to create a better design and to perform a better usage of a system, its variety has to be considered - the possible states the system is capable of exhibiting. To reach and maintain a viable design or use situation there is a need for a requisite variety according to the complex environment (the system). This is a complexity has to be carefully managed, according to van Gigch (1991) and Flood and Carson (1993).

Control and Communication

Communication is a precondition for feedback mechanisms and control is the result of negative feedback. This communication ability is important because of the need for an ongoing interaction within systems and between the designers and the users in information systems development (Xu, 2000). Communication is a unidirectional flow of material, information or energy within and between systems and Lübcke (1988) defines it as the transferring of information, divided in verbal and non-verbal communication. The latter a signal-system or instinct-based patterns of behaviour with a communicative function. There is also intentional communication where symbols are transferred between individuals or groups with the intention to communicate a message or something meaningful. The receiver's awareness or knowledge of this intention is crucial for the success of the communication process. Langefors' infological equation I=i (D, S, t) is an important finding displaying this.

Wiener (1964) claims that society is understandable only by the study of messages or information and the possibilities of transferring these, that society offers. As a visionary he also stated that the evolution of these messages and these means of information transfer between man and machine, machine and man and between machine and machine would take on a significant role in the future society.

Receiving and using information is the process of adjusting to the random event chain of environment and towards an effective or efficient way of life within the borders of these events. An effective life is a life with access to top quality information. Communication and control is then essential for human life (Wiener, 1964).

2.3.3 Learning

Learning in a cybernetic perspective could be considered a process related to negative and positive feedback. Langley (1996) states that learning could be viewed upon as "the improvement of a performance in some environment through the acquisition of knowledge resulting from experience in that environment" (p. 5). This means that learning is connected to thinking in feedback loops. We learn from experience by connecting cause and effect, but feedback, O´Connor and McDermott (1997) claims, is a circle and sometimes it takes time for something to travel round the circle and thereby making it harder to connect cause and effect. Learning from experience could then be biased or not happening. According to O´Connor and McDermott (1997), it makes more sense to think of causes as influencing factors rather than causes. In systems thinking it is the relationship between the elements that makes them a cause or an effect and that relationship depends on the total, overall structure of the system. The changing of the right element could make a big difference in a system, but this does not mean that the particular element was the cause of the perceived behaviour. It only means that changing it was the easiest way to change the structure of the system because of the implications of this change.

2.3.4 Abstraction

Abstraction is one of the fundamental ways that we as humans deal with complexity (Booch, 1997) and thus a central concept of systems thinking. Abstraction makes it possible to generalise and create systemic hierarchies to better understand and to penetrate the system at hand. Abstraction must not be confused with simplification or aggregation. Abstraction comes from the recognition of patterns or similarities in the real world and the decision to concentrate on these and to ignore the differences. Abstraction is highlighting some properties of a system while surpressing others. Good abstractions emphasise details that are significant when interacting with a system. Booch (1997) also defines abstraction as follows:

> *An abstraction denotes the essential characteristics of an object that distinguish it from all other kinds of objects and thus provide crisply defined conceptual boundaries, relative to the perspective of the viewer (p. 41).*

Van Gigch (1991) presents another characterisation of abstraction, stating that abstraction is:

- To *isolate* or separate certain characteristics from all others.
- Finding what is *common* within a group of objects.
- Finding the *general* and the universal
- The antithesis of analysis (synthesis)

Van Gigch (1991) also claims that the meta-perspective is a fruitful context when discussing abstraction. Abstraction is a stage-by-stage process and the level of abstraction is raised at each level. It raises the level of generality and attempts to reach and apprehend the universal on a meta-level. System science is a meta-discipline whose level of abstraction is above those of other disciplines.

When Booch (1997) writes about the role of abstraction he refers back to Millers chunking of information. This is due to our cognitive limitations as previously attended for. To organise and exploit our memory capacity we group phenomena together in “chunks”. Booch (1997) also refers to the words of Miller (1995) saying that by organising our stimulus input simultaneously into several dimensions and successively into a sequence of chunks, we manage to break the bottleneck of the information processes. This process is what we, according to Booch (1997), means with abstraction. When dealing with complexity or a complex system, we abstract from it. We cannot master a complex system, instead we generalise and create a model of the object we study.

2.3.5 Hierarchy

A concept related abstraction and systems thinking is hierarchy, helping to organise, to understand, to communicate and to learn about complexity. Considering hierarchy, van Gigch (1991) claims that:

1. A system is made up of other systems
2. A system always has a system comprising it

In hierarchy there is also a distinction between the interactions among subsystems and the interactions within subsystems. According to van Gigch (1991), components of decomposable systems can be considered independent. The principle of decomposability and hierarchical structures has in recent years been applied to program design and computer programming where structured design and modularity are important concepts. These modules should exhibit high cohesion and low coupling.

A set of abstractions often forms a hierarchy and by identifying these hierarchies we simplify our understanding of the problem. Booch (1997) defines hierarchy as a ranking or ordering of abstractions.

2.3.6 Emergence

When studying systems and their properties, emergence is an important concept. According to Flood and Carson (1993), emergence, or emergent properties, is not something that is law bound. It is a characterisation of a system, meaning that the whole of something is more than the sum of its parts. This means that emergence contributes to the complexity of a system because of the new properties, not found in the parts themselves, emerging when all the parts come together in a system. Related to the concept of emergence is synergy, describing the emergence of unexpected and interesting properties.

2.4 Systems Approach

When designing complex systems, systems approach (van Gigch, 1991), is a method of inquiry emphasising the whole system and its optimisation. Fundamental to systems approach is the refusal to study systems with their related problems without considering the relationships with the larger system in which they are contained. It is an integration of the analytic and the synthetic method. According to Ackoff (1981) there are three steps in the systems approach:

1. Identify a containing whole to the object that is to be explained.
2. Explain the behaviour or properties of the whole.
3. Explain the behaviour or properties of the object, regarding its roles and functions within the whole.

Systems approach is applied systems theory and systems design (as defined by van Gigch, 1991) and a way of comprehending or understanding something by looking at the whole, studying it as a “black box” with an input, a processing of throughput and an output. This can be combined with another level of abstraction, the system being studied as a “white box” with internal processes and elements. Systems approach could also be regarded as a methodology of design, a conceptual framework, a scientific method and a theory of organisation (van Gigch, 1991). Systems approach places the planner of a system in the role of a leader with creative, inventive and new ideas setting trends rather than following them. An important consideration within systems design and systems approach is that "systems must be planned; they cannot just be allowed to happen" (van Gigch, 1991, p. 62). According to van Gigch (1991) there are other important matters within systems approach, for instance:

- To find the relatedness of methods of solution in order to extend their possible application, and to facilitate understanding of new phenomena.
- To seek the overall effectiveness and not a local optimum. To deal with the problem of suboptimisations
- To deal with the need for generalisations, to foster a broader perspective.
- Understanding and dealing with complexity.
- Clarify the integration perspective that all subsystems work together towards the total systems objectives.
- Evaluation and using different measuring strategies depending on the variables that are being considered.
- Expose the need for planning and control by self-regulation to ensure that the system moves in an appropriate direction (cybernetics).

"The systems approach integrates the analytic and the synthetic method, encompassing both holism and reductionism". These words could be found on the Principia Cybetnetica Web (1998) and they are well in line with Langefors (1995) stressing the importance of changing perspectives when dealing with a problematic and complex situation. This means viewing a situation from a local and global perspective interchangeably. The systems approach considers systems as structured hierarchically, consisting of different levels with an expanding abstraction at higher levels. A system can not be fully understood at the lower levels. Each level in the hierarchy has its own laws, which cannot be derived from the lower levels (Principa Cybernetica Web, 1998).

2.4.1 Decision Making

According to van Gigch (1991), system approach is a decision-making process for modelling and designing systems, and a thinking process, which pervades all problem-solving activities. Van Gigch (1991) considers decision making a conversion process where the inquiring system takes inputs in the form of evidence and information and converts this into an output in the form of decisions or solutions.

Within limited space and time, the process of conscious decision making can be reduced to four main steps, according to Barsalou (1999):

- identification of alternatives
- estimation of probabilities for different consequences
- estimation of the value or utility of the consequences
- integration of the probabilities and the values for finding the most suitable or best alternative

Barsalou's (1999) theories concern classical decision making, which considers the satisfiesing and/or optimisation of a phenomenon. O´Connor and McDermott (1997), on the other hand, claim that there is a learning process involved in decision-making, a changing of our selves with feedback from our actions. Learning creates and recreates our mental models and it is one of the most basic feedback loops in living. Experience results from actions and decisions are based on results leading to other actions. This is an unconscious decision making with what can be considered a craftsmanship perspective towards design.

According to van Gigch (1991), decision-making is considered an iterative cycle, taking place in the context of an inquiring system. The process of choice consists of selecting the best alternative among those available. If the alternative is implemented it leads to an output or a result. According to van Gigch (1991), the epistemology of an inquiring system in which decision-making takes place consists of the following:

1. Values, morality and worldviews held by the problem owners.
2. Rationalities and metarationalities (the extension to the level above or beyond the actual problem).
3. Reasoning methods and logic, to satisfy needs, means-end chain and the limit of the mind.

4. Premises and assumptions manifested in the search for consensus and the different points of views and worldviews.
5. Cognitive styles, the individual minds in a scale from analytical to heuristic.

Within decision making there are also trade-offs, the decrease in one part of a system as a cost for increase in another part. The optimal solution is not absolute, rather a negotiated compromise and the study of trade-offs must, according to van Gigch (1991), be formalised to provide decision-makers with appropriate recommendations on the alternative to chose. There are also false trade-offs that promotes partial improvements or optimisations. These are suboptimisations and the systems approach aims to improve more than just the subsystems, even though all of them may be desirable or commendable. These must be integrated towards meeting the overall objectives of the larger system. Together with the aim of optimal solutions van Gigch (1991) also has a pragmatic view of the subject, stating:

> *To have a solution that is optimum but not feasible is meaningless. Suboptimisations are both necessary and inevitable* (p. 146)

The necessary and good suboptimisations can be found by letting lower-system criteria agree with higher system criteria, and by pareto optimality (increase of utility in one part should not decrease utility in another). Considering the scope of the system and the suboptimisations that satisfies the requirements of systems approach are other ways (van Gigch, 1991).

Summary of Systems Science

The field of systems science is in one way a rather fuzzy domain. Depending on the source, when studying the subject, there are definitions to be found not always unanimous. As a summary, though, the following could be summarised from the material.

System science can be considered a scientific approach, related to many traditional disciplines from mathematics, technology and biology to philosophy and social sciences, and dealing with “systemhood” properties and the complexity of systems. It is also considered a meta-theory comprising systems theory, systems thinking and systems approach.

Systems theory takes a holistic approach to different disciplines searching for generalities and common principles in complex entities. It is a reaction against reductionism in searching for the unity of science dealing with open systems and wholes.

Systems thinking is a way of looking at reality stating that in order to understand the elements and relations within a system, the system as a whole must first be understood. Everything is connected to everything and feedback, emergence and ethics are important concepts to consider. A change somewhere in the system has an effect on the whole system.

Systems approach is a method of inquiry, a way of dealing with systems as wholes and the optimisation of the whole system. It is a search for relatedness and generalisations by changing perspectives between the holistic and the reductionist view, seeing the system in both large and small. According to Ackoff (1981) it is a tree step procedure.

2.5 System Design

A focus of this dissertation is the design situation conceptualised as a system. System design can also be considered on a more general level, a meta-level. According to van Gigch (1991), system design is an essential part of the systems approach, a creative process and a methodology of design. System design questions the assumptions on which old systems are built, together with the systems role in the context of the larger system. It takes a holistic perspective including induction, synthesis and optimisation of the whole system. Systems design deals with the difference between the actual design of a system and the optimum design with a focus on future results (van Gigch, 1991). The most important question is about the very purpose of existing for the system. This requires an understanding of the systems external relationships. According to van

Gigch (1991), the systems design process concerns the whole of a system, and induction and synthesis are the mental tools used.

Booch (1997) presents a more pragmatic view, stating that the meaning of design is to invent a solution to a certain problem and that the purpose of design is to construct a system that:

- *Satisfies a given functional specification*
- *Conforms to limitations of the target medium*
- *Meets implicit or explicit requirements on performance and resource usage*
- *Satisfies implicit or explicit design criteria*
- *Satisfies restrictions on the design process itself* (Booch, 1997, p. 22)

Van Gigch (1991) claims that systems design is a method of inquiry into the problems of soft system domains and an ongoing (continuos), cybernetic (displays feedback) and fluid (hard to define) process. System design is divided into three steps or phases:

1. *Policy making* (the preplanning phase), where an agreement of the problem takes place. The decision-makers worldview is considered and the agreement is based on the present knowledge and information. Goals are set and expected results are agreed upon and a search for alternatives is begun.
2. The *evaluation phase* identifies the outcome of the alternatives with their attributes and criteria. Agreement on decision models and methods are set.
3. In the *action-implementation phase* the chosen design is implemented with considerations of optimisation, suboptimisations, complexity, conflicts, control and results.

The essence of systems design, the questioning of the assumptions on which the existing systems are created, makes it essential to study the process from a meta-level. This means studying the design process that produces the modelling of the system. According to van Gigch (1991), the meta-system design consists of three levels:

1. Reality
2. Modelling
3. Metamodelling

Reality concerns the nature of reality. The choice between paradigms, the adoption and acquisition of knowledge and meaning by taking the problem through the different levels of different knowledge models.

Modelling is a recursive decision-making process in which the reality is modelled and where the problem is defined, the chosen model is applied and the problem is solved.

The *metamodelling* phase is important since neglect could lead to system failures. In this phase the epistemology of the inquiring system is determined (See chapter 2.4.1). The first subphase involves identifying the global system, the whole system, the total system and the subsystems. Different inquiring systems may be appropriate and the epistemology of each must be investigated. Problems need to be identified on each level of recursion. The rationalities and meta-rationalities must be identified. Rationality is considered synonymous with reason, motive, cause or justification for a particular behaviour. Behaviour and decision-making are considered rational when consistent and justified by the rationalities.

2.5.1 Complexity

As this work considers the design situation as a system, a designer-design-user system with significant human interaction, there are different levels of complexity to be considered. Van Gigch (1991) states that complexity is a result from human interacting with a system, depending on the interface between the human and the system.

Flood (1990) defines complexity as a concept referring to the basic components of systems existing in the real world. It features the elements, the interconnected relations and the attributes of these, together with the systems behaviour arising due to the relationships of the system. Flood and Carson (1993) states that: “we associate complexity with anything we find difficult to understand” (p. 24), and that in a complex situation there are two things involved, people and things (or artefacts or objects that can be seen or touched). “Complexity is a quality of things and of the appreciation that people have of things” (Flood and Carson, 1993, p. 25). Complexity is defined with material from Klir (1991), stating that:

1. Complexity has many varied and interrelated parts, patterns or elements and is hard to understand fully.
2. Complexity features an involvement of many parts, aspects, details, notions and necessities studying or examination to be understood or coped with.

According to Flood and Carson (1993), complexity is something that possibly could be understood by studying the number of elements and the number of relationships between the elements. When studying complexity and relating it to people and consciousness, there are also psychological factors to be considered, factors such as notion, perceptions, interests and capabilities, together with cultural and political factors. Equally important as the number of parts and relationships are the attributes or properties of these. A complex system has the following properties, according to Flood and Carson (1993):

1. A large number of parts and interactions.
2. Significant interactions.
3. The system exhibits nonlinearity, which means that different starting points could lead to different end points.
4. Asymmetry within the system.
5. There are nonholonomic constraints on the system, which considers laws of wholeness, situations when parts of the system moves away from central control.

Other aspects on the concept of complexity are the classifications of complexity identified and accounted for by Warren Weaver. Flood and Carson (1993) and van Gigch (1991) present and explain Weaver’s three ranges of complexity and these ranges or classifications of complexity can be comprehended as follows:

- *Organised simplicity*, the least complex categorisation concerning non-living systems. This type of complexity originates from element interaction in systems of more than three components and it could contain either a small number of significant factors or a large number of insignificant factors.
- *Unorganised or disorganised complexity*, also concerns non-living systems. The properties of these systems are defined in terms of statistics or probability. In these systems there are many variables that exhibit a high level of random behaviour.
- *Organised complexity* is a complexity found in living systems and characterised by following:
  1. There are only a finite number of components.
  2. There is a limit in breaking down the system into its components. The limit is ”irreducible wholes or units”.
  3. The total system has properties of its own, which means that the whole system represents more than the sum of its parts.

However, these ”ranges of complexity” does not fully cover what could be found in social sciences. Flood and Carson (1993) broadens the characterisations of complexity by including Peter Checklands *People range.* This is a complexity range characterised by the fact that every situation is seen from a certain perspective and could be considered relativistic since it is appreciated differently by different people. Complexity grows when there are different perspectives on a phenomenon. When the complexity depends of human interacting with the system there are also subjective and objective aspects on complexity. The objective aspect concerns systems that could be studied explicitly and the subjective aspect is the behavioural aspect, depending on the perspective or worldview of the interacting persons.

The complexity of the designer, design and user situation is characterised by both the people and things and the people-consciousness perspectives, together with psychological or cognitive aspects. The different interpretations and experiences within a situation constitute the complexity involved. The designer, design and user situation could be considered belonging to the complexity ranges of organised complexity and the people range as being relative to the person experiencing the system or the complexity of it.

Van Gigch (1991) addresses the managing of complexity and the fact that that human beings has a tendency to decompose systems. This could be dangerous, since meaningful functional relationships between parts of the system then could be lost. This is called the pitfall of reductionism. There is a human need to simplify without losing the power of generality or prediction possibilities, but systems are not made more understandable by excluding complexity.

In complex systems with the characterisation of organised complexity, the system could be measured by the number of entities or by the number of interrelationships among the parts. Another way of measuring complexity is through the information-need required to reduce or to eliminate the uncertainty present in a complex system (van Gigch, 1991). Klir (1991) refers to the information need when dealing with a complex system. He refers two general principles of system complexity:

- First general principle: the complexity of a system should be proportional to the amount of information recognised to describe the system. This is a descriptive complexity where information is used in a syntactic sense. (ex: number of entities and relationships).
- Second general principle: the system complexity should be proportional to the amount of information needed resolve any uncertainty associated with the system involved. The amount of information needed to understand a phenomenon determines its degree of complexity. The more information needed, the greater complexity perceived.

These two principles covers the things-people-consciousness perspective on the complexity of a system, making it possible to understand the complexity through the systems entities, relations and the information need.

2.6 Information system

The focus of this work is the design situation when designing interactive information systems. An information system can be considered a system for collecting, manipulating, storing, transferring and presentation of information (Andersen, 1994). With a semantic perspective to the subject an information system consists of two parts, *information* and a *system*. The concept of a system is addressed earlier in this chapter, and information is data processed by an interpretation process and is unique for each person or human being. Langefors (1995) made an important contribution to this with his infological equation, stating that in order to communicate there has to be mutual information within the communicating parts. The infological equation, I=i(D,S,t), states that information (I) is the product of an interpretation process (i), including data (D), a person's total preknowledge (S) and a period of time (t) to process the data. There must be an information intersection between the communicating parts, making communication possible and meaningful.

Avison and Fitzgerald (1997) claim that "an information system in an organisation provides facts useful to its members and clients which should help it operate effectively" (p. 1). Thus, an information system makes it possible to control the environment, not only to react on it.

