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Incorporating User Values in the Design of Information Systems and Services in the Public Sector

A Methods Approach

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Abstract

This thesis is motivated by the aim of public-sector organizations to become more efficient by quality improvement efforts and the introduction of information systems. The main objective is to explore methods for the design of information systems and information-system-supported services in the public sector, which meet the users' needs.

The thesis is based on six connected studies. The first study was to describe the structure of how the staff at public-service units seek advice. Based on data collected through interviews, a quantitative analysis was performed at primary healthcare centers. In the second study, the use of Quality Function Deployment (QFD) for orientation of public services to a quasi-market situation was investigated. The study displayed how clinical-social-medical services can be orientated to better suit the referral institutions' needs. The third study was performed to adjust a QFD model to a method for the design of information systems in the public sector. The development of the model was performed in a blocked-case study. In the fourth study, the model was extended and applied in a case study where it was used for participatory design of information-system-supported services. In the fifth study, the possibility of integrating the QFD model with process graph notations was investigated. The study was performed according to a participatory action research methodology. In the final study, an information system was designed using the QFD model developed and implemented for a public sector profession, occupational therapists.

The main contribution of the thesis is the QFD model, called Medical Software Quality Deployment (MSQD), for the design of information systems and information-systems-supported services in the public sector. The advantages of MSQD are that it focuses the design work on the users' needs and provides support for active participation of users.

Further advantages are that the requirements are traceable and the design features are prioritized.

As a support for the efforts being made in the public sector to increase efficiency, MSQD can be used to design appropriate information systems. The prototype implementation illustrated several optional ways of how this support can be implemented using low-cost technology. MSQD can further be used to develop services to better match the users' needs. Hence, it can be used for inter-organizational information systems design and, thereby, positive gains can be made in the collaboration between different public service organizations.

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To Karl

Contents

The following papers are included in the thesis:

I. Timpka, T., & Hallberg, N. Talking at work - professional advice-seeking at primary healthcare centers. *Scandinavian Journal of Primary Health Care* 1996: 14:130-135.

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V. Johansson, M., Hallberg, N., & Timpka, T. Method Integration in Requirements Engineering–Enterprise Modeling and Quality Methods. Submitted to *the International Journal of Requirements Engineering.*

VI. Hallberg, N., Johansson, M., & Timpka, T. A prototype computer network service for occupational therapists. *Computer Methods and Programs in Biomedicine.* 1999: 59(1):45-54.

Chapter 1
Introduction

Public-sector organizations are today regarded almost as a natural part of Western societies and their services are more or less taken for granted. However, these services are costly to provide (SPRI, 1998), which became painfully clear during the economic recession in the late 1980s (Pierson, 1996). Due to increased unemployment, amongst other reasons, tax revenue decreased and thus the governments had fewer resources to spend on public services, such as healthcare and social welfare. Therefore, rationalization and increased cost-effectiveness in the public sector have been found necessary (Rafuse, 1995). Still, service quality should be maintained as high as possible.

The two opposite ways of funding public services are the *public financed*, via taxes, and the *private financed* where the individual clients pay for the actual cost, either directly or through insurance. In the private-financed sector, the clients' payment and the possibility to select between different providers enforce cost-effectiveness and service quality through competition, at least theoretically. Meanwhile, in the public-financed sector this incitement to force the service-providing organizations to increase efficiency is lacking. Therefore, to increase the cost-efficiency in the public sector the determination of how to deploy the resources was moved down from the government via local authorities to the managers of the service-providing organizations (Clayton & Pontusson, 1998). This decentralization has resulted in increased autonomy for the local organizations, implying an increased economic responsibility.

To force the local organizations to become more cost-effective, models for public competition and mix-market were introduced (Saltman & von

Otter, 1989). Recently it has been found that public competition and mix-markets caused other problems. For instance, the involvement of the government did not always decrease, it changed from planning provider to controlling function. Another issue was that the service providing organizations had to spend resources on, for example, marketing of the service, thereby the savings that were made were accrued by the competing systems themselves (Freeman, 1998). Therefore, countries that introduced these models of competition have started to make returns from them by reintroducing some governmental planning mechanics (Whitehead, Gustafsson, & Diderichsen, 1997; Figueras & Saltman, 1998). But even if these models have had limited success, the need to improve cost-efficiency in the public-sector organizations remains.

1.1 Improved cost-efficiency in public-sector organizations

Several approaches to achieve increased cost-efficiency in public-sector organizations have been suggested, such as improving the management of the organizations and reengineering the service-providing processes (Fox, 1998; Klein, Motwani, & Cole, 1998), customizing the content of the provided services (Wright, Williams, & Wilkinson, 1998), and introducing information systems (Tien, 1998; Lock, 1996).

1.1.1 Improved organizational management and service providing

It has been claimed that when providing healthcare services, increased productivity and efficiency do not contradict high quality (McDougall, Covert, & Melton Brandon, 1988). In attempts to increase the cost-effectiveness of the services provided in the public sector, quality improvement methods from industry have been introduced (Taylor, 1996; Klein, Motwani, & Cole, 1998). For example, *Total Quality Management* (TQM) (Bergman & Klefsjö, 1994) has been suggested as an approach for improving the organizations' ability to respond to demands and needs of their environments (Gaucher & Coffey, 1993; Migueles & Brustowicz, 1997; Lichner Ingram & Chung, 1997). Further, *Business Process Reengineering* (BPR) (Hammer & Champy, 1993) has been suggested for rapid reengineering of the service processes to provide the service more rationally (Schneider, 1995). These two strategies result in the parts of the organization that do not contribute to the service providing being

identified and excluded. However, by questioning the cost-effectiveness over time of these kinds of methods and what benefits clients have gained, it has been claimed that they are inadequate for the public sector (Taylor, 1996). A further example from the area of health care is *managed care*, which has been developed as a way of performing a cost-effective, cohesive service with a sustained level of quality. All parties involved in providing the service should jointly focus on maximizing health advancement. However, there are several different techniques and views of how this goal should be achieved (Fairfield, Hunter, Mechanic, & Rosleff, 1997). To gain full benefit from the new organizations and reengineered service processes, information systems have proved to be a prerequisite (Mankin, Cohen, & Bikson, 1996; Davenport, 1993).

1.1.2 Service content

It is not cost-effective for a society to provide services that nobody asks for or wants. Therefore, it has been suggested that services provided by public-sector organizations must be adjusted to meet the needs of the environment, e.g., the needs of clients, customers, and other service providers (Werner, 1988). In other words, the services provided should be the ones requested and should harmonize with the service of the other providers so that the total service becomes as cost-effective as possible. The importance of gathering the needs from society and developing health-need assessments has been argued for (Wright, Williams, & Wilkinson, 1998). *Quality Function Deployment* (QFD) has been suggested as a method for customization of healthcare services (Gaucher & Coffey, 1993). Other methods proposed are *professional auditing* and the *introduction of clinical guidelines* to ensure the quality of the public service (Bentzen, 1993; Robinsson, 1996; Grol, 1993; Wilkinson, Cropper, Blankenhorn, & Balasubramanian, 1991). However, both audits and clinical guidelines have been questioned as to whether they are cost-beneficial or not (Haycox, Bagust, & Walley, 1999; Berger, 1998).

1.1.3 Information systems

Using computer-based information systems for the purpose of making the public-sector organizations more cost-efficient has been proposed and even argued as a necessity (Sahney & Warden, 1988; Lock, 1996; Clayton & Mulligen, 1996). Even though information systems have been

used for a long time, for instance in healthcare organizations, it has been questioned whether their full potential has been taken advantage of (Bleich, 1998). Further, even if providers have experienced some benefits and do not want to reverse the steps taken, doubt has arisen as to whether the introduction of computer-based information systems is justifiable in economic terms (Vimarlund, Ljunggren, & Timpka, 1996; Lock, 1996). Reasons for the drawbacks include the difficulty of designing systems for the complex work situation (Bardram & Sølvkjær, 1996) and insufficiency of the development methods used (Blum, 1991; Timpka & Johansson, 1994). Further, it has been claimed that standard software development processes are too complex and need to be adjusted to the situation of use (Dandekar, Perry, & Votta, 1996).

1.2 Summary: research needs

Society requires cost-effective services from the public-sector organizations and hence governments have put pressure on the public service organizations, e.g., by budget-frame restrictions (Pierson, 1996; Rafuse, 1995). Several options exist for public-sector organizations to become more cost-efficient, e.g., reengineering of provided services and the introduction of information systems (Gaucher & Coffey, 1993; Schneider, 1995; Clayton & Mulligen, 1996). However, taking full advantage of reengineered services requires information systems that support the work involved (Mankin, Cohen, & Bikson, 1996; Davenport, 1993). But so far the benefits and cost-effective of the information systems introduced have been called into question (Bleich, 1998; Vimarlund, Ljunggren, & Timpka, 1996). As a prerequisite to achieving information systems that better suit the needs of the public sector, design methods currently used must be improved (Blum, 1991; Timpka & Johansson, 1994).

1.3 Research objectives

The main research objective of this thesis is to explore methods that can be used for:

- Design of information systems[1] that support service providers in their daily work.
- Design of information-system-supported services, i.e. simultaneous (re-)design of a service and design of an information system that supports the *new* service.

In order to achieve these objectives studies are performed in the public sector areas of healthcare and social welfare. Specifically the objectives of this studies are:

- To study the communication patterns of professional communication at healthcare units: in particular how the professions seek advice and information for medical, client-relation, and organizational issues. Further, to study the association between different professions, teams and centralized organizations, and the advice-seeking process.
- To study the effects of using Quality Function Deployment (QFD) for orienting a social medical service towards a quasi-market situation.
- To develop a QFD model for the design of information systems in healthcare environments.
- To develop an extended version of the QFD model for designing information-system-supported services.
- To study the possibilities and effects of using the extended QFD model together with process graphs for the visualization of a business.
- To design an information system using the QFD model and to implement a prototype of this information system.

[1] There are several definitions of the term *information system*. In this thesis *information systems* is used generally. Information systems are equipment, machinery, methods, and tools that move, manipulate, and store information (Rood, 1994), with the main focus on computer-based information systems.

1.4 Delimitation

The objective of this thesis is primarily restricted to the public sector. There are several possibilities for improving the efficiency of public-sector organizations, but the two focused on are introduction of information systems and improvement of services. The studies performed involve the area of healthcare and social welfare in the public sector of Sweden.

Computer-based information systems consist of both hardware and software. Hardware is today relatively standardized and its cost decreasing. Meanwhile, the software needs to be adopted for the purpose of its intended use and its cost is increasing. Therefore, concerning the computer-based information systems the main focus will be on the design of the software part of the information system.

However, the work presented in this thesis is motivated by the efforts in the public sector to be more efficient. It is beyond the scope of the thesis to evaluate whether the contributions will have a positive effect on the efficiency of public service organization.

Chapter 2
Background

This chapter presents the relevant research settings, various scientific and engineering