An information system can also be defined in terms of two perspectives relating to *function* or to *structure* (Xu, 2000). From a functional perspective an information system is a technologically implemented system for recording, storing and distributing data or information. From a structural perspective an information system is a collection of data, models, processes, technology and people, all forming a structure that serves a certain purpose. In information system development it is necessary to consider an information system as a socio-technical system (Xu, 2000), and to use different technologies covering the different socio-technical interactions. Avison and Fitzgerald (1997) have a similar perspective, saying that information systems concern people as well as technology. The interactions between them are such that in these human systems it is important perceiving the whole system, since they are less predictable due to human beings.

Avison and Fitzgerald (1997) claim that it is easy to understand and model data and processes, but to fully understand an organisation it is essential to include people in the model, and thus the complexity has increased.

An information system does not have to include a computerised part, but the focus of this report is on *computerised information systems*, where data can be processed to provide information at the proper level of detail for some specific purpose. The interaction between a computerised system and the human part of the system takes place through the user interface of the computer system.

According to Xu (2000), the development of a complete theory of information systems as a whole, is an important goal in systems science and information systems research. It requires well-founded concepts and modelling methods for different types of knowledge and the systematic procedure of systems theory, which could include mathematical models, that help the modeller structure the thoughts and to achieve precision in analysis and synthesis.

2.7 Information Systems Design and Human-Computer Interaction

When studying design of interactive information systems, and the design of computer applications and their interfaces, human-computer interaction is an important consideration. HCI or human-computer interaction is a scientific discipline within the field of computer science. Löwgren (1993) defines it as “a discipline concerned with the development of interactive systems for human use” (p. 13). This includes related activities such as design, implementation and evaluation.

According to Löwgren (1993), there are two levels of an interactive system: the system *services* and the user *interface*. Both of these must be seen from a user perspective, since services may not be identical to the functions of the system. The interface is what makes the services available to the user. The services of a system determine what can be done with it and how well it is going to work. The interface determines how this can be done, determining the usability of the system. Mandel (1997) states that the best designed interface is the one that let users “do what they want to do, when they want to do it and how they want to do it” (p. xi) without thinking explicitly on the interface.

Löwgren (1993), Mandel (1995) and Andersen (1995) among others stress the importance of letting the user play a significant role in the development process in order to enhance a motivation and a learning process within the design and usage of information systems. Pourdehnad and Robinson (2000) also consider this perspective, stating that it is a question of improving the financial returns and the competitive advantage, depending on customer, or user, satisfaction. A greater customer satisfaction can only be obtained by increasing the knowledge and understanding of the customers needs and requirements. It is important to understand these needs and requirements together with the interactions between them and the factors creating them.

2.7.1 The User

There is no single or particular user, this means that the general user does not exist. There are a lot of different users, just as there are no typical person. No one is the average person. All users are individual with their own worldviews and abilities. A workplace consists of individuals or users in what can be considered as a small society (Löwgren, 1993). In this society, or in this system, the users can be considered as subsystems and there are all kinds of interactions influencing the work situation. It is important that the designer considers this and does not take himself or herself (the designer) as an example of a user. This is clarified by Langefors' infological equation (Langefors, 1995).

When a user interacts with an information system, established research within cognitive science states that recall is easier than recognition and that pictures are better remembered than words (Löwgren, 1993). To select the proper actions the user has to see the available alternatives and when evaluating the outcome, the user must perceive what has happened. Perception is an important concept when interacting with an interface. In the field of perception, gestalt effects are an important topic. Humans are good at perceiving patterns, which, according to (Löwgren, 1993), comes from our concept-based processing. Considering user interfaces the perception of a pattern means that the user expects that entities grouped together must be logically related in some way. In spite of other possible techniques, our vision is still an important subject. Humans have a wide field of vision but it is only in the centre that we see things clearly. We also seem to have certain colour interpretations innate in our perception system. There are also cultural aspects on colour use to be considered in design (Mullet and Sano, 1995).

2.7.2 The Designer

For a designer, a general knowledge about user complements the study of specific situations, but it does not replace it. The designer must cover a larger area of the situation than the user. Ashby's Law of Requisite Variety (Flood and Carson, 1993) states that the designer must be capable of dealing with at least as many system states, preferably more, as the user in order to master the situation.

It is important that the designer understands the user (Löwgren, 1993) and to do so usability engineering can be performed. This is achieved by analysing the users, their tasks by doing a user task and then analysing it to find out needed user skills and computer experience, and their needs. Based on this analysis, usability goals are formulated and tested. The designer then makes a hierarchical decomposition of tasks, objects and the different roles in the workplace. The relations are that a role has tasks, which affects domain objects. The designer then has to find the best possible *trade-off* between all the requirements, constraints and needs in the workplace.

The importance of a user perspective is apparent in the material, determining how well the system services will be performed. This also has a significant financial influence. The fact that there is no general user is stated in Langefors (1995). Cognitive and cultural aspects on the user are also important as is the designer's preknowledge, variety and mastering of the user and the design situation, a situation characterised by a continuous process of change.

2.8 Design

According to Löwgren (1993), essential knowledge when designing a system is knowledge about the user and the user domain, the system services and the usability goals that must be met. The tools and materials of design also have to be known, that is the elements and the design options on various levels. Löwgren (1993) mentions six levels:

- System services, identifying objects and tasks that the system should support.
- Conceptual models for understanding the system on a general level with the use of different modelling types or techniques. Metaphors are very useful as the system acts as a conversation or a communication partner. The use of metaphors takes advantage of the users previous knowledge.
- The dialog structure is due to conversational aspects on the system. For every user action there should be some sort of feedback.
- Interaction techniques, techniques used when the user is carrying out the tasks by manipulating the interface objects or interacting with a menu tree.

- Graphic design
- Input/output, the hardware through which the user and the application interact.

Consistency is important within a system and in design, meaning that the same thing should be done in the same way in similar situations. A system has different interaction modes if the same action means different things in different contexts. Design is a trade off between conflicting goals, different criteria and principles (Löwgren (1993). According to Mandel (1997), "the system must adapt to the user" (p. 46).

Poltrock and Grudin (1995) points to four other principles essential to the design process:

- Early focus on users. Designers should have a direct communication from the start with the actual or intended users, to understand cognitive and behavioural characteristics and the actual work that is to be done.
- Early-and continual-user testing. An empirical approach, requiring observation and measurements of user behaviour, evaluation of feedback is the only feasible solution.
- Iterative design. The modifications of a system under development have to be based on results from behavioural tests during the project.
- Integrated design. All aspects of usability should evolve in parallel rather than sequentially.

Design must be an integral part of the development lifecycle. From an initial understanding of the problem, based on background research, followed by an iterative cycle of development and evaluation, the best design solution is found. The designer is a planner and a co-ordinator, but not an artist. This does not mean that aesthetics is of no importance. The designer is more of a craftsman and the design is valued for its fitness to a particular user and task and is always related to the intended *function* of the product. Design is concerned with finding the representation best suited to the communication of some specific information. The end result is a functioning system with a trade-off between functional and aesthetic criteria and concerns. But functional and aesthetic criteria also include symbiotic components with synergy effects emerging from high quality design (Mullet and Sano, 1995).

Löwgren (1993) does not consider design as an engineering activity where the goal of the design process is to find one specific single solution. With another approach a new design emerges from several alternatives. If a designer comes up with alternatives it is easier to discuss them and the discussion could then focus on the advantages and disadvantages of the proposed design. There is, according to Löwgren (1993), an obvious need for a meta-design perspective.

2.8.1 Gestalt Theory

Important concepts or tools in design are the theories of perceptual organisation or the psychology of perception, founded by the Gestalt school in Germany (Mullet and Sano, 1995). The gestalt laws are general psychological aspects or theories on how we as humans perceive phenomena, may it be an object, an interface or a system. This means that the theories and ideas of the Gestalt school are by no means limited to this movement. Its main is ideas and basic principles are also influencing and found within the systems movement. Gestalt theory is a holistic movement in psychology with its origin in the German Gestalt school around 1910-1920. *Gestalt* means "an organised whole whose parts belong together" (Klir, 1991, p. 25). Klir also cites one of its founders, Max Wertheimer:

> *The fundamental formula of Gestalt theory might be expressed in this way. There are wholes, the behaviour of which is not determined by that of their individual elements, but where the part-processes are themselves determined by the intrinsic nature of the whole. It is the hope of Gestalt theory to determine the nature of such wholes.* (Wertheimer (1923) in Klir (1999) p. 25).

In a similar way *gestalt* is defined by Flood (1990) as an organised coherent whole, whose parts are determined by the laws of the whole, also stating that gestalt means that what is seen is what appears to be seen, not what actually may be perceived.

Summary

Applications, utilities, programming languages and operating systems are all parts of an information system that must communicate with the user. The user interface is a communication system and a critical factor in that communication. Other important considerations within human-computer interaction are the system services, conceptual models of the system, dialogue structure, interaction techniques, graphic design and the hardware. A well-designed information system creates a vehicle that should simplify and render more efficiency to the user work and the output of the human-computer interaction.

3 Problem Definition

Users communicate with information systems by the interface. Certain demands or claims need to be placed on the interface and on the information system behind the interface. Interactive information systems must be easy to comprehend and to navigate through. There should be no unnecessary effort or time spent conquering a work process that should develop naturally. Still after years of research, there are problems and users fail and gets lost when browsing through applications within information systems. The purpose of this dissertation is to analyse the possibility and the consequences of applying systems thinking and systems approach on the design of information systems, on the area of design (the designer), use (the user) and the design. This is done to find the preconditions for and the possible considerations needed to master the design situation for future benefits.

3.1 Problem presentation

Information, as a fundamental aspect of communication, is considered in Langefors (1995). In Langefors' infological equation, I=i(D, S, t), it is stated that for two or more individuals to be able to perceive the same problem or representation in a way that makes communication possible, the involved parties has to have essential information in common to be able to communicate. Given pure data, background knowledge and a period of time to process the data, the information gained must include a match between two communicative parties. There must be an information intersection of a certain amount, making communication possible and meaningful.

Within information systems design and human-computer interaction, this means that there must exist information or knowledge that is shared by both the user and the designer. This creates a triad of the user, the designer and the design that within itself must carry a general intersection needed to be applied in applications and information systems. This also makes the user a necessary and not only a desirable communication and development partner in the process of designing information systems.

Considering the vast amount of research on human computer interaction and on design, the amount of designers and people involved in developing software products and the even larger amount of users interacting with information systems, there is a need for a complementary focus on design. The perceptually grounded approach to design of user interfaces is not enough, since users still run into problems when interacting with information systems. “Humans do make mistakes, but with proper design, the incidence of error and its effects can be minimised” (Norman, 1990, p. ix). We need to find the conditions for the design situation.

This complementary perspective should be considered together with the cognitive aspects of human-computer interaction. In order to achieve this, a holistic view on the designer-design-user triad is adopted and the question is asked weather something can be gained or achieved by considering this threesome as a system as perceived within the field of system science. Fundamental are the consequences or implications that possibly can be deduced from of this perspective.

3.2 The Problem

The aim of this dissertation is to identify the appropriateness and adequateness of applying systems thinking and systems approach on the design process, together with identifying and analysing the possible consequences emerging. Criteria for estimating appropriateness and effects will be specified and three objectives have been identified:

1. To create a characterisation of the design situation.
2. Apply systems approach to the design situation.
3. To analyse the effects and consequences from applying systems approach on the design situation.

The first objective considers a characterisation of the design situation with a focus towards information systems. This means to find and to exhibit the complexity of the situation and the dynamic relationships involved. The second objective is to apply a systems approach to the design situation, to define the design situation as a system and to study the components of that system. Doing so it is necessary to apply a holistic view when identifying the system boundaries together with the systems hierarchies. The third objective is to find and analyse the interesting effects and consequences of applying systems approach to the design situation.

3.2.1 Focus

This dissertation does not directly address the whole of an information system. It considers its origin, the design situation with a focus on the user, the design and the designer of the information system. This is a consideration that, as stated earlier in this report, is related to and developed from the notion of the interface as a communication system.

The interface is what a user actually interacts with and interface design is an element of a larger context, the design of the information system behind the interface. This perspective is central to this work and sets the frames and a system boundary to the work. According to this author, the design situation prior to developing an information system determines the preconditions for a successful development of interactive information systems.

4 Methods

A scientific dissertation could comprise several different techniques or methods for collecting and retrieving information regarding a specific problem space. This chapter deals with the possible and sufficient methods to use in order to address the actual problem of this work and to achieve its aims and objectives. To reach a decision on the appropriate methods, the aims and objectives of the work, as presented in the previous chapter, has to be put into focus. The aim is to identify the appropriateness and adequateness of applying systems approach on the design situation and to find criteria for such a possibility. The possible and interesting effects or consequences of this approach are also considered.

4.1 Selection of methods

Considering the aim and the objectives of this work, a characterisation of the design situation, possible methods are a written inquiry, a literature survey and interviews. For the first objective, a standardised inquiry is possible but of lesser interest since the characterisation of the design process is not the explicit goal or objective of this work, but a partial one. To characterise the design situation means obtaining exiting knowledge and experiences from an existing situation. To obtain a holistic view and a wider perspective on the characterisation of the design situation the interview and the literature survey can be considered sufficient and complementary, due to the methods different levels of abstraction.

According to Patel and Davidsson (1994), the interview is a proper solution to obtain information and to complement lack of written information within a problem area. This will be a necessary choice of method, since material focusing on both systems thinking and design within human-computer interaction can be hard to come by. The interview is also a method preferred to a written inquiry, since it is a wider communicative form including gestures and implicit cues making way for follow-up questions. On the negative side there is problem of generality with only one or a few interviews (Patel and Davidsson, 1994).

According to Dawson (2000), a literature survey consists of two parts, the search for relevant information and the review of the same. It is a systematic gathering of published information including material from the Internet. Important is a critical attitude towards the material and their sources. Dawson (2000) presents some points that need to be considered in the process. What kind of article is it? Is the author well recognised? Are the arguments logical? Is it possible to differentiate opinions from facts? Does the article support or contradict your material? What are the references? These questions need to be implicitly present when studying the material. A literature survey is a suitable selection of method when studying systems thinking, or systems science, and when studying information systems design including human computer interaction. Both areas are well covered in scientific literature. The aim and the problem definition of this work are not to be overlooked. It is important to keep that in focus in order to stay within the boundaries of the system of this work.

The objectives and the areas of concern imply that existing knowledge is to be studied and used. But when combining the two main areas of this work there is a probability that not much work will be found and thus interviews is an obvious alternative choice. The aim to explore a unified focus of systems thinking and design within human-computer interaction or information systems design, finding commonalties and a fruitful and rich synthesis between systems approach and the design situation, promotes the use of both the literature survey and interviews as methods of this work. An important consideration in combining these two methods, is the limited generality of only a few interviews and the high generality of the literature survey, due to a higher level of abstraction.

5 Materials

System science has an important impact on information systems research, which Xu (2000) considers from a global perspective. Important for this work is the possible usage of systems science as an ongoing process, considering the challenging nature of information and the complexity of designing, constructing and managing new global communication networks of the 21st century. According to Xu (2000), system science has become a necessity. Upon having a global perspective on the subject of information systems, there is also a local perspective. The global system is an aggregation of all the local systems contained. To get a comprehensive view of information systems, systems approach can then be applied by changing perspectives between global and local views. The local view is of the subsystems, such as the designer-design-user system or the design situation of this system. The global view can comprise the development of an information system.

In order to get a comprehensive view of the design situation, its content, components and ingredients, materials have been searched for and gathered from two different types of sources. The selected methods used to reach the objectives of this work are a literature survey and extensive interviews.

This dissertation is a theoretical work with an empirical part, with a focus on the design situation. In order to study this there are the aims and the objectives from the problem definition to consider:

1. Create a characterisation of the design situation.
2. To apply systems approach to the design situation.
3. Finding and analysing the effects and consequences of applying systems approach.

5.1 A Characterisation of The Design Situation

5.1.1 Literature

A literature survey is performed to find and to retrieve material that should be considered when characterising the design situation. The literature survey that has been performed covers books and articles within the areas of systems thinking and information system design with human-computer interaction. There are three types of literary material focused upon:

- Material on design from selected books on systems science.
- Material on design from selected books on human-computer interaction and information systems design.
- Selected scientific articles on system science and design of information systems.
- Web-sites of established scientific magazines.

Unfortunately no material was found when performing a unified search explicitly on human-computer interaction and systems science. Databases like Elsevier, accessible on the library of Högskolan i Skövde was used. When doing a web search on this unified search with the help of Netscape and Google search engines, some material was found. Due to scientific unreliability of this material only some general material were used.

The presentation of this survey considers the materials that can be applied to or refer to the design situation. When doing a literature survey on the concept of the design situation there are first some general basic concepts concerning the design situation presented, material considered general in most of the literature.

When some specific area of concern is studied it is important to identify the correct level of abstraction or the system boundary of what is approached. The system at hand has to be identified. Another foundation and a basic concept of this work is the concept of design itself, present in every possible perspective in this work. When considering design, the meta-design level is crucial (van Gigch, 1991) in creating a framework for the design situation.

5.1.1.1 System Identification

To be able to relate to a system or to approach it in a scientific way the system under study must be identified. This means determining what the system is, its boundary and environment. The environment being made up of all systems not included in the whole system (van Gigch, 1993). According to Flood and Carson (1993), there are two approaches to this, the structural approach vs. the behavioural:

- Identify and define the significant units of the system and their interactions. This is related to the hard systems reasoning with a structural perspective to of the system, where the elements and interactions are assumed in advance.
- With the behavioural approach a specific type of interaction is chosen and used for identifying the system. The outcome is then a behavioural system.

To get a comprehensive view of the design situation both *structural* and *behavioural* aspects of the design situation will be considered in the material.

When the first step of system identification is done, the choice between the structural or the behavioural approach, there are four heuristics in the form of questions that could be used (Flood and Carson, 1993):

1. Be suspicious of obvious boundaries.
2. Is the potential component connected to the system? How strong is the connection?
3. Does the potential component contribute to goal-fulfilment?
4. Can the system control the possible component?

An information system can be considered as being made up of two parts, a system and of people. According to Flood (1990), the concept of a "system" comes from the natural sciences and "people" from social sciences. These concepts can be referred to as either an organisation or to consciousness. If such a system is of the real world a methodology for system identification is needed. If a system is something out of consciousness, the abstract notion of a system is needed to organise the thoughts and to develop something meaningful. We also need methodologies to encourage participation, the representation of viewpoints and different visions, and to deal with the difference between possible interpretations (Flood, 1990).

Flood and Carson (1993) claim that the complexity of a system is "in the eye of the beholder" and thereby depends or is relative to the person interacting with the system. Complexity is something related to people and things. The complexity of computer interaction depends to a large extent on mans limited cognitive abilities, and a good designed user interface helps the users through the presence of affordances and cues (Norman, 1990). Other important aspects of complexity are that people's actions can not be considered without bringing into account the effect things (computers) have on their actions (Flood and Carson, 1993).

From the perspective of Löwgren (1993), the user interfaces, the system services and system functions together constitute a system. The subsystems are related to each other in a way that the user interface provides access to the services and the system functions realise the services as perceived by the actual user. These services are crucial in determining how well the system meets the user requirements.

> *If the services are wrong, the system is wrong. If the services are right the user interface must be designed to enable the users to use the services optimally* (Löwgren, 1993, p. 15).

5.1.1.2 Design In General

Design is an evolving matter. When the design process is started, problems are identified and design is continuously modified. There is a continuous testing, re-testing and re-modification "until time, energy or the resources run out" (Norman, 1990, p. 142). This natural design process is well characterised by the work of craftsmen producing hand made artefacts. Over time, the process should result in a functional and pleasing product. Improvements take place through natural evolution with each previous design considered. Bad features of design are modified and good features are kept in a process of hill-climbing heuristics (Norman, 1990).

According to Norman (1990), the items of today are too complex with too many variables involved for a natural design process. Some obvious features are considered but often a new version of a product, due to commercial aspects, are already in the design process before the previous one has been released and thus evaluated. The important aspect of feedback in the design process is to a large extent neglected today. According to Norman (1990), often a new “improved” version is released, where the design is not based on the previous release of a product, but on pre-previous releases, which naturally could result in problems.

In designed physical systems a feature is an ambiguity that must not be oversimplified and this type of complexity cannot be dealt with by techniques that depend on randomness (Flood and Carson, 1993). But, solving a complex problem such as designing a system or interaction with an interface is often dealt with in an intuitive manner that must not be confused with randomness. Intuition is based on non-formalised unconscious experience and mental schemas. According to Langefors (1995) intuition is making assumptions of the attributes of a problem by observing, then creating a mental model and at the end reaching a solution. This process needs to be complemented with an analysis taking care of inconsistencies that could evolve within the mental model.

Flood and Carson (1993) have a perspective of systems design as an element of a system engineering process. This process contains the activities leading to the creation of some entity, together with the procedures and information flows associated with these operations. System engineering has the following steps:

- System analysis, with a recognition and a formulation of the problem. The project is organised and a definition of the system is established.
- System design, with a forecasting phase proceeded into the building of models and simulations where optimisation and control are important concepts.

- Implementation
- Operation

Löwgren (1993) has a more pragmatic perspective to design stating the importance of usability goals, the measurable requirements on the usability. Usability goals are criteria or requirements specifications of the user aspects on reliability, functionality and compatibility for instance. They are a basis for the explicit design process producing of design. The context of the design and the design situation also has to be identified.

Summary

Design is an iterative and evolutionary process including a continuous testing and re-testing of what is designed. Feedback is thus an important part of the design process. There are at least two approaches to the process, an intuitive process (not to be confused with randomness) and a more systematic system engineering process. Important are the usability goals of the design process and the identification of the context of the design.

5.1.1.3 Meta-design

In the design process there are closely related concepts of representation and of modelling, of creating a model of the system or product to be. Van Gigch (1991) claims that the process of modelling needs different levels of inquiry. When deciding what knowledge or expertise is required to design something or to solve a problem, this could be made much easier by differentiating these different levels of inquiry at which the matter is considered. Van Gigch (1991) identifies the three levels of abstraction and inquiry:

- Reality, the level of intervention/implementation (operational level)
- Modelling, designing solutions to the problems encountered at the implementation level (tactical/object level)
- Metamodelling, the level of dealing with generic problems, regardless of their origin (strategic level)

According to van Gigch (1991), modelling is one step from reality and metamodelling consists of identifying and setting the requirements for modelling. Modelling is the process of converting our perceived view of reality into a representation of it. Metamodelling is the process of specifying the requirements to be met by the modelling process or establishing specifications for it. Modelling implies abstraction of properties from objects in order to obtain a representation. A model is at a level of abstraction higher than objects. The process of abstraction applied to modelling itself, to obtain a model of the modelling process is metamodelling. By metamodelling, van Gigch (1991) claims, a process of design is implied that is carried out at a meta-level where we define how the process of modelling is to be carried out. It defines the epistemology and design foundations of modelling. At the meta-level, the area of concern is the design of the decision-making process. Metamodelling should also ensure congruence between the logic and the authority of the system.

Good design, according to Mullet and Sano (1995), is based on reflection and consideration of truths at a higher level of abstraction than the actual design, a meta-design. Modern design movements have emphasised the rational dimension, but without rejecting use of intuition as an important generative element. Method and intuition complement each other and has to do so.

5.1.1.4 The Design Situation

The design situation is not a reflection of the design process. In this work the design situation is considered a system with specific components and relations between and in between them. The design situation is the *context* that results in and comprises a design process. The result of a design process is the design of something, an artefact, a product or a solution to a problem. The design process includes actors and components and is the work that needs to be done in a design situation to achieve a design of something.

One of the most important aspects of an interface is that it is meant to be efficiently and correctly used. In order to fulfil such a goal, Norman (1990) presents two principles of design for understandability and usability:

1. Provide a good *conceptual model* allowing prediction of actions. A conceptual model is a part of an important design concept: mental models, the models we as humans have of others, of the environment, and ourselves and of our artefacts.
2. Make things *visible*. Visibility is one of the most important principles of design. The right entities with correct information should be made visible, together with cues and feedback.

Another important concept according to Norman (1990), is mapping, a relationship between two or more things. Natural mappings are physical analogies and cultural standards leading to immediate understanding.

5.1.1.5 The Designer

"The main purpose of the user interface designer, is to act like an architect" (Mandel, 1997, p. 31). The designer takes the requirements and the needs of the user and merges this with software capabilities, to design a software product to be built and used. The designer models the objects the user is about to work with and the interaction techniques needed to manipulate these objects. According to O'Donnell and Davis (2000), there is a meta-theory for information systems developed, recognising the importance of task characterisation to system design and according to them there are three levels of analysis:

- cognitive (the interface)
- technical (the hardware)
- organisational (the context of the information system)

Designing and maintaining an information system is a dynamic process with goals and techniques continuously changing. For a designer not to miss the integration of the subsystems, a larger context must be made explicit (Xu, 2000). Xu also states that there are two paradigms in literature, science and system. Both of them have related inquiring systems, the science paradigm relates to analytical thinking of a reductionist nature. The system paradigm says that systems are comprised of parts and there is an emphasis on the whole system with its interrelated parts. This means that system designers must not only be aware of the subsystems and their interactions. They must also identify types and characteristics of the sub systems and their interactions in order to define the level of abstraction at which an analysis can be made to select the appropriate inquiring system.

To anticipate the design impact, to discover the effects of the possible alternatives the designer should take on the role of a “planner leader” (van Gigch, 1991). This means that the designer should be influencing trends within area of concern and not only be influenced. To be able to plan ahead and to foresee and avoid unwanted results from the design process the designer should be “proactive, instead of reactive” (van Gigch, 1991, p. 36). This can be connected to Ackoffs (1981) view of the designers role as one of creativity and commitment, two properties needed for stimulating and moving the work process forwards.

Designers are not typical users. Norman (1990) and van Gigch (1993) among others state that they are experts in their field and of the designed product, which is a totally different perspective compared to the user, the layman. Designers are experts on the designed device and users are experts on the task to be performed by the device.

When a user becomes a designer or when a designer becomes a user, this close interaction means that the operation of the device is done from knowledge in the head. It is not so with the first-time or infrequent user that to a great extent has to rely on knowledge in the world. According to Norman (1990), this is a fundamental difference and because of this there is no substitute for interacting with and studying the actual user of a proposed design.

Another important consideration for the designer is *aesthetics*. The ability to create a design based on cognitive demands and valued for its fitness to the user and the task. The designer is not an artist and design aesthetics should always be related to the intended function of the designed product (Mullet and Sano, 1995). Aesthetics in design is concerned with finding the combination of and the representation best suited to communication of information within a specific task

(Mullet and Sano, 1995). Design is always a trade-off between functional and aesthetic criteria.

5.1.1.6 Ethics

Van Gigch (1991) considers the *morality* of systems design as something guiding the conduct and behaviour of those involved in a design process. The outcome and the consequences of a design process are something that has to be considered. Important is the effect that technological systems and new solutions has on the social situation in which an implementation is made. It is pointed to the fact that every technology has side effects that has to be dealt with, and according to van Gigch (1991) it is important that system designers act on and consider ethical or moral considerations to avoid inappropriate side effects.

The concept of *change* can be seen as an inevitable factor in a development project. Causing change is connected to influence, persuasion and communication (van Gigch, 1991), which could mean control and influence between the designer and the user or the client. The setting of the goals of a project is also a process in need of ethical considerations. The questions "Are the goals good? Who decides? have to be asked (van Gigch, 1991). Other topics the designer has to consider is the understanding of the goals or objectives of the involved persons as well as the overall goals and to anticipate the consequences of the design.

5.1.1.7 Cognitive Aspects

There is a problem of focus in the design process. Humans have limited resources for conscious attention. When focus is on one object, attention is reduced on others. The result could mean danger or user mistakes. There is a need for design using forcing functions (affordances) reducing the risk of such mistakes. According to Norman (1990), designers must be aware of the problem of focus in their design and consider the balance between safety-useability-aestethics-manufacturability.

What the user often needs is standardisation, "if you can't put the knowledge on the device, then develop a cultural constrain: standardise what has to be kept in the head (Norman, 1990, p. 170).

Löwgren 1993) briefly considers the cognitive skills needed to attend to when designing graphical interfaces:

- The learning process is automating lower level tasks so the user can spend his or her mental energy thinking on a higher level.
- Decision-making is used in situations that are generally familiar but not automatic. A schema is retrieved from memory based in the characteristics of the situation. If there are no schemas the mind creates new ones.
- Long term memory delivers a schema that seems useful for the current situation a goal. In routine performances the automatic procedure is delivered from long term memory and executed instantly
- Perception. In order to select actions the user has to perceive what is available. On evaluating the outcome the user must perceive what has happened.
- Gestalt effects. Humans are good at perceiving patterns, which comes from our concept-based processing. When talking about user interfaces the perception of a pattern means that the user expects that entities grouped together must be logically related in some way.
- Vision. In spite of a wide field of vision, it is only in the centre that we see things clearly. We also seem to have certain colour interpretations innate in our perception system. There are also cultural aspects on colour use.

The cognitive aspects on design are important, since these aspects are the basis for an effective usage and exploitation of the cognitive abilities of mankind. Helpful tools apart from the gestalt theories are standardisation and consistency in lower level tasks due for automatization. Learning and decision making are other important concepts that will be looked upon more thoroughly.

5.1.1.8 Learning

Learning is a *cybernetic feedback-relation* between the learner and what is to be learned. Pourdehnad and Robinson (2000) consider learning within product and service development, with the design process divided into three learning phases, before, during and after design. Learning is a cybernetic process and the first phase of Pourdehnad and Robinson (2000) focus on useful insights, information, knowledge and understanding gained from studying the future environment of the new system. The second phase consist of knowledge and understanding required, addressing the needs and requirements of the customer or user. The third part focus on creating an effective feedback system for the whole process with results obtained from groups, interviews and tests. Other contributing factors were questioning the nature of the involved system and its role in the larger system, the interaction between the parts of the system and creativity generated when constraints were removed and creativity removing constraints (Ackoff, 1981).

We learn better, according to O’Connor and McDermott (1997), when we enjoy experiences as well as gaining something from them. They also claim that learning is taking decisions and changing what we do in response to the feedback we get. There is a dynamic equilibrium within the learning process - nothing is ever fixed in space and time. This means that in more complex skills there is a need for feedback through time, learning comes from repetition. Feedback through time is for operating more efficiently.

Considering the learning process involved in the design situation O’Connor and McDermott (1997) look into the possible fallacies to be aware of and presents three fallacies that have to be considered when dealing with learning through feedback:

1. Cause and effect are separate and the effect comes after the cause. This is false. A system holds both feedback and feedforward.
2. Effect follows cause close in time and space. There are always delays in a system so this fallacy could lead to false conclusions. In systems thinking the explanation does not lie in different single causes but in the system as a whole and the relationships within it. There is a need for carefulness when studying repeated patterns or occurrences and to deduce schemes from these.
3. The effect is proportional to the cause. This is true of physical objects, but cannot be generalised to living or mechanical systems, with an even more uncertainty on living systems. Sometimes an action has no effect at all because of the different possible thresholds within a system. In a closed system the final state is completely determined by the initial conditions, but open systems

are very sensitive to starting conditions. A small difference can lead to a completely different result.

O'Connor and McDermott (1997) also present different causes for why learning can be prevented, which is devastating for the design process.

- Deleting part of feedback. Feedback may go on unnoticed due to concentration on another part of the feedback loop.
- Dynamic complexity. Human systems are complex systems and there is a continuous flow and chains of influences within the system and from its environment.
- Time delays, and the difficulty of connecting cause and effect.
- Surprising properties or synergetic effects, what seems to be obvious at first sight may be far from so.

Learning is an intrinsic process and a quality within human beings. Learning also has a quality within itself, depending on the feedback mechanisms, within a development project for instance. These feedback mechanisms must be well prepared for and handled with care by the designer or the project management. The quality of these mechanisms is based on and depends on the quality of the relations and the communication processes within a design project.

5.1.1.9 Decision Making

According to (Barsalou, 1992), decision-making is the identification of possible choices, the identification of possible outcomes generated by each choice, and the assessment of utility and probability for the occurrence of the possible outcomes. Decision-making within human information processing can also be considered as a function of the context, the problem and the person (O'Donnell and Davis, 2000). The context variables recognise differences in the decision environment influencing the interpretation of the decision tasks. Problem variables include decision attributes (alternatives, reference points for instance) and decision cues within the information. Person variables represent decision-making skills, together with the knowledge and the problem solving ability. The interaction of these variables determines the decision-making strategy executed by processing information in a mental problem space.

5.1.1.10 Meta-decision Making

Wang (2000) brings up the concept of meta-decision making as the process of deciding how to make decisions considering human-computer interaction. This interaction is described as a constant decision making loop including three basic types of tasks:

- Problem or opportunity recognition
- Meta-decision making (pre decision making)
- Primary decision thinking

These are often considered in the context of problem solving, which is after the problem recognition phase. This is a general process, which also can be applicable on the design situation. Wang (2000) defines meta-decision as "The decision on how to make the practical decisions required throughout the whole decision process" (p. 112). This process also includes selecting information, selecting techniques, information and methods for problem recognition. Most important is it to identify the problem and the opportunities.

It is important to give thought to and consideration to the design of the decision process (van Gigch, 1991 and Wang, 2000). These processes include both modifications and possibly redesign of the decision making. There is no general right decision algorithm and sometimes the right decision does not produce the best result because of a constantly changing environment. The main aim, according to Wang (2000), of meta-decision making is the formation of hierarchical structures, which aim to improve the quality of decision making in practice. Pourdehnad and Robinson (2000) states that "decision-makers need a system that allows them to get closer to reality, but in the context of a broader system that contains the situation they are dealing with" (p. 32). In decision practice the decision-maker must also be aware of his or hers own predisposition and prejudices, parts of their infological "S" (Langefors, 1995), in relation to the specific decision to be taken.

Meta decision making should also integrate the “soft” approach of imagery and intuition with the “hard” approach of analytical thinking to form a new thinking style (Wang, 2000) This is an approach within systems thinking also present in Langefors (1995), for instance. Designing the decision making process also concerns constant modifying of the process, and at each stage select the appropriate thinking style and decision style. The decision styles are the autocratic and the democratic and the thinking styles are the systematic and the intuitive (Wang, 2000).

5.1.1.11 User Centred Approach

To achieve a good design the designer need to know about the user as a human being, which means insight in psychology and other disciplines to gain knowledge about humans in general. The explicit and intended user is also important to study (Löwgren, 1993). Mandel (1997) discusses the same questions and states “Know thy users, for they are not you!” (p. xi). There are many types of users, clerks, managers, secretaries etc, and Avison and Fitzgerald (1997) claims that it is desirable that all users of a system are involved in the development process. They all have a stake in the success of the information system.

According to Norman (1990), an important concept is *user-centred design* with a focus on the following:

- make it easy to determine possible actions
- make things visible (including the conceptual model of the system)
- make it easy to evaluate the current state of the system
- follow natural mappings between intentions and required actions, between actions and their effects, between visible information and the interpretation of the system state

The user must be able to figure out what to do and to tell what is going on. Other important considerations are the use of different kinds of knowledge. The designer should use “knowledge in the world” by taking advantage of external constraints and affordances, together with “knowledge in the head”. The user should be able to combine knowledge of the head with knowledge in the world.

Considering the design process in a broader perspective and in the view of the financial stakeholder, it is evident that the financial returns and competitive advantages of a product primarily depend on *customer* satisfaction. This customer satisfaction can only be obtained by acquiring a comprehensive knowledge and understanding of what the customers needs (Germana, 2000). Decision-makers (designers) need a situation that get them closer to van Gigch's reality level of the design process, but still within the context of a wider system containing the situation at hand. A user centred development project is the obvious answer to such demands, but there is also a problem to this. It is not enough to know what consumers or users want and need, these wants and needs must be understood, which means that the interactions between the different and various wants and needs must to be understood together with conditions and variables that create them. There is also a learning process needed together with the information gathered. Learning in the design situation can be considered a cybernetic feedback mechanism. Germana (2000) uses Ackoff's (1981) definition of the content of learning, as consisting of four or five hierarchies:

- Data consists of symbols representing objects, events and their properties.
- Information is data that have been processed into a useful form and answering questions beginning with who, what, when and how many.
- Knowledge consists of know-how and is contained in explanations.
- Understanding is contained in explanations and answers the why-questions.
- Wisdom is the ability to perceive and evaluate consequences of behaviour over a longer period of time.

Langefors (1996) view on data and information are similar, in that data refers to signs used to represent information. Information is knowledge structured in a way that it can be communicated, not the physical sign representing it. Knowledge that can be communicated can also be stored, this means that information is also storable knowledge.

A basis for all development projects is that there should be a financial return to the investments done. The user centred approach, including user and customer satisfaction, is one precondition for such a return. The awareness of the different types of users and their needs, and the interactions between them and their needs, must be understood to possibly increase the result or the financial benefit.

5.1.1.12 Constraints on Design

Norman (1990) considers the concept, stating that design is a time consuming activity and that *time* is one of the obstacles in achieving good design. The *market* with its demands for new frequent versions is another obvious constraining factor. *Individualism* could be another problem, since the design often results in a personal touch to the item or systems designed. This means that different manufacturers differentiate the design for it to be distinguished from others. One consequence of this is that when there is a perfect product (if any), it has to be changed when manufactured by someone else (Norman, 1990).

A general consideration is that when a satisfactory design result is achieved, further change may be negative. In design it is important to know when to stop (where to place the system boundary).

5.1.1.13 Representations

According to Bødker (1998), design is a collective activity and the representations that are used are important in their role as mediators in the relation between designers and their products, between designers in a team and between the design team and the future user of the application or information system. What Bødker (1998) calls the activity system of design includes activities from different participants. It is a complicated and complex situation full of conflicts and contradictions. According to Bødker (1998) there is an absolute need for designers to interact with the future users in order to understand the system to be.

Design crosses boundaries between work activities and representations play an important role in the design process, since designers need to externalise proposals and present them to others. The designer needs to make a presentation of the future product. Various kinds of representations plays important roles and they reflect expectations and experience of their creators. What designers set out to create, though, will always differ from the actual creation (Bødker, 1998).

A representation sets a purpose and allows participants to move in a certain direction. They are affordances in design. The designer needs to look beyond the application and establish a context of use. Important according to Bødker (1998) is also how representations support and represent the design process at a higher level, the meta-design. It is important to create partly overlapping design activities, regarding participants, to maintain human mediation as an important tool in design.

5.1.1.14 The User Interface

The user interface is a two-dimensional representation of a workspace, and even though Edwards (1997) considers Spatial Information Theory and GIS (Geometric Information Systems) the thoughts presented could be considered relevant to graphical user interfaces in general. A combination of cognitive and geometric approaches in space organises space-time events into two basic representational structures, views and trajectories.

According to Edwards (1997) views are collections of perceptual experiences or events with some thematic connection. Trajectories are ordered sequences of perceptual experiences of a similar type or the same nature. By combining these it is possible to deduce conditions for perceptual experiences and spatial data. These conditions can be used for:

- Processes of planning and wayfinding
- Design of computer interfaces
- Human Computer Interaction

Views and trajectories are two basic representations grouping space-time events, according to Edwards (1997). Trajectories are based on sequential order and views are hierarchical groups. These representations are used as basics for reasoning about the user interface and to build representations which are hybrids of order and hierarchy.

By using time to order perceptual sequences and space as a substrate for grouping perceptual events within views, the result, Edwards (1997) continues, is a template for spatio-temporal data structures. This is one of the keys to the development of geometric-cognitive representations. Another key is the observation that people learn and structure spaces by traversing them many times. Multiple trajectories of the same space are therefore a primary mechanism behind spatial cognition.

According to Mullet and Sano (1995), science today has brought knowledge and technology down to a level where interface design can be performed by practically everyone. With the right tool or programming language anyone with a tool skill could design and create, for instance, a visual interface of a computer application. Apart from this technical knowledge the cognitive demands of an interface is well explored and scientifically established.

When studying the navigation structure or the trajectory depth of an interface, with its graphical abstractions and aggregations, there were unfortunately no material found.

5.1.1.15 Design Steps

To exemplify the design process with its different steps, one “general” methodology has been studied - the SDLC methodology. SDLC is the traditional Systems Development Life Cycle, designed in the sixties and known in literature as traditional systems analysis or the waterfall model (Avison and Fitzgerald, 1997). Methodologies are important and the communication ability of an Information Systems Development Methodology (ISDM) is important because of the ongoing interactions between designers and users (Germana, 2000).

The term life cycle indicates the iterative nature of the process and “systems analysis” covers different analysis and design aspects, but not the business or technical aspects of development. It is a traditional and historic methodology, and according to Avison and Fitzgerald (1997) most alternative approaches carry the same basic principles and the same general structure. The iterative nature of this methodology makes it possible to use in a more general way, and also to apply on the different parts of the design, such as the interface design. The methodology has the following design steps and originally it was considered a sequential process. But reality and the changing environment of information systems make it an iterative process by necessity (Avison and Fitzgerald, 1997).

1. Feasibility study. The first step is a study of the reasons why a system should be replaced or created.
2. Systems investigation. This step is the finding of details and facts of requirements, constraints, data types and volumes, exceptions and problems.
3. Systems analysis. Systems analysis is the phase where the present system is considered and analysed based on knowledge from the earlier steps.
4. Systems design. This step leads to design of a new system. The new facts gathered might change the design suggested in the feasibility study. Both technical and manual parts of the system are designed and a design documentation is performed
5. Implementation. If needed, new hardware is purchased and software is written or purchased and installed. All aspects of the new system have to be proven before converting from the old system. A period of parallel running of the systems is recommended. Quality control and documentation, such as manuals are important in this step.
6. Review and maintenance. This final step occurs once the system is in operation. There are possible changes in the system to consider and in the organisation and its environment. Maintenance due to errors is applied and an evaluation process takes place due to future gains, both technical and organisational.

The SDLC model can be complemented with a last phase, the liquidation or termination of an information system. This is accounted for by Anderson (1994), among others. According to Avison and Fitzgerald (1997) there are some well-known weaknesses of this traditional approach that needs to be considered:

- Focus is on the operational part of an enterprise and a consequence is that the tactical and strategic levels of a business in not well covered.

- The models and processes are unstable since businesses and their environments do change.
- Focus is on the output of the system, which is decided early in the process. This could lead to inflexibility.
- User participation is not a main issue with possible user dissatisfaction as a consequence, both of the system and the documentation, leading to incomplete systems.

Design and the design steps is an iterative process and most approaches are based on the principles and the steps of traditional waterfall model. The static or sequential nature of this model is now complemented with the iterative nature of design today and its user centred approach.

Summary

This literature survey consists of materials and concepts regarded as relevant and related to the design situation of information systems and their interfaces. The importance of system identification together with aspects on feedback and complexity are presented. Feedback is also fundamental to design and to achieve good design, meta-design is a necessity with reflection and considerations at a higher level of abstraction. The design situation as the context of the design and the designers role and aesthetics is considered. The importance of ethics, considerations of the outcome and consequences, and man's limited cognitive abilities is also accounted for together with the importance of feedback and communication in learning. Decision-making is important in design as is the knowledge of how to make the practical decisions required. There are different kinds of users and a user centred approach is considered necessary for an appropriate design and future financial returns. Important constraints on design are time and market considerations (Norman, 1990). Representations are important tools for externalising user interface prototypes for discussion. The steps of the design process are also accounted for with the example of a method.

There are some concepts not present in this survey due to lack of time, appropriate material and the necessity of performing of a system identification on the work, where certain limits and boundaries are to be set. The important project team and other design methods than the one presented are not accounted for. The organisational aspects of a company influencing the design situation are not considered, just like the business or technical perspectives. These aspects are possibly introduced to the design project from the customer and will, if necessary, be included in the conditions for the design process (Norman, 1990). The system identification performed in this work is based upon an explicit design focus.

5.1.2 The Interviews

To find a complementary and perhaps a contradictory perspective from the literature survey, two extensive interviews has been performed. The interviews have been performed with usability designer Peter Anderson at WM-data, well acquainted with the design situation and its implications, and with systems developer Malin Dahlberg at Volvo IT.

The main topic of the interviews was the human-computer interaction aspects of the design situation. There was only one question asked, " What is design and what is the design situation?" From this the interview was built by referring to general and important concepts of the design situation extracted from the literature survey. Depending on the different background and experience of the persons interviewed the concepts were or were not considered relevant. Bo Peter Andersson and Malin Dahlberg were asked to present their perspective or view on the design situation according to their knowledge and experience of these concepts.

Both interviews were then carried out in the same manner. In order to possibly get an unbiased presentation or description of the design situation, there were only one explicit question used, What is design and the what is the design situation? The interviewed persons were then exposed to key concepts and asked to explain or analyse them if the concepts were considered relevant to *their* design situation. These concepts were written down and used in a way appropriate to the materials and the flow of thoughts from the interviewed person. The concepts used were the design situation, design, context, preconditions, boundary, focus, influencing factors, components/ingredients, meta-design, the design process, perspectives, actors, method, roles, ethics, follow up, validation and verification. Prior to the interviews the context of this work was presented with its main ideas, goals and objectives.

No recording were made of the interviews in order to get a freer and more relaxed, intuitive and creative situation. Notes were taken and the interviews were written down immediately afterwards.

5.1.2.1 Extensive interview: Bo Peter Andersson

The first extensive interview was made with usability designer Bo Peter Andersson on WM-data Usability on May 7, 2001. Andersson previously held lectures at Högskolan i Skövde on design in a wider social perspective and is well informed on the subject. He was also among the first group of student at Högskolan i Skövde graduating in cognitive science. The main perspective of Andersson and the company he represents is that of usability. The importance of usability from their business perspective are approached from the following advantages and is presented in written material from the company:

- A focus on goals and objectives, results and efficient development by studying user demands, preconditions and work situation early in the process. This makes it possible to create qualitative and quantitative usability goals.
- Less change when in use. An early identification of possible changes grounds for a cost efficient development.
- Less need for support due to an adjusted interface design.
- Increased productivity from a usable and relevant interface, which lessens the amount of mistakes and increases motivation.
- Increased sale through the power of competition from useful products and IT-solutions.
- A better goodwill for the company from an efficient user interface.

Services provided by Andersson and his company to reach solutions with regards to usability are:

- User profile survey, to get to know the users, their knowledge, knowledge, habits and attitudes. Understanding of the user is important when creating a useful IT-solution.
- Identification of suitable information structures supporting the users by letting them participate in the development process.
- Rapid prototyping for visualising design of user interfaces, making early evaluations of the systems functionality possible.
- Expert evaluation of usability problems within existing system solutions.
- Usability web survey for user evaluation of the solution, based on a specially designed web inquiry.
- Team and lab tests of the proposed solution. In the team test the solution is explored together with the users and in the lab test the solution is tested under scientific and realistic conditions. The lab test gives explicit usability goals possible to measure. Video recordings are the tool used.

5.1.2.2 What is design and what is the design situation?

Design is not an explicit task, rather *the managing of a design situation*. It is a matter of politics, of marketing ideas and of economics when managing a project. Very important is the finding of the *right persons* for a design project, to put together a project group with different persons with different background and skills needed within a design project. *Polemics, politics, debate and discussions* eventually result in a design of the target product of the project. This process is lead or managed by the project leader in a co-operative manner, with the interaction of involved persons or individuals. Design is the result of peoples work and *social capacity* within their work group. It is not a result of methods or methodologies on a general level. Very important is the *social climate* within the project group in its creation of a common base from which work expands.

Methods and goals

Method could be used in the next step of the design process, the measuring of usability and finding the goals. The usability goals are of extreme importance since they define the system to be designed. When these goals are settled a political and a social process continues to harbour the project. The design goals are the bridge between the project leader and the involved persons. The goals are also important for setting the timetable for the project and to reach an agreement on how to carry through the project and to test the design.

Perspective

Design is having an overall, *generic perspective,* a holistic “helicopter-perspective” to deal with the proposals that is to be dealt with and considered within the project. There is an absolute need for what is considered necessary *theoretical reasoning* concerning users, customers and goals before presenting a prototype. A prototype is a visualised base for the discussions within the ongoing work process. It is important to start the work process with a theoretic reasoning in order to reach an optimal result.

In some projects there are external persons, such as an Art Director involved, often in projects developing web-design. Once again there is a need for a theoretical reasoning and a discussion before work is done on the actual visualisation of the design. An important consideration in projects like these within WM data Usability is the actual politics and discussions in order to finish a project with a good result which is generating new contracts or jobs. The politics of these discussions consider what is to be done, the user has to be known and the actual practical work in “freezing a prototype”. This prototype is merely a topic for a discussion, but when Art Directors or external personnel are involved the prototype, “the skeleton” of the system, could be confused with the actual product.

The *customer*

The customer is a very important influencing factor on the design situation or design process. Discussions between the customer or client and the design team are of outmost importance, often enough the clients are also the users of the design to be. The design situation is created in the discussions with the client, and once again design is created out of interaction between people, not from methods or methodologies. From these discussions a quick or rapid design follows as a foundation for the future work within the project.

Preconditions

The project leader creates the design situation through *sensitivity and awareness* of what is needed and not until the design situation is defined and goals are set, the use of methods are applied to the process. Another important precondition for a successful project is the level of the different *competencies* within the project group. Important is also the competence of the client. The competence of the client is of interest when the requirement specification is considered. Optimal to design projects is a simple initial requirement specification. If the customer or the client present a “complete” requirement specification without appropriate knowledge of the possibilities and possible problems, the project gets a false start. One of the main tasks for a design project is to develop such a specification within the project. What a design project really is about is the development of a prototype that will function as a requirement specification for the rest of the work.

It is important for the success of the project that the client does not make a too detailed requirement specification due to lack of competence. Mostly this is not done, and the client considers developing the specification a part of the design process.

There is no “academic standard” that is followed or used within these projects and in the design process we perform. Instead focus is on good *communication* and a positive social environment in the project group, which are considered the most important preconditions to a successful project. Each project is unique. The design situation is a complex situation that has to be considered and planned with care. The user and the skills of the user are important as the explicit knowledge of major principles of human-computer interaction.

Ethics

What happens when implementing a new product or a new design? This is an important question. The product or the design has to be considered in its context and the new consequences or effects have to be found and discussed. An inquiry and investigation among the users has to be done. What happens in the user situation? Is this design unethical, is the new designed product ethical justifiable? Decisions and decision making must be considered and there is a pre- and a post-design situation that has to be managed. The pre-design situation is fairly simple, but the post situation is more complex. What happens? This has to be enlightened and discussed, but there are no general considerations discussed apart from questions of safety and possible embarrassment of the user. The outcome of these discussions is a product specific consideration with regards to use, context or user situation. These discussions constitute the affordances and the constraints on the project during the development of the design.

Method

When the basic foundation of theoretical reasoning has created a working environment, there is a chosen method that can be applied or used as a toolbar for use when needed. The method used in WM data Usability is the Delta method for qualitative system solutions. It is used to ensure that new systems are developed according to the users needs and wishes, to find the future user situation and to define the requirements of the system according to this. These requirements should be able to measure and to be tested. The Delta Method is developed by Swedish universities and industries with support from NUTEK and consists of several activities that could be used as a complete methodology or used partially, to suit specific needs and requirements. The activities are:

- System identification
- User study
- Task analysis
- Design preparing
- Conceptual design
- Usability goals
- Prototype development
- Usability testing

In this area, design is the same as a system. When design is discussed, it is the design situation as a system.

Meta-design

The design situation is a meta-design process, an analytical approach to the design task. What the design situation is all about is considering the conditions for the design process, to think about and of design. The design situation is not the creation of the actual design of the product itself. The design situation consists of humans or people in a project, together with a “helicopter perspective” on the task, a meta-design situation. This is shown in figure 1. It is a matter of capturing

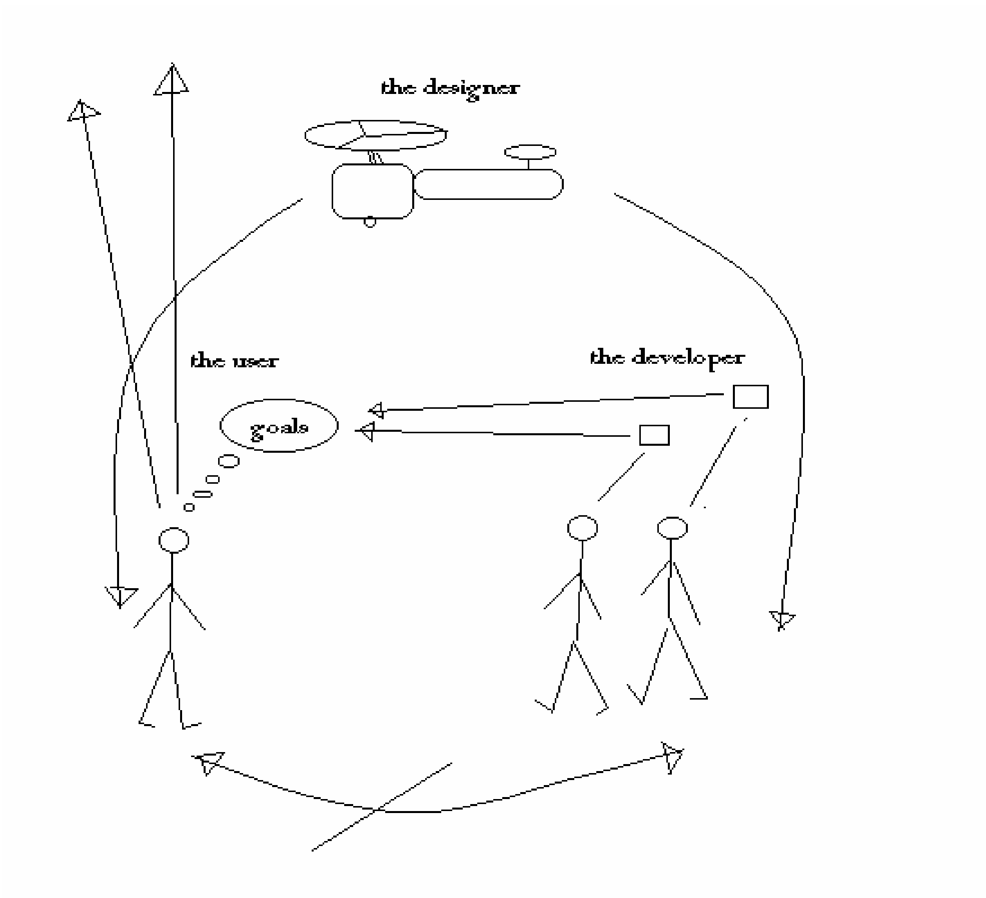

Fig. 1, Capturing the user goals. Picture from a sketch by Bo Peter Andersson. Figure 1 shows the danger of different developers or designer seeing or understanding only their own specific parts of the user goals. This is possibly due to lack of communication and results in users seeking inappropriate solutions or goal fulfilment elsewhere, resulting in a non-optimised work situation.

the goals of the users, the preconditions, threats, possibilities, reasons and conditions for the whole design project. If the project team does not do this in a proper way, or if the project management does not properly manage the communication between the users and the developers, the users will go less appropriate ways to reach or achieve their goals. The "helicopter perspective" is a holistic approach from a project management point of view. These thoughts are displayed in Figure 1, based on a sketch by Bo Peter Andersson.

Change

Change is necessary and inevitable from the designers point of view. Not so from a developer or a customers perspective, where change is problematic and often something expensive. Change is the core of or the heart of design, and the change factor is the consequence of a necessary user interaction. User interaction is also a way of finding problems at an early and more appropriate stage of the development process diminishing costs and workload. A prototype is a tool for making the necessary changes, which means that work is progressing towards the goals. Of course change could be a problem in itself considering time and economy. Sometimes we have to use a bad scenario as a threat to make the customer see the danger of a negative attitude towards change. It is important to create a design situation that can tolerate and live through changes. The changes that are an important part of and a necessity for design to develop and eventually result in a product. The goals set the limit to when to stop this development process.

Summary

According to the deep interview with the usability designer, design is the managing of a design situation. The graphical design is then an intrinsic ability within the designer. Design is putting together a project group with the right persons, where the politics, discussions and the social climate in the team result in a design. The goals are a bridge between the members of the team and a generic and holistic perspective and theoretical reasoning are of great importance. The customer is an important influencing factor and the sensitivity of the project leader together with the different competencies within the team are preconditions for a good result. Each project is unique and good communication and the social environment are necessary considerations.

The importance of ethics is stressed. What happens when implementing a new design has to be considered in its context. Design methods are not considered necessary and only used when needed. The design situation is a meta-design process where the conditions for the design are considered. There has to be an awareness of the goals, threats, possibilities, reasons and conditions for the whole design project. Change is a necessity, the core of design and a consequence of necessary user interaction.

The usability designer's perspective on design is a meta-design perspective, and the actual design is a result from having this perspective on the work process.

5.1.2.3 Extensive interview: Malin Dahlberg

The second extensive interview was made with systems developer Malin Dahlberg on Volvo IT on May 16, 2001. Dahlberg is a graduate from Högskolan i Skövde where she studied cognitive science. She graduated in 1999 and was then transferred from her previous work at Volvo PV to Volvo IT. Her work is in the area of systems development, which is her main interest in this area. Her focus or perspective on design is based on a wider holistic perspective on the development process as a whole. This is unfortunately not is reflected in her actual work situation.

5.1.2.4 What is design and what is the design situation?

Design is a part of the systems development method consisting of analysis, design, implementation and maintenance. But it is also a way of thinking of the visual representation and creation of an object. In reality, design is something totally different from the system development process taught in courses on Högskolan i Skövde. The design process is often a very brief transition process between analysis and the actual coding of the application or information system.

Roles

One of the most important roles or persons within a project is the analyst. Unfortunately the analysis or the feasibility study is often enough not performed within the project. Earlier approaches and considerations on systems development included everything from the feasibility study to the implementation of the new system. At the moment we are building up a base of competencies within todays projects. At Volvo IT we are now creating a new system development model with more specialised involved persons or roles. Hopefully an improved focus will be on the analysis phase of the development with communication and co-operation between persons or actors as another important feature within the projects.

The project team

The roles within the actual design situation in the project team or project process are the project leader, the analyst, the programmer-implementer and the technical architect. The role of the tester of the system is applied to all involved persons.

Documentation

Considering design in a wider perspective there is an important part that is often neglected due to time, money and complexity; documentation. Documentation is considered important throughout the whole process, especially with a future perspective and the lessons learned from old, complex systems of which no one knows anything. These systems without documentation are creating huge and sometimes catastrophic situations when there is a need for redoing or updating systems due to the demands of today's requirements. But, strangely and unfortunately this almost never gets into the reality of systems development. Documentation is an iterative and time-consuming activity too easy to neglect and put aside. The analysis and design of systems or interfaces are in reality not documented as should be.

Communication

Previous experiences tell us that "everybody doing everything" is not a very good way of working. Experience in all fields is gained, but too much discussion about everything all the time does not render an optimal solution. In newer projects, the roles within the project are more specialised together with a focus on communication and dialogue. Especially important is the awareness of the importance of working close to the customer. The customer is the only source of verification weather or not the system is good or acceptable. A constant dialogue with the customer, and of course with the user is of outmost importance. In reality this is not always possible, unfortunately. The best situation one can hope for today is the chain of analyst-customer-designer-programmer in an open dialogue.

Representations

Doing the actual design of an interface, a most important tool is pen and paper. Drawing, creating pictures and representations of the product to be is one of the best tools to use. The customer or the user can be asked: “Is this the way it should look? What should happen at this moment?” etc. The navigation structure also needs to be considered and decided upon and a dialogue with the customer is the only way of achieving a sufficient result or design. There is a truly important need for a holistic view on interface design, with the context, the user, the graphical user interface and the navigation structure as equal parts of a design system.

Flexibility and complexity

One of the dangers with the user-customer centred approach is the lack of knowledge of the customer. There often is a wish for total flexibility and everything that is possible to achieve, together with “flashing red buttons” and other cosmetics. Graphical design has its rules and regulations and has developed through centuries for the creation of optimal usability. One important designer task is really to reduce flexibility by inserting constraints and affordances in the design, to create natural flows within interface use. The amount of flexibility is closely connected to the amount of complexity.

Methodology

The basis for the methodology used within the company is RUP (Rational Unified Process), and from the 34 roles within a RUP project 8 roles have been selected and used:

- requirement and business engineer

- architect (technical solutions)
- analyst
- designer
- implementer
- configuration manager
- tester
- project leader

The user

Considering the context of a project the fewer persons involved the better. The participating persons or roles should cover the competence needed. This is a necessity throughout the project together with a holistic perspective. One problem is the limited contact with the actual user to be, which hinders a comprehensive understanding of the actual needs since the customer often is not the user. We need to ask ourselves “Who is the user?” and work from here, accepting that all of the requirements and needs can not be satisfied since system thinking and knowledge often is missing. There is only a few persons view of the system that is considered and everyone works in a different way. In practice there is no holistic view of the work. Another problem is the possibility of having the “wrong” contact person outside the project but within the company. This could be a person not representative of the future users of the system.

Prototypes

Often working prototypes are used for anchoring a product with the customer, but these prototypes are dangerous for verification or validating design. The customer often believes that the prototype is the actual product. It is also important not to build in too many functions in a prototype that perhaps can not be implemented in the real system. A prototype is a shell or a skeleton, not a product. This is one reason why paper prototypes are preferred.

The customer

One of the main obstacles in the design situation of today is that one the largest customer of Volvo IT is Volvo PV, now a division of the Ford company. There is now an uncertainty on how to work towards the customer due to transition problems and possible new standards, methods, authorisations and traditions. Who is authorised to order a job? What is he or she authorised to order? These are unsolved questions all through the customer hierarchy creating problems for the project teams.

Meta-*design*

Considering design and putting a meta-perspective to the subject, it is unfortunately not a practised concern involved in the process. Design is often directed towards production systems and the meta-perspective is more of a heuristic decision making, based on existing guidelines and standards executed with help from the designers own experience. Based on standards and guidelines, a common consideration is use of what worked the last time. The actual meta-design process is a consideration at a higher level within the company's hierarchy. There is a network within the whole enterprise dealing with these matters, creating specifications on how design should be performed and on how the result should be visualised.

Change

The concept of change within the design process is to a large extent depending of the size of a project. The implications from the task itself and the size of the task create a basis for considerations on how to manage changes in the process. Unfortunately documentation of these changes is weak. Traceability is not a topic practised, even though there is an awareness of the implications when not dealing with this in a proper way. Documentation and traceability are expensive parts of a project and still there is a tradition within the company that changes are remembered by the persons dealing with them and thus kept within the project within this very person.

Ethics

Documentation is often not taken care of in a proper way, but what is done is a logging of the users of the system and their recent changes within the system. This could be put under ethical consideration, but this question is not being addressed in a way that it perhaps should. The reason for this logging is finding sources of disturbances in the production. The actual customer-user is not logged in the same systematic way even though there sometimes are logging being done.

Follow-up

An important issue in the design situation is the follow-up on design and decisions made through the process. The follow-ups are taken care of by the project leader, who is keeping a record of the doings and decisions within the project. All problems in the design process and the system that are faced by the team, is logged, i.e. system failures, failures of use etc.

A technical perspective

Within Volvo IT the design process is still to a large extent considered from a technical point of view. The culture in the company still has a very technical focus and technicality has a high priority in decision making. This is a natural consequence since a lot of work is directed towards production systems with text based interfaces. Graphical user interfaces in production are on its way but is not a standard today.

Time and complexity

Considering the design situation there are two concepts that stand out in the design process, time and complexity. The time frames for design to be done are always too small and too little time in the beginning of a project always renders greater costs in the end. Complexity is a consequence of too much functionality. Complexity and functionality always goes hand in hand. “Is this really needed?” is a question that should be asked more commonly and with greater awareness.

Summary

According to the systems developer, design could be different things, a part of a development method, a way of thinking when creating a visual representation and, in her reality, a brief transition process between analysis and coding. There are important roles in a design project and the analyst is of great importance. Others are the project leader, the programmer and the technical architect. Documentation is a neglected field and communication and dialogue are important attributes to a project. The customer is also important as a source of authorisation and of verification of work accomplished. This makes representations crucial together with a navigation structure. The systems developer also stresses the need for a holistic view on interface design where the context is properly accounted for.

Dangerous are the wishes for flexibility, closely connected to the complexity of the design. The method or methodology used is a modified version of RUP (Rational Unified Process) and the fewer persons involved the better. In reality, there is a problem with the limited contact with the user, so there is really no holistic perspective on the work. The meta-design is unfortunately taking place elsewhere in the organisational hierarchy. Change is an important concept and also how to manage changes. Documentation is weak, though. Ethical considerations are not present, as they should be. Design is considered from a technical point of view and time and complexity stand out in the design process. The time limits are always to small and complexity is a consequence of too much functionality.

In contrary to the usability designer's experience of the design situation, the system developer's are of a more practical and technical nature. This is not considered an optimal situation and important considerations on the design process are in reality not present in design projects.

Summation of interviews

The two interviewed persons' experience and working context differ in a substantial way. The usability designer is working with interfaces in different types of development projects, and the systems developer has more controlled working conditions with applications directed towards productions systems. Apart from this their ideas and visions of the good design situation are of a similar nature. They both stress the important role of the customer and a carefully put together project team with different competencies. The importance of the user and finding the usability goals is stressed. Both have a method and a methodology for keeping the work together, even though the usability designer does not have a tightly coupled relation to the method. They both consider a holistic perspective as a necessity, but this is not practised within the more technical focus of production systems.

Their views on design coincide, but their experiences differ. For the usability designer, design is really the managing of a design situation of a meta-design character. In reality, design for the system's developer is a mere transition process or at its best a part of and a way of thinking within a systems development project. The ethics of the design project is of great importance to the usability designer, but not a topic considered in work of the systems developer. For the usability designer change is the heart of design due to user interaction, but a poorly considered topic within the work of the systems developer where documentation is weak and traceability is not considered. For the systems developer lack of project time and wish for flexibility are two substantial contributors of complexity within design projects.

5.2 Applying Systems Approach to the Design Situation

Avison and Fitzgerald (1997) consider applying of systems approach to information systems development, and as a consequence, on its parts or subsystems. Avison and Fitzgerald (1997) claim that systemic activities are a feature of several methodologies for information systems development. At one level of abstraction the system approach focus on the interactions between the system and its environment considering the system as a black box. This holistic view is of great importance to acknowledge the emergent properties derived from the system. Equally important as studying the system in the widest possible context with a holistic view, is the perspective of the system as a set of interacting functions or elements (Flood and Carson, 1993).

Information systems are complex systems including both people and technology. The interactions within the system make it relevant to apply a holistic perspective (Avison and Fitzgerald, 1997). Systems including people are not predictable in the same way as a technical system. Organisations are open and living systems, which stresses the importance of the interaction between the organisation and its environment. According to Avison and Fitzgerald (1997), the computer aspects of an information system are that of a closed system and therefore more deterministic to its nature. The human aspects are open and therefore non-deterministic and unpredictable.

Within systems approach, the analyst should look at the organisation as a whole with an awareness of the possible areas of concern external to the boundaries of the system developed. According to Avison and Fitzgerald (1997), this also points to the need for multidisciplinary development teams with a variety of possible solutions as a result, since different analysts observe the world in different ways. As a consequence of this there are, or should be, a continuous learning process going on among the participants of a development project (Pourehnad and Robinson, 2000).

The modelling of data and information within a smaller enterprise, with an ER-schema for instance, is not necessarily a very complex task due to its static nature.

To understand human relations or an organisation, people must be included in the model. This inclusion creates a more complex situation due to the unpredictability of peoples thinking and behaviour (Avison and Fitzgerald, 1997). This can be elucidated by Beers (1994) Viable Systems Model, an important tool for designers studying organisations from a holistic perspective (Avison and Fitzgerald, 1997). The functional elements of Beer's model are:

System 1: The execution of physical work or the production within the system.
System 2: Coordination of the system based on input from System 3.
System 3: A controlling function of the stability within System 1.
System 4: The intelligence function with two main tasks, switching and capturing information.
System 5: A policy making function (Beer, 1994).

This categorisation of a viable system can also be applied to the central person in design projects, to the situation of *the designer* within a development project. Applied on the designer the different parts of and the interaction within the Viable Systems Model could be considered as:

System 1: The design based on the skills and experience of the designer
System 2: The co-ordination of these skills
System 3: The intelligent use and manipulation, the switching of information between cognitive abilities and practical skills.
System 4: Decision making, perspective shifts between usage and design
System 5: Meta-design/meta decisions (reflection, meta-modelling and policy)

Avison and Fitzgerald (1997) consider Beer's Viable Systems Model as a sophisticated guideline for the management of a complex system including a negative feedback of control.

Xu (2000) discusses and defines *the design approach*, and suggests that information system design and development should start with a system concept phase in four steps to develop an understanding and to define what is called the design approach:

- Identify and define systems/subsystems/dimensions and interactions.
- Examine systems/subsystems/dimensions separately and collectively.
- Apply the law of requisite variety referring to the match between the dimensionality implicitly represented in an information system and dimensionality within design and development.
- Deal with systems/subsystems/dimensions and interactions of different types with appropriate inquiring systems and tools.

In this introduction some important considerations of the design situation have been presented. The importance of combining a holistic view with a closer focus on a system, the complexity emerging within a system when people are included, and the need for a synthesis of different perspectives in a development project together with the learning process attached. A closer look at the designer role in a project is made with help from Beer's model and the systems approach is presented in the perspective of Xu (2000). This introduction is performed to make it possible to elucidate certain criteria for applying systems approach on the design situation.

5.2.1 Criteria for Systems Approach

As a summary of this introduction, considering the work of Avison and Fitzgerald (1995), Beer (1994), Flood and Carson (1993), Pourehnad and Robinson (2000) and Xu (2000), three criteria are specified to be used to examine the relevance of applying systems approach on a particular system of interest:

1. The system must be possible to identify, define and describe on an appropriate abstraction level with regards to its boundary and environment.
2. It has to be possible to study the system on different hierarchical levels.
3. Applying systems approach must contribute to understanding of a phenomenon or a process.

If these criteria are fulfilled the applying of systems approach can be considered appropriate.

5.2.2 Applying Systems Approach

Applying system approach to the characteristics of the design situation of the previous chapter can be considered as an extension of this characterisation. The design situation has been characterised from two different sources, a literature survey and two complementing extensive interviews. The behavioural and structural components within the design situation, together with the important concepts related to this, have been identified and exposed.

The application of systems approach will result in a perspective switch, from finding the content to extracting the essential components, processes, relations and interactions into a comprehensive system reflecting the design situation from a holistic perspective. From the different parts of the materials, essential and basic components have been abstracted to generate a generic and holistic exposure of the system. When performing a system identification based on the aim of this work, the context of the design situation can be considered a development project of an information system. The actual system that will be studied is the design situation. System identification is presented in figure 2.

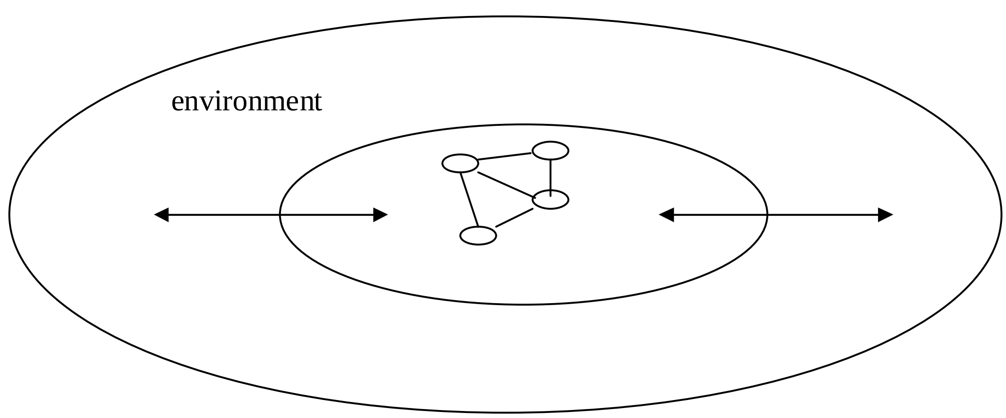

Fig. 2, System identification from a holistic view

Another approach to study a system is the traditional approach from the science paradigm with a reductionist view of the system. This means the studying of each and every component of the system without considering the whole system, without a holistic view. The problem with this view is the pitfall of suboptimisations and the loss of understanding of the whole system, see for instance Ackoff (1981). There is also the problem of getting lost among the countless parts or elements of a system that can be found. There is a danger that "The effectiveness of the whole is diminished by the shortcomings in many of its the parts", as Mullet and Sano (1995 p. 169), state. A holistic view is necessary for abstracting and selecting the appropriate subsystems.

When studying systems, Norman (1990) states that mental models are an important concept within design and he presents three models:

- The design model – a conceptualisation of the designer's view regarding functionality, learnability and usability.
- The users model – what the user needs to express the needs and requirements within the model, which is essential since it determines what is to be understood. The user requires knowledge of the system from the system image.
- The system image – in which the designer must ensure consistency with the conceptual model of the system.

When considering the materials of this work, trying to capture the design situation, there are some question needed to be asked; What is it that constitutes the design situation? What actors, objects and relations are essential for the making of a design situation? A system identification has to be made (Flood and Carson, 1993). Answering these questions means abstracting and identifying the main components and relations necessary to the design situation according to the materials of this work. Achoff's (1981) three steps of the systems approach are also to be considered. The containing whole of the design, the design situation, is explained and the objects within the design situation are explained, regarding functions and roles within the whole.

In doing so, the *interpretation* of the materials have resulted in six generic components and related attributes. There are four components and two inevitable attributes of the system identified, and together they constitute Norman's (1990) system image of the design situation. There is one important aspect to the design situation not listed here, the meta-design. Due to the materials of this work, meta-design is considered an implicit and indivisible part of the design itself. The components of the design situation that have been identified are of a general nature and they have been found through an analysis of the materials of this work. The components are:

- the designer
- the user
- the customer
- the design

Important system attributes or features found in the materials are:

- communication
- complexity

The necessary interaction and communication within the design situation is of a fundamental nature, expressed in both literature and interviews. The importance and the presence of complexity is not quite so obvious. Complexity is tightly coupled with communication as an intrinsic quality of human systems. The factors in the materials pointing to complexity as an inseparable attribute to the design situation, are certain preconditions, the social situation, the different perspectives involved and the politics within the design project. Complexity is related to people and things (Flood and Carson, 1993) and it is a consequence of mans limited cognitive abilities (Norman, 1990). O'Connor and McDermott (1997) and Avison and Fitzgerald (1993) states that human systems are complex systems.

Apart from the user, the customer and the designer, as a representative for the design team, there are also stakeholders to be considered. The concept of the customer could be expanded to include the company represented, or the enterprise initiating the project. In turn, the company also has its stakeholders that are concerned with the outcome of the project in a wider perspective. These stakeholders are not considered at this level of abstraction. According to the materials of this work, the stakeholders have an indirect influence on the design situation and the *interpretation* is that they are not an explicit element in the design situation. There is no explicit or direct link between the stakeholders and the design situation found in the materials of this work.

5.2.2.1 Tentative Models of Significant Interactions

The identified systems and components are of both abstract and concrete nature and for each of these a tentative model of a preliminary nature will be presented. These models or systems are to be used to clarify connections or relations and processes. The systems and their components are *interpretations* based on the materials of this work, exposing extracted significant components and relations.

For each tentative model the important factors belonging to the *context* of the system are identified. The general *consequential* factors are to be deduced from the model and its context, but the consequences have to be differentiated from the factors belonging to the context of the system. The consequences are emergent factors deduced from the design situation and its components.

The design situation

The system of actors, objects and relations of the design situation are identified and described in a tentative model of significant interactions. The design situation is described in Figure 3 according to the interpretation of the materials this work.

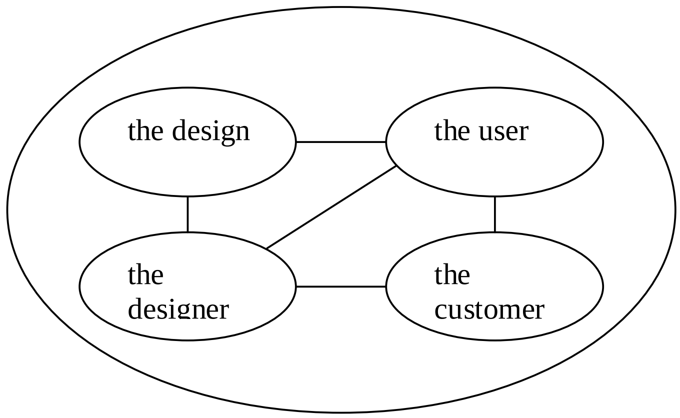

Fig. 3, A tentative model of significant interactions for the design situation

The main characters or objects of *the design situation* are *the designer* (van Gigch, 1991, Norman, 1990, Mandel, 1997, the interview with the usability designer), *the user* (Löwgren, 1993, Mandel, 1997, Avison and Fitzgerald, 1997, the interviews with the usability designer and the system developer), *the customer* (Germana, 2000, Pourdehnad and Robinson, 2000, the interviews with the usability designer and the system developer) as parts of a design project, together with *the design* itself. Between these elements there is a need for a well functioning interaction or *communication*. The design process is depending on this communication process, according to the interview with the usability designer, as is the *complexity* of the situation due to different personalities, perspectives, interests and goals for instance (Flood and Carson, 1993, Avison and Fitzgerald, 1993). *The user* and *the designer* are found to have a direct relation to the design, but no direct connection is usually found between *the customer* and the actual design. This is an influential relation, according to the interviews with the usability designer and the system developer.

The context of the design situation can be a development project of an information system and the contextual factors found within its subsystems. The consequence of the design situation is the system design and the consequential factors found within the subsystems or elements of the design situation.

The design situation is a complex, interactive, dynamic and evolutionary meta-design activity, according to the interview with the usability designer. Significant features found in all the materials, both the interviews and the literature, are the important concept of holism and ethics. A *holistic* perspective is a necessary attribute of all participants in the design situation, seeing the whole system of the design situation, when considering design on all levels of abstraction, according to the interviews with the usability designer, the systems developer and van Gigch (1991). The *ethical* considerations on design, and the processes within the design situation, is another attribute found in the materials of this work (van Gigch, 1991 and the interview with the usability designer). The social climate including communication and continuous decision making processes is another prominent feature according to the interview with the usability designer.
In order for a system to work or function there are the subsystems to consider. When considering this level of abstraction, there is a necessity that each of the subsystems is functioning towards the overall goals. These subsystems are a precondition for the whole system to function. Each of the subsystems of the design situation, together with its relational attributes of communication and complexity, will be considered.

5.2.2.2 Context and Consequences

Looking into each of the subsystems, the designer, the user, the customer and the design, the significant factors and relations constituting the system in Figure 3 are to be identified and defined. What factors or elements make the components (subsystems) of a system act and function the way they do? Considering this, it is important to differentiate these factors or components from those originating from and belonging to the *context* of the system and those that are general effects or *consequences* possible to derive from the system and its context.

The designer

The components and relations of the designer are deduced and identified from the materials of this work, and they represent the abstract components and relations within the designer system. They are described in Figure 4, a tentative model of significant interactions for a designer:

- ethics
- personality
- knowledge
- aesthetics
- paradigm
- ability

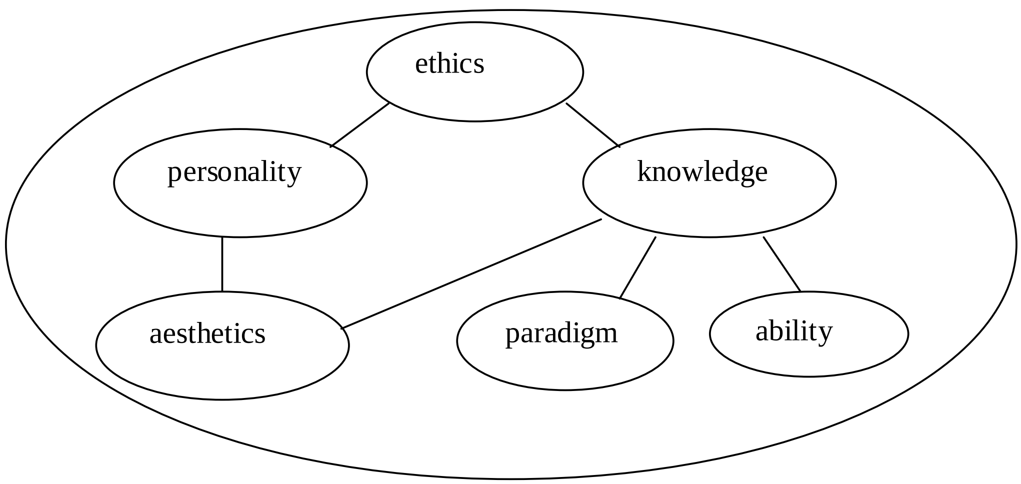

Fig. 4, A tentative model of significant interactions for the designer.

The *ethics* of the designer is a fundamental component, according to van Gigch (1991) and the interview with the usability designer. From the actual problem to be solved the goals are set and ethical considerations should be made within this process. The *ethics* and morality of the designer is related to the *personality* and the *knowledge* of the designer. According to the interview with the usability designer, ethical considerations also influence the social situation and the effects of the actual design when implemented in a context. In the co-operative social situation of a design project, the *personality* of the designer is important, according to the interview with the usability designer. The "S" or the total *knowledge* (Langefors, 1995) of the designer is related to the designers *paradigm* and perspective on the situation for work to be performed in. The *ability* of the designer includes skills and experience, according to the interview with the usability designer. Considering *aesthetics,* the designer can be considered an expert, not on the task but on entity that is to be designed, and on the design process and its conditions. The *aesthetics* of the designer is based on the designer's knowledge and personality. The design *ability* is to create a design based on cognitive demands appropriate for the user and the task (Mullet and Sano, 1995).

The context of the *designer* is shown in Figure 3 and it can also be considered made up of the *time* and *resources* attributed to a design project, according to the interview with the systems developer. There are also the user *needs* and *requirements*, *the project team*, *expectations* on the project and the *feedback* evolving from the communication and interaction within the design situation, according to the interviews with usability designer and system developer. The *designer* interacts with the *user*, the *customer* and the project team within a social situation and the result is the design eventually accomplished. According to the interview with the usability designer, the designer, as "the expert" within the design situation, must consider the goals of and the requirements on the design. From the *knowledge,* the *experience,* and the *paradigm* of the designer a methodology is chosen (van Gigch, 1991). The designer system has *dynamic* properties due to interaction and communication within the social situation of the design project. New knowledge and experience is gained through *feedback* and learning within the project (Pourdehnad and Robinson, 2000).

The Consequences deduced from the designer as a system (Figure 4), are the understanding of the necessity of *social competence* due to personality, ethics and knowledge according to the interview with the usability designer. Others consequences are and *motivation*, *creativity* and *commitment*, deduced from the ability of the designer (Ackoff, 1981) and *implementability* of design from the aesthetics of the designer and the whole designer system (Löwgren, 1993 and the interview with the usability designer). These are consequences deduced from applying systems approach on the designer system and to be distinguished from the components and the context of the designer.

The user

The components and relations of the user are deduced and identified from the materials of this work, and they represent the abstract components and relations of the user system. They are described in Figure 5, a tentative model of significant interactions for the user:

- ethics
- aesthetics
- knowledge
- personality
- needs

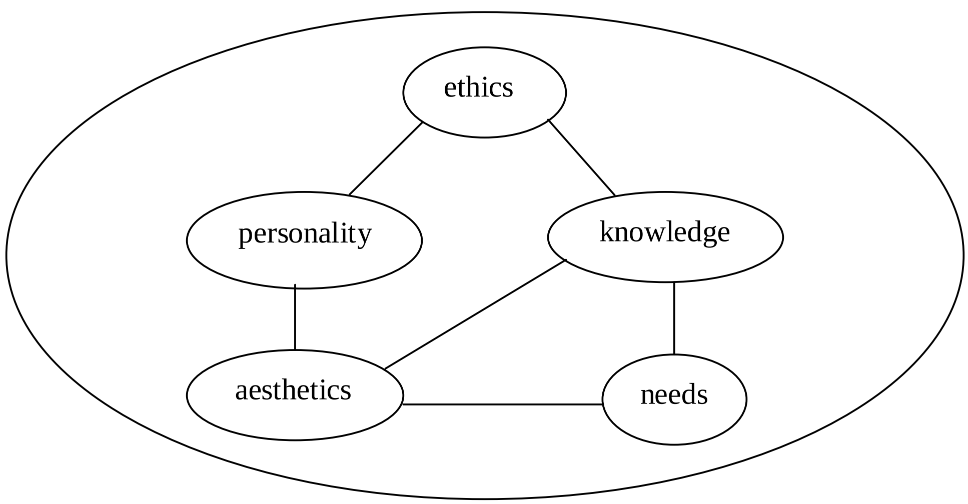

Fig. 5, A tentative model of significant interactions for the user

According to the interview with the usability designer, the *ethics* of the user is a component to consider within the user situation. The new design and the implementation of it and the communication process with decision making are to be considered. The ethics of the user is related to personality and knowledge. The user *aesthetics* is the stylistic preferences that should be applied to the design (Ackoff, 1981), influenced by the *personality*, *knowledge* and *needs* of the user. The *knowledge* related to *ethics* and the *needs*, indicates that the user is the task expert and a source of important requirements and needs for the system to be (the interview with the system developer, Löwgren, 1993 and Norman, 1990). Within the design situation it is the users cognitive needs on the design related to usability, according to the interview with the usability designer, Norman (1990) and Löwgren (1993), that is considered and satisfied by the competence and aesthetic ability of the designer. As a part of the communication process involved the *personality* of the user is important, according to the interview with the usability designer.

The context of the user is shown in Figure 3. There is also the *project team,* the *time* of the *project*, other obligations and the *expectations* on the project (the interviews with the usability designer and the systems developer). When communicating with the designer and the project team there is a *feedback* mechanism present, resulting in new insights and new knowledge (Pourdehnad and Robinson, 2000, Norman, 1990).

The consequences deduced from the user as a system (Figure 5), are the understanding of the necessity of promoting *learning,* deduced from the fulfilling of the needs, which leads to possible *changes* of both needs and requirements (the interview with the usability designer and Germana, 2000). These *changes* also result in an increased *complexity* as a consequence of human interaction with a system (Flood and Carson, 1993, Avison and Fitzgerald, 1997). According to the interview with the usability designer, *change* is the heart of design and lack of resistance to change is a possible consequence due to failure in the user centred approach (Ackoff, 1981).

According to the interview with the interview with the usability designer, the consideration of these changes, needs and requirements are of an outmost importance to the final design result. Other consequences deduced from the user system and its context are *motivation*, *creativity* and *commitment* (Ackoff, 1981). According to Löwgren, 1993 and the interview with the usability designer, p*articipation* and *implementability* are two needed and related consequences together with the *social competence* also related to the users *participation* in the social situation of the design situation. These are concepts that are consequences deduced by applying systems approach on the user system, and to be distinguished from the components and the context of the user.

The customer

The components and relations of the customer are deduced and identified from the materials of this work, and they represent the abstract components and relations within the customer system. They are described in Figure 6, a tentative model of significant interactions for a customer:

- ethics
- knowledge
- personality
- needs

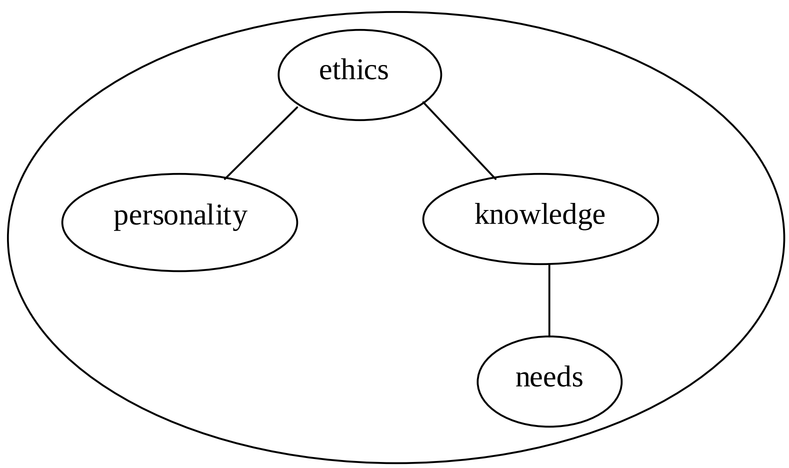

Fig. 6, A tentative model of significant interactions for the customer.

According the interview with the systems developer, the customer acts as a *client* in the design situation. The *ethics* of the client concerns the morality of the whole project, according to the interview with the usability designer. A development project or implementing an information system generates effects on both the social and the working life of those affected by it, and according to the interview with the usability designer there are ethical considerations to be taken in this process. The overall goals or requirements are the customers as an initiator and financier of the project, according to the interview with the systems developer. These goals are shared with stakeholders internal or external to the company represented by the customer, according to the interviews with the systems developer and the usability designer. Within these goals there are also ethical considerations that has to be made towards the whole project and the implementation of the result.

Related to ethics of the customer is *personality* and *knowledge*, important in the communication and the necessary discussions within the design team, according to the interview with the usability designer. Customer satisfaction within the design situation can only be obtained if the designer acquires knowledge and understanding of the customers *needs* (Germana, 2000, Pourdehnad and Robinson, 2000). The *needs* are closely related to the *knowledge* of the customer, according to the interview with the usability designer.

The context of the customer is shown in Figure 3. There is also a connection to the business and the stakeholders that the customer as a client represents. According to the interview with the systems developer, the customer sets the *time* limits, the resources and the financial frame to the design project and thereby gives rise to one aspect of the complexity of the situation. The clients *expectations* and the *project team* can be considered as other contextual elements (Pourdehnad and Robinson, 2000, Germana, 2000).

Consequences deduced from the customer as a system (Figure 6) and its context are the understanding of the customer *influence* and the necessity of *feedback* to the design team, according to the interview with the usability designer, and the decision making regarding *time* and *resources* for the project, according to the interview with the systems developer. The *customer's* needs or goals are validated in the communication process between the designer, the customer and the user. Since the customer initiates the project, the authorisation and authentication of the design process is within the power of the customer, according to the interview with the systems developer. These are consequences deduced by applying systems approach on the customer system and to be distinguished from the components and the context of the customer.

The design

What constitutes the design? What makes the design manifest itself the way it does? The following components and relations are deduced and identified from the materials of this work, and they are considered significant within the design system including both concrete and abstract elements. They are described in Figure 7, a tentative model of significant interactions for the design:

- method or methodology
- social climate
- the designer
- the user

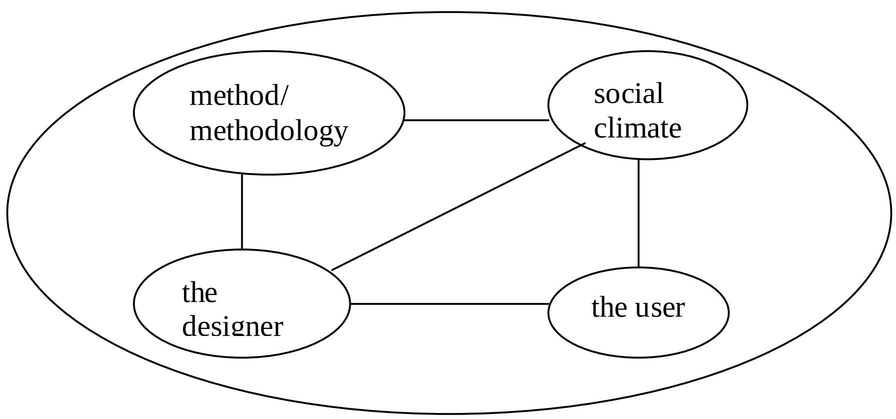

Fig. 7, A tentative model of significant interactions for the design.

The *method* applied on the design situation is closely related to the role of the *designer* and it also influences the *social climate* of the design team, according to Avison and Fitzgerald (1997) and the interview with the usability designer. The *user* is related to the *designer* and the *social climate,* due to the interactions and communication within the design process, according to Löwgren (1997) and the interview with the usability designer.

According to the interview with the usability designer and Mullet and Sano (1995), an important consideration within the applied method is *the user centred* *approach* and *usability*, which could be considered related to Ackoff's (1981) "selecting a mission" for a project. The mission is a general purpose of the process for its participants and stakeholders. The importance of the designer and the user interaction is accounted for earlier, by Germana (2000) and others. As experts on design and on the task both the user and the designer, according to the interview with the usability designer, influence the social climate of the design team.

The context of the design is the design situation shown in Figure 3, which, according to the interview with the usability designer, should be of a meta-design character. The *meta-design* perspective defines the reasons and the (philosophical) design foundation for the whole design project including the metamodelling of the design situation (van Gigch, 1991). Contextual factors belonging to the design are also *demands* from "the market" influencing the design process (Norman, 1990). *Time* and *resources* for a project are also parts of the design context, but these are already accounted for.

Consequences deduced from the design as a system (Figure 7) and its context are the understanding of the need for *learning*, *evolution*, *feedback*, *change*, *participation* (see Ackoff (1981), Andersen (1995) among others) and *engagement* or *commitment* (Ackoff, 1981) taking place within the social climate of a design project. This also points to the concept of and the importance of consensus (Ackoff (1981) as a result from focusing on the ultimate values of the design situation. These concepts are consequences deduced by applying systems approach on the design system and to be distinguished from the components and the context of the design.

Communication

Communication is an activity, which is taking place within the relations and the interactions of a system. Communication is an important consideration within the design situation. The following components participating in communication are identified within the design situation:

- the designer
- the user
- the customer

The components communicating within the design situation are the humans in the system. All components of the communication system within the design situation have previously been accounted for. The objects of communication constituting the design (what is communicated: goals, requirements etc) are exchanged between the *customer*, the *user* and the *designer*. They go through a political process of negotiation within a social situation influenced by the social climate and eventually result in a design. According to the interview with the usability designer, design is managing the design situation through *communication*. Some sort of consensus then should be reached within the communication process (Ackoff, 1981). The *communication* happening in the relations within the system is a complex concept within the design situation.

The context of the communication is the processes of *politics* and *theoretical reasoning* with *decision-making* taking place within a *social climate* of a certain quality, constituting the social situation, all according to the interview with the usability designer.

Consequences related to communication are *feedback* and *learning* within the design process (Pourdehnad and Robinson, 2000), leading to *changes* that has to be managed, according to the interview with the usability designer. The goals and objectives of the project have to be validated in a communication process between the involved participants. Without communication there is no relevant design since design situation is a social process, according to the interview with the usability designer. Due to involved participants and their different perspectives there is a *complexity* involved in the design process (Flood and Carson, 1993, Avison and Fitzgerald, 1997).

Complexity

Complexity is a consequence of, and an important property to consider within the design situation. This means that the factors responsible for the complexity of the design situation must be made explicit. What are then the factors responsible for complexity? As stated earlier complexity is a result of human-human and human-system interaction (van Gigch, 1991and Flood and Carson, 1993, Avison and Fitzgerald, 1997). The social situation and the design project can then be identified as overall contributors of complexity within the design situation. This makes the design situation itself an illustration and a description of the complexity present. Understanding and dealing with complexity makes it necessary to understand the contributors to complexity.

Complexity is a part of and an effect of human interaction and human interaction with and within a system (van Gigch, 1991, Flood and Carson, 1993). The interaction is taking place within the *social situation* of the *design project* and c*omplexity* is closely connected to the human *communication* performed in the social situation.

Complexity is a quality or a property of a context, the design situation of a development project for instance. The participant’s different *personalities*, the *social competence*, the *cognitive styles* and *worldviews* can be regarded as conditions for or natural sources of complexity, according to the interview with the usability designer and Avison and Fitzgerald (1997). The personalities, inherent to the participants, are important factors within the *social situation* and the political process constituting the *design project* and the *design situation*. *Time*, *flexibility*, *change* and *functionality* are other factors affecting the complexity of the design project. The *time* scheduled for a project, the *users* and the *customers* wish for flexibility and the needed *functionality* (the interview with the system developer), the *changes* due to a *feedback* process of *learning* and evolution (Norman, 1990) all contribute. According to the interview with the system developer, complexity is the dark side of flexibility. The more functionality, features and possibilities, the greater the complexity.

5.3 Analysis of Effects and Consequences

The aim of this dissertation is to study the possibility and the contribution of applying systems approach on the design situation of information systems design, together with identification of the appropriateness in doing so. This means that systems approach has been applied to the design situation to make it possible to find and analyse the effects or consequences evolving.

The design situation and the system images of the previous chapter are tentative models and an interpretation of what could be considered as the most prominent and important features constituting the design situation with its elements and relations. Related to the content of the models are the *contextual* and *consequential* factors. This analysis considers the effects and consequences possible to deduce from applying systems approach on the design situation.

To be able to do this, three objectives were identified:

1. A characterisation of the design situation.
2. To apply systems approach to the design situation.
3. To analyse the effects and consequences of applying systems approach.

In the previous chapters the first two objectives of this dissertation has been addressed, processed and presented. A characterisation of the design situation has been made. This is done from a literature survey complemented with two extensive interviews. Then an application of systems approach has been performed on the results from achieving the first objective, exposing the design situation from two levels of abstraction.

The third objective is finding and analysing the effects and consequences of applying systems approach to the design situation. This analysis includes a presentation of the tentative models related to the design situation. From the models and their contextual factors of the previous chapter, the deduced general consequences are looked upon and analysed. A supplementary analysis of the normative aspects of the models is also performed.

5.3.1 The Design Situation

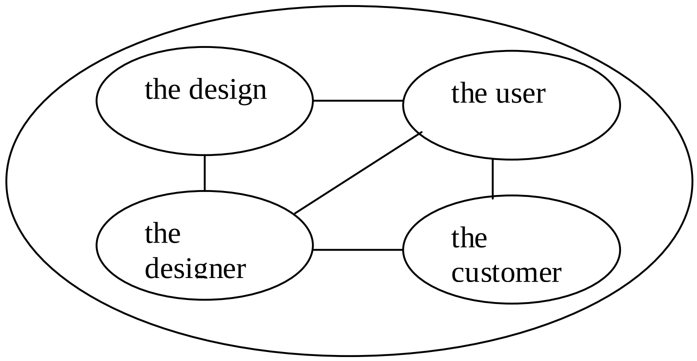

Fig. 3, A tentative model of significant interactions for the design situation

The design situation is a complex, interactive, dynamic and evolutionary meta-design activity. *The context* of the design situation is the development project of an information system, together with the abstracted contextual factors of the subsystems. The communication and the complexity evolving are important attributes to the design situation. There are also stakeholders and business considerations to be considered together with software and hardware aspects. The *consequence* of the design situation will be the actual application or information system and its interface and the general consequences inherited and abstracted from the subsystems.

Supplementary analysis

When studying Figure 3, the design situation as a system and as a whole, three inevitable actors and one object are exposed, the designer, the user, the customer and the design. There are relations found between all these entities, except between the customer and the design, which has an indirect relation. Between the designer and the user and between the designer and the customer there are communication processes, between the designer and the user there is also a design process. The importance of *holism*, of a holistic perspective on all levels of abstraction, and *ethical* considerations from the designer, the user and the customer are all attributes of a good design situation. There is an apparent complexity exposed due to necessary interaction between the participating actors. This complexity has to be managed and there is a need for appropriate tools for dealing with this complexity. Systems thinking and systems approach are, according to the materials of this work, appropriate tools to manage the complexity of the design situation.

The input to the design situation is the task and the output is the designed solution. The actual design is a result of decision-making and information processing within the communication processes of the design situation, together with the present social situation characterised by a certain degree of complexity. The communication within the interaction between the elements of the design situation makes it a dynamic, constantly changing system.

The dynamic features and the need for holism and ethics are treated in the usability designer-interview, as is the importance of the social situation within a design project. Flood and Carson (1993) discuss the use of systems thinking in dealing with complex systems.

5.3.2 The Designer

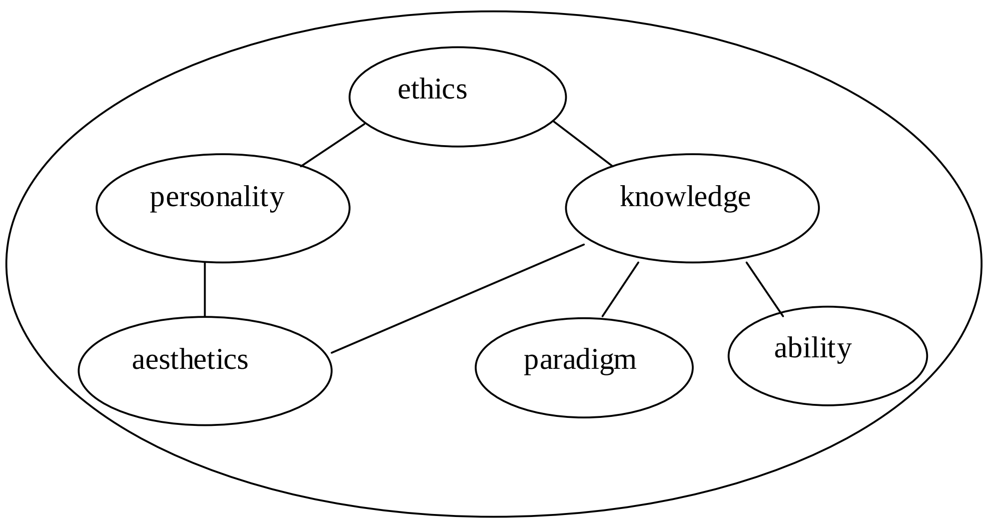

Fig. 4, A tentative model of significant interactions for the designer.

Systems approach applied to the designer in Figure 4 shows the importance of designer *ethics*, of *knowledge* and *ability* (skills and talent), of the *aesthetics* of the designer for presenting the design according to the users requirements. The *personality* of the designer is an essential element of the social climate. Based on the knowledge of the designer a *paradigm* of work is chosen. The dynamic property of the designer is also identified.

General consequences and analysis

A consequence of applying systems approach to the designer as a system, are obtaining understanding of the elements of the designer system in order to describe and explain the identified consequences and concepts deduced from the model (Figure 4). The consequential concepts are *social competence, motivation*, *creativity*, *commitment* and the importance of the factors leading to *implementability* of design, these are all to be considered within the designer system. Another contribution is the identification and the understanding of the complexity characterising the designer system and the design situation. Systems approach applied to the designer makes it evident to consider these factors within the designer system. The necessity of considering these factors in a design project is supported in the materials of this work.

Supplementary analysis

The work of the designer is based on the goals and the requirements of the user and the customer, expressed in the social interaction within the design project. The designer can also be considered to have a responsibility for system identification and the choice of paradigm including methods or methodology. The choice is based on the knowledge and experience and the personality of the designer. Within the communication process of the social situation, the designer must be a decision-maker and should be a leader as well as a visionary. In order for the designer to fully master the design situation there is a need for *ability* leading to creativity and commitment. Creativity is a source of inspiration, which makes it possible to remove constraints on and within the design process. Commitment generates inspiration and also helps to remove the users possible resistance to changes in the work environment. The design process is a decision-making process where the designer should act as a “planner leader” generating a proactive influence on the design process according to systems design.

Since the result of the design situation or the design process is to be implemented in a real world context there are ethical considerations to be taken considering the consequences of this implementation. The relations and the decision-making within the social situation also demand ethical considerations from the designer. Design can be seen as the product of a communication process. As an expert on design, which includes aesthetic values, the designer's perspective also should include meta-design considerations, the conditions and reasons for the design to be expressed in a certain way. This also should include dealing with generic problems, regardless of their origin, requirements to be met by the modelling or the design process, the decision making and the important process of reflection and thinking. The meta-design perspective of the designer is established in literature (van Gigch, 1991) and in the interview with the usability designer, where design was considered a meta-design activity. The fundamental importance of the designer and the designer's different roles is identified by applying of Beers Viable Systems Model to the role of the designer. The designer could be considered a keeper of all the necessary elements of a viable system.

The role of "The expert" is not something static. It is a dynamic property due to constant interaction within the social situation and the dynamic feature of the goals and the requirements.

The designers role as an architect, a leader and a visionary is discussed by Mandel (1997) and van Gigch (1991) and the designer's "S", total life experience (and knowledge), by Langefors (1995). Ackoff (1981) considers the use of creativity and commitment and the meta-design perspective could be studied in van Gigch (1991). The ethics of the designer is accounted for in van Gigch (1991) and in the interview with the usability designer who also discuss the necessary social ability. The Viable Systems Model is presented in Beer (1994).

5.3.3 The User

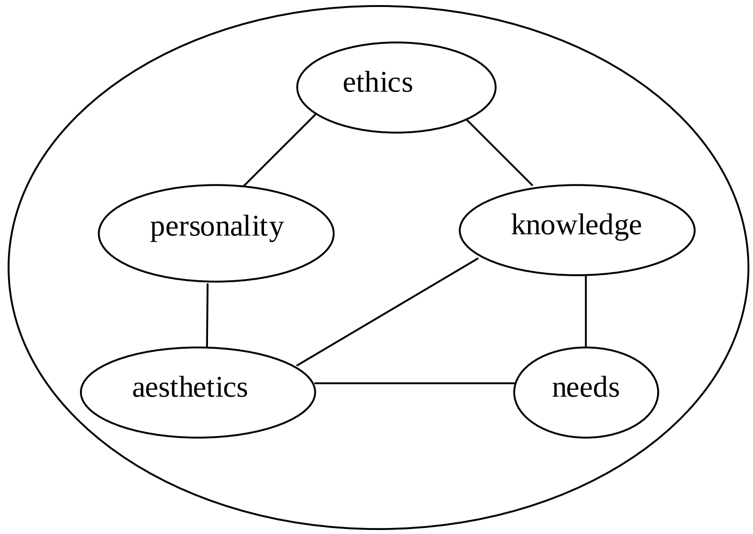

Fig. 5, A tentative model of significant interactions for the user.

The importance of user *ethics* is shown in figure 5. The *ethics* of the user is of a general nature and that of a task expert, with considerations on the new design within the communication processes of the design situation. *Personality* and *knowledge* are factors that influence the ethics of the user. The *aesthetics* of the user influences the design situation and is related to the personality, knowledge and the needs of the user. The *needs* (cognitive and others) of the user are determined by the knowledge and the stylistic preferences, expressed through the aesthetics of the user.

General consequences and analysis

A consequence of applying systems approach to the user as a system are obtaining understanding of the elements of the user system in order to describe and explain the identified consequences and concepts deduced from the model (Figure 5). The consequential concepts are *learning* and *change*, the possible *resistance to change* (which needs to be dealt with) related to *implementability*, *motivation*, *creativity* and *commitment*, *participation* and *social competence*. These are all to be considered within the user system. Another contribution is the identification and the understanding of the complexity characterising the user system and the design situation. Systems approach applied to the user makes it evident to consider these factors within the user system. The necessity of considering these factors within design projects is supported by the materials of this work.

Supplementary analysis

The user is a task expert and the keeper of the necessary needs and requirements on the design considered in the design process. Together with social, contextual, cognitive and other needs, the users stylistic preferences and aesthetic values should be considered and integrated into the design process. This participation can generate a user commitment to the design process, needed to overcome a possible resistance towards change as well as an inspiration.

From the user perspective the design process is a result of a communication process with other participants in the development team. This makes the *social situation* within the project essential. In the design process there is also a learning process involved due to the human interaction. An important part of the learning process is the increased user knowledge and experience with the task to be designed. This could results in a need for (necessary) changes in the design.

In order for the design process to develop, to exploit, make use of and to deal with these changes, user participation is a necessity. The user element of the design situation should be an active component. The striving for an optimisation of a system design demands user participation. The *knowledge* and the perspective of the user are dynamic features due to the learning process included in the design situation.

User participation and usability goals are a necessity within a holistic perspective on the design. These matters are discussed in Löwgren, (1993), Norman, (1990), and in the interview with the usability designer. Social competence and communication is accounted for in the interview with the usability designer. Aesthetics, resistance to change, commitment, creativity and motivation are discussed in Ackoff (1981). Learning is accounted for in Pourdehnad and Robinson (2000) and the user needs are considered in Bødker (1998) and Mandel (1997).

5.3.4 The Customer

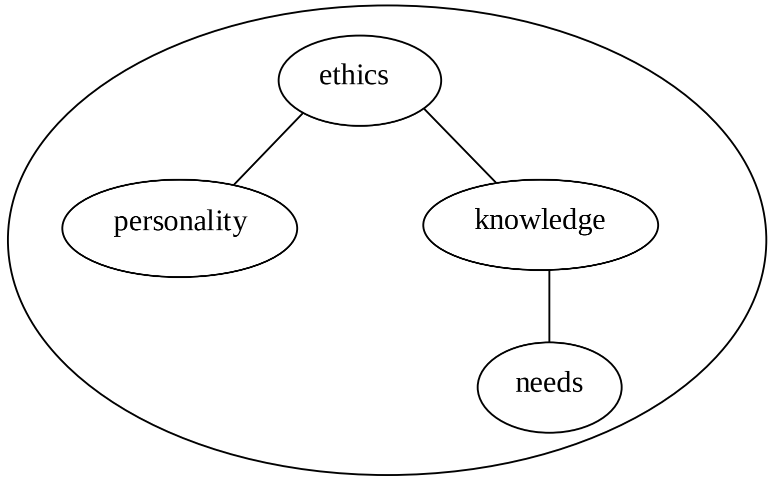

Fig. 6, A tentative model of significant interactions for the customer.

As “the client”, the customer is an essential actor in the design process. Apart from setting the timely and financial frames on the project, and thereby give rise to complexity at a more practical level, the overall goals and requirements of a development project are tightly connected to the customer. The project as a whole need to be considered as is the *ethics* of the whole design project. As shown in figure 6, p*ersonality* and *knowledge* influence the *ethics* of the customer, essential to the design situation.

The *needs* and requirements on design are related to the *knowledge* of the customer. One important aspect on a development project is financing, deciding on the appropriate level of resources to and funding for the project. This also includes other concerned stakeholders. The customer, as a part of the design situation, has dynamic properties due to new insights and external factors. Environmental changes, business, organisation etc, and interaction with stakeholder can have an impact on the design situation communicated through the customer.

General Consequences and analysis

A consequence of applying systems approach to the customer as a system, are obtaining understanding of the elements of the customer system in order to describe and explain the identified consequences and concepts deduced from the model (Figure 6). The consequential concepts are *influence*, *time* and *resources* for the project and *feedback* to the design team. These are all to be considered within the customer system. Another contribution is the identification and the understanding of the complexity characterising the customer system and the design situation. Systems approach applied to the customer makes it evident to consider these factors within the customer system. The necessity of considering these factors within design projects is supported in the materials of this work.

Supplementary analysis

In the communication process the customer is also necessary for performing authentication of involved personal, authorisation of decisions, and as a source for validation of major decisions related to the design situation. The customer is an important actor on the design situation in setting the standards for the whole project.

The customer, just like the user and designer, has complex *dynamic* features due to at least two factors. The customer is connected to and performing in a negotiating process with those parties belonging to the *environment* of the design situation. These parties could vary and change due to financial and business reasons. Due to the communication processes within the design team there are also the effects of new insights and of seeing new possibilities to consider. With this new knowledge and needed flexibility, there are changes and increased complexity to consider.

Complexity due to interaction by the customer is discussed in the interview with the systems developer as is authentication and project frames and requirements. The importance of customer satisfaction is discussed in Germana (2000) and Pourdehnad and Robinson (2000), and the customer as an influencing factor and the ethics is accounted for in the interview with the usability designer.

5.3.5 The Design

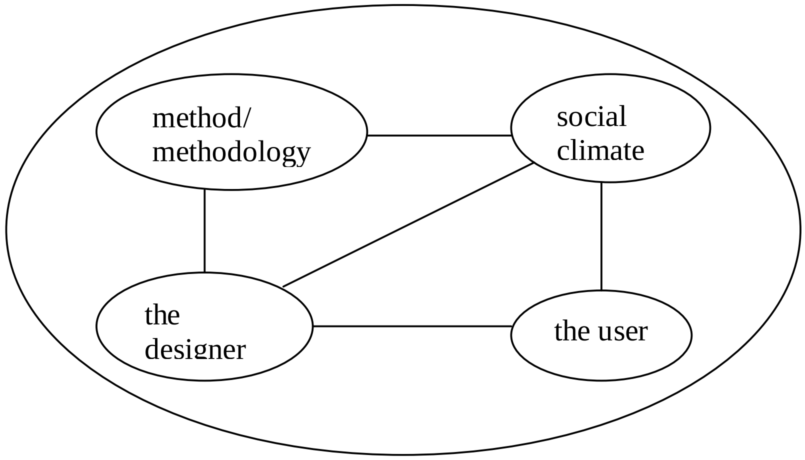

Fig. 7, A tentative model of significant interactions for the design.

Design is a product, the result of a design process, and the process producing the product. It is an abstract process and a concrete phenomenon at the same time. Design, both as a product and a process is dynamic and evolving over time. As a product it is evolving due to the interaction and communication between the designer, user and customer. As a process it is that interaction and communication.

The *designer* and the *user* are accounted for earlier and together they act in a *social climate*. Based on the task and the social climate the designer chooses the appropriate *methodology* or *method*.

General consequences and analysis

A consequence of applying systems approach to the design as a system, are obtaining understanding of the elements of the design system in order to describe and explain the identified consequences and concepts deduced from the model (Figure 7). The consequential concepts are *learning*, *evolution*, *feedback* and *change*. These constitute the dynamic property of the design. Other consequences are *participation* and *engagement* or *commitment* among the involved actors in the design process or project. All these concepts are to be considered within the design system. Another contribution is the identification and the understanding of the complexity characterising the design system and the design situation. Systems approach applied to the design makes it evident to consider these factors within the design system. The necessity of considering these factors within design projects is supported in the materials of this work.

Supplementary analysis

The designer and the user are accounted for earlier in this chapter. The importance of an appropriate method within design is made clear when applying systems approach on the design system. The method or methodology is a selection made by the designer, influencing the important social climate within the design team. Related to design is the concept of meta-design, the meta-modelling of the design and the design process, a consideration of the designer.

Design can be considered a result from an interactive communication process with the perspective of a user centred approach. This communication process is based on the actual task of design, with the goals to be achieved and the systems services and functions to be accomplished. Usability, achieved through a user centred approach, can be considered a general purpose of the design situation, the way to a good design and user situation. This is achieved within the social situation with a user participation in the design project and the design situation. This points to the need for management of the social situation within the context of the design situation. The human interaction within the design process generates a complexity needed to be considered and to be sufficiently managed

Considering design as a dynamic system with a learning property, the system has to be adaptive and manage changes. The adaptive behaviour of the design system is of a cybernetic nature, concerning regulation and control from the participants within the social situation.

According to the interview with the usability designer, design is to a large extent a *dynamic* result of a communication process with a user centred approach and within a certain context and a social situation. Learning is discussed in Pourdehnad and Robinson (2000) and evolution, feedback and change in Norman (1990). Ackoff (1981) discusses participation and commitment. Methods and methodologies are accounted for in van Gigch (1991) and the interview with the systems developer and Van Gigch (1991) discusses meta-design. User involvement increases the complexity of the situation due to increased human interaction (van Gigch, 1991). Usability and the user centred approach is discussed by Löwgren (1993), Mandel (1997) and Avison and Fitzgerald (1997). Communication and the social situation are accounted for in the interview with the usability designer.

5.3.6 Communication

Communication is to a large extent related to the complexity within the design situation. It should not be considered a component or an object of the design situation, rather an important feature of it due to the interaction taking place within the design situation.

General Consequences and analysis

Communication is an intrinsic and inevitable feature of the design situation. Communication must be understood together with its identified concepts and consequences. The consequential concepts of communication are *feedback* and *learning*, which leads to *changes* and *complexity*. These are all to be considered in within the design situation. The identification and understanding of the *complexity* involved is also necessary. These factors are all to be considered within the design situation. The necessity of accounting for these factors in design projects is supported in the materials of this work.

Supplementary analysis

Communication is a prerequisite for the decision processes to take place in order to reach the goals of the design process. The human interaction within the design situation also includes an interpretation process of the objects of communication to possibly obtain some sort of consensus.

The politics that takes place within the social situation constitutes a social climate of a certain quality within the project team. Politics is negotiating, discussions, decision-making and meta-decision making in order to achieve a common goal.

Politics is related to creating and integrating different perspectives and objectives into a common platform for all participants. The selection and the right combination of involved persons are important in a project and a basis for the success of the design process.

Communication involves theoretical reasoning (the meta-design of the design project) concerning the design situation, the project, the design process, its goals and objectives, together with a decision making process including a meta-decision making perspective. Communication can or should include a feedback mechanism of learning, resulting in a continuous need for changes in the process and a possible need for consensus regarding design decisions. Without communication there can be no proper validation process of the goals and objectives in the design process. The validation process also includes discussions and reasoning, a social process, and is as such influencing the level of complexity involved.

The politics, the social climate and the theoretical reasoning of the design situation are discussed in the interview with the usability designer. Meta-decision making is considered by Wang (2000) and meta-design by van Gigch (1991).

5.3.7 Complexity

Communication within the design situation is inevitable and complexity is a consequence of that. *Complexity* is a result of human-human and human-system interaction. In the design situation there can be two main factors identified with complexity as a consequence, the social situation and the design project itself. This means that complexity is an inherent property of the design situation, due to factors previously accounted for. In the design situation, complexity has to be prepared for, dealt with and overcome. Knowledge and awareness of the conditions for complexity are tools for doing so.

Supplementary analysis

Important contributors to complexity within the design situation are the design project and the social situation. These are related to the perspectives of the participants, the personalities, social capacity, cognitive styles, worldviews within the political process within the design project.

The time restrictions, due to financial considerations in the background of a design project, also contributes to complexity. This means that project planning, project management and the inclusion and use of customers (and stakeholders) knowledge is essential. There is a need for a comprehensive and holistic management view of the design situation with its preconditions and consequences in order to deal with the complexity and make it manageable. Three other possible contributors to complexity are identified as:

- The unreflective wish for systems *flexibility* from both customer and user. Too much flexibility generate complexity in design and uncertainty and doubt when interacting with a system, leading to ineffective use and poor result. These are considerations related to Flood and Carsons (1993) discussion about the influence that interacting with objects has on a user.

- Fear of change and *change* in design as a consequence of a learning process. Both aspects contribute to complexity, the first from a social perspective and the second from a project management view. Change is also an attribute to the systems interaction with the environment, with external stakeholders and business considerations for instance. When dealing with change there is a need for holism and a systems view of a problem situation, since change anywhere in a system could affect the whole system. Related to the concept of change is emergence or the emergent properties of a system due to interaction of its parts.

- Necessary or unnecessary *functionality* is a consideration needed. The technological possibilities of today, implying that what seems possible to develop sooner or later will be developed – and put into use, is a possibility as well as it could be a blind alley, both contributing to complexity.

Complexity as a consequence of human interaction and communication within *the social situation* has been stated earlier in this work. The perspectives, personalities, goals and worldviews of the different participant have to be merged into a unity within a politic process of negotiation and considerations. The negotiations and the adjustment of personal views and opinions is a cybernetic feedback process to ensure homeostasis within the dynamic equilibrium state of the system or of the design situation.

The time and the financial considerations, together with the need for flexibility and functionality, are discussed in the interview with the systems developer, change is discussed by Ackoff (1981), and complexity as something related to people and human interaction by Flood and Carson (1993).

Summary

The context of the design situation is the development project of an information system and the consequence of the design situation will be the design of the system and the actual system. The gains and consequences of applying systems approach on the elements of the design situation can give rise to an understanding of the following:

- Social competence, motivation, creativity, commitment and the importance of factors leading to implementability deduced from the designer system.
- Learning and change, the possible resistance to change (needed to be dealt with) related to implementability, motivation, creativity, commitment, participation and social competence deduced from the user system
- The influential character of the customer and the important time and resources for the project and the necessity of feedback to the design team.
- Learning and evolution, feedback and change, participation and commitment deduced from the design system.
- Feedback and learning, leading to changes and complexity due to communication and interaction.

6 Results

The aim of this dissertation is to identify the possibility, appropriateness and contribution of applying systems thinking and systems approach on the design process within information systems design and human-computer interaction. This is done to obtain knowledge and understanding of the preconditions of the design of information systems. What are the necessary components and relations within the design situation? In the materials of this work the design situation is characterised and systems approach has been applied to the design situation. Possible effects and consequences evolving from applying systems approach is analysed and presented.

First some general aspects from the literature regarding information systems and the complexity of these (Xu, 2000) are presented. It is a complexity generated by the fact that information systems include both interaction between technology and people and an interaction between the system and the environment (Flood, 1990). Due to the human unpredictability of the interactions within these systems, it is considered very important to apply a holistic system perspective on the design process (Avison and Fitzgerald, 1997). The need for multidisciplinary development teams was also stated (Avison and Fitzgerald, 1997) together with the intrinsic learning process as a consequence of the different perspectives on design (Avison and Fitzgerald, 1997 and Pourdehnad and Robinson, 2000).

The possibility and *appropriateness* of applying the systems approach to the design situation can be considered answered by fulfilling the criteria for doing so identified in chapter 5.2. The criteria identified were:

1. The system must be possible to identify, define and describe on an appropriate level with regards to its boundary and environment.

The design situation with its elements and relations has been identified and defined. The design situation is considered within the context of information systems development and has the elements of the designer, the user, the customer and the design.

2. It has to be possible to study the system on different hierarchical levels.

The design situation as a whole has been identified and described together with the next sublevel in the systems hierarchy. Each element has been identified together with included subelements and their relations.

3. Applying systems approach to the design situation must contribute to improved understanding.

The three steps of systems approach, according to Ackoff (1981) were applied to the materials of this work. The containing whole, the design situation, to the object of design is identified and explained. The behaviour and the properties of the design situation are accounted for. The behaviour and the properties of the objects within the design situation are explained, regarding the roles and functions within the design situation.

This means obtaining an understanding of the design situation and of the consequences from applying systems approach, that otherwise not would be possible to obtain. The amount of learning and understanding achieved when a task is performed is a qualitative consideration and thus hard to measure and evaluate. In chapter 5.3 an analysis of the effects and consequences of applying systems approach on the design situation and the knowledge obtained have been presented. The content of the analysis can be considered as a fulfilment of the third criteria of improved understanding when applying systems approach.

The appropriateness of applying systems approach on the design situation is connected to the value of doing so. Value, just like learning and understanding, is a qualitative consideration and hard to identify. To find the appropriateness and the contribution of applying the systems approach on the design situation, three objectives were set up. These objectives can be considered met and accounted for.

A characterisation of the design situation is made. The systems approach has been applied to the design situation, and the effects and consequences of doing so have been analysed. The complex, interactive, dynamic and feedback nature of the design situation is exposed, with its four basic components: the designer, the user, the customer, the design and their interactions, together with the communication taking place and the complexity involved.

The importance of personality, ethical considerations and aesthetics within the user and designer is shown, as is motivation, creativity, commitment, participation and social competence, together with necessary user needs and learning leading to change. The importance of the customer and the necessary inclusion of customer ethics, knowledge and needs is also shown together with the influential nature of the customer and the importance of customer feedback. The dual nature of design is exposed as its necessary user involvement with learning and evolution, feedback and change and participation and commitment as consequences.

The importance of communication within the relations of the system has been identified. Communication is a fundamental concept, including politics, theoretical reasoning and feedback. The complexity of the design situation, inherent to communication, is exposed as well as its possible sources. Complexity needs to be dealt with and managed within the design situation.

The contribution of applying systems approach on the design situation can be summarised as:

- The tentative models constituting the design situation.
- The main components of the design situation have been identified.
- The position, the roles and the necessary elements of the design situation are shown.
- The nature of the relations, the necessary communication within and between the components is shown.
- The design situation as a hierarchical system has been discussed.
- Arguments for holism and holistic perspectives within the design situation are presented.

- The dynamic features of the design situation and its subelements have been shown.
- Consequences of applying systems approach on the design situation and deduced from the models, are identified, described and explained.
- Understanding of the conditions for the design situation is obtained through the consequences from applying systems approach.
- The complexity of the design situation is exposed.
- The nature of the communication involved is shown.

Through the systems approach the importance of applying a holistic view upon the design situation and the design process is established, as is the need for appropriate tools when dealing with the complexity of the design situation. The design situation is a communication process and within this process there is a social context or situation generating complexity. This means that communication and complexity is inevitably interlinked and thus has to be considered and managed. Systems thinking or systems approach can be considered an appropriate tool for dealing with both these fundamental features of the design situation.

6.1 Discussion

The first thoughts when starting to work on this dissertation, was more directly focused applying systems approach to the reading of, browsing and navigating through applications. During the work the focus shifted towards the more general design situation in order to identify the conditions and the preconditions necessary for designing proper and easy navigated information systems. Applying systems approach on the design situation was not an attempt to capture or define the cognitive considerations to be used for creation of a workspace or a perceptual system. Rather it was to find a situation possibly *generating* design and usability of design with the interface as an element of the comprising information system.

The application of systems approach on the design situation, according to this work, is not only a reasonable approach but also an approach well suitable to be considered in development projects. When performing a system development project or a design project, including the design of user interfaces, the systems approach can be considered a reasonable choice.

A contribution of applying systems approach on the design situation are the system models and their identified and exposed content, and the dynamic properties and consequences deduced from them. The main actors and objects and their properties and the properties of their relations, the important system features of communication and complexity have been identified together with the importance of the customer. The subsystems and the elements of these have also been identified, generating an improved understanding and comprehension of the requirements and preconditions of the design situation.

Three criteria for applying the systems approach on the design situation are identified and met, stating the appropriateness of applying systems approach. The three objectives of this work are considered and achieved. In achieving these, the content, the complexity and the relations within the design situation is exposed. A definition of the design situation as a system, together with its elements or subsystems, relations and features, has been specified. The hierarchy of the systems within the design situation was identified as was the consequences deduced from applying systems approach on the design situation. The understanding of the importance of the customer’s role in the design situation is a substantial contribution. From the materials and the result of this work, the systems approach must be considered not only appropriate, but a proper approach to apply or use on design projects and when trying to meet the over all goals within a development project.

The figures in this work, or the system models presented, are tentative models created to obtain an understanding of the conditions for the design situation. Even though every design situation is unique, with its own preconditions and system boundaries, there is a generality characterising the models. Important is systems approach as a perspective leading to and creating a comprehensive view of the problem area or the design situation at hand with identification and understanding of the conditions for and the components and relations of the design situation.

Information, understanding and knowledge can be obtained and the central parts and relations of a design project are identified and can be brought in to consideration. This means an understanding of the conditions of the design situation and the decision making that has to be performed. The system models created and presented in this work are based on and formed by the *available* material, but even so, a substantial general knowledge can be deduced from these. In another specific project or work the models could possibly have a slightly different constitution or structure. But I think that there are reasons to suppose that the central concepts and relations for most design projects have been identified and presented together with concepts and relations that should result in a useful and a proper design situation.

6.1.1 The Materials

In the performance of this work, the interviews made were initially considered a complement or a support to the material gathered and extracted within the literature survey. But due to the limited material found when browsing through literature concerning systems thinking in a combination with a designer and user perspective on human-computer interaction, the interviews became more interesting to consider. An important fact and perhaps a weakness of this work are then that only two interviews have been performed. This makes the generality of the material from the interviews uncertain and open to question. More interviews with more structured and specified questions would perhaps generate another and a more stable result.

There is a huge amount of scientific material on systems science and on information system design with a design focus (human-computer interaction), but no scientific articles of a recent date were found that welded these two areas together by considering them from a unifying perspective. This made a systematic search for the design situation more problematic, meaning that a huge amount of material in both areas was covered and searched, practically until a deadline was set. Within both areas, materials considered relevant by the author and to the design situation were gathered and included in the work.

A strength of this work is its contribution to further and expanded understanding of the conditions for the design of information systems. Another contribution is the comprehensive view of the design situation, and the positioning of systems approach as a suitable and appropriate way of dealing with the design situation in a development project (and thus with a development project as such). A weakness is possibly the lack of precision in the results due to the limited material of this work.

6.1.2 Future Work

An interesting future work would be a similar work including more interviews with a higher degree of structure and standardisation. Another to empirically evaluate design projects of different paradigms, to compare similar projects of the same size but with different approaches, systemic or systematic. To perform an empirical study, an inquiry complemented with interviews, of design projects with designers working in different paradigms. Also performing an evaluation of the result from a user perspective. It would be a project comparing the actual design result from applying systems approach, to the result of designers working within the traditional development approach.

In future work an extension of this work would be possible. This could mean taking the design approach one step further, to the original assumptions of this work and the actual design of the graphical user interface. Applying systems thinking and systems approach on the actual graphic design and navigation of an interface. That is, applying the systems concept on the cognitive and navigation aspects and demands of the user interface. There were no literature found regarding the combination of systems approach and the design situation with a human-computer interaction perspective. To get deeper in the material, a wider and a more specialised inquiry should be performed to capture and deduce a more exact and concrete system image of the graphic design. The main actors would probably be the same but other important relations and connections would probably be visualised, presented and open for analysis. According to this author, there is still a need for a more general platform or a blueprint, a standard recommendation, for creating interfaces, web-pages and such, aimed for browsing and navigation.

With these future thoughts and a few words by Robert Hunter, I humbly bid the reader, together with my studying years farewell. The late Jerry Garcia of the Grateful Dead sang these words in one of their songs:

…what a long strange trip it's been! (Truckin', 1970)

References

Ackoff, R. L. (1981), *Creating The Corporate Future*. John Wiley and Sons, Inc, New York.

Andersen, E. S., (1995), *Systemutveckling-principer, metoder och tekniker*. Studentlitteratur, Lund.

Avison, D. E. and Fitzgerald, G. (1997*), Information Systems Development: Methodologies, Techniques and Tools* (second edition). McGraw-Hill, New York.

Barsalou, L. W., (1992) *Cognitive Psychology: An overview for Cognitive Scientists*. Lawrence Erlbaum Associates, Hillsdale.

Beer, S. (1994), *Brain of the Firm*. John Wiley & sons, New York.

von Bertalanffy, L. (1955) General Systems Theory. In: *General Systems, Foundations and Applications* (1975), Society for General Systems Research (TRITA IB-ADB 5008)

Booch, G. (1997), *Object-oriented Analysis and Design*. Addison-Wesley.

Boulding, K. (1991) General Systems Theory-The Sceleton of Science. In: Klir, George J., *Facets of System Science*. Plenum Press, New York.

Bødker, S (1998), Understanding Representation in Design. *Human-Computer Interaction*, Vol 13 No 2, pp. 107-125, LEA, New Jersey.

Dawson, C.W. (2000). *The Essence of Computing Projects, a student's guide*. Prentice Hall, England.

Edwards, G (1997), Geognostics – A New Framework For Spatial Information Theory. In: Hirsch, S C & Frank, A U (Eds.), *Spatial Information Theory*, pp 455-470. Springer, Berlin,.

Flood, R. L. (1990), *Liberating Systems Theory*. Plenum Press, New York.

Flood, R. L./Carson, E. R. (1993), *Dealing With Complexity*, Plenum Press, New York.

Germana, J. (2000), The Whole and Main Ideas of Systems Science. In: *Systems Research and Behavioural Science*, Vol. 17, pp. 311-313, John Wiley and Sons, New Jersey

Klir, G. J. (1991), *Facets of System Science*. Plenum Press, New York.

Langefors, B. (1995), *Essays on Infology*. Studentlitteratur, Lund.

Lübcke, P. (Ed.) (1988), *Filosofilexikonet*. Forum, Stockholm.

Löwgren, J. (1993*), Human-Computer Interaction*. Studentlitteratur, Lund.

Mandel, T. (1997), *The Elements of User Interface Design*. John Wiley & Sons Inc, New York.

Miller, J.G. (1995), Living Systems. McGraw-Hill, New York.

Mullet, K. and Sano, D. (1995), *Designing Visual Interfaces*. SunSoft Press/Prentice Hall, New Jersey.

Norman, D.A. (1990), *The Design of Everyday Things*. Doubleday, New York.

O´Connor, J. and McDermott, I. (1997), *The Art Of Systems Thinking*. Thorsons, London.

O'Donnell, E. and Davis, J.S. (2000), How information systems influence user decisions: a research framework and literature review. In: *International Journal of Accounting Information Systems,* Vol. 1:3, pp. 178-203 http://www.sciencedirect.com (2001-04-04).

Patel, R. och Davidsson, B. (1994). *Forskningsmetodikens grunder*. Studentlitteratur, Lund.

Poltrock, S.E and Grudin, J. (1995), Organisational Obstacles to Interface Design And Development. In: Rudisill, M., Clayton, L., Polson, P.G., McKay, T.D. (Ed.), *Human-Computer Interface Design*. Morgan Kaufman Publishers Inc, San Fransisco.

Pourdehnad, J. and Robinson, P.J. (2000), Systems Approach to Knowledge Development for Creating New Products and Services. In: *Systems Research and Behavioural Science,* Vol. 17, pp. 29-40, John Wiley and Sons, New Jersey.

Rosen, R. (1986), Some Comments on Systems and System Theory. In: Klir, George J (1991), *Facets of System Science*. Plenum Press, New York.

Van Gigch, J. P. (1991), *System Design Modelling and Metamodelling*. Plenum Press, New York.

Wang, Z. (2000), Meta-Decision Making: Concept and Paradigm. In: *Systemic Practice and Action Research*, Vol 13, No 1, pp.111-115, John Wiley & son, New York.

Wiener, N. (1964), *Materia, maskiner, människor*. Tema/Rabén & Sjögren, Stockholm.

Xu, L. D. (2000), The Contribution of Systems Science to Information Systems Research. In: *Systems Research and Behavioural Science*, Vol. 17, pp. 105-116, John Wiley and Sons, New Jersey

Principia Cybernetica Web (1998), http://pespmc1.vub.ac.be/DEFAULT.html (2001-05-10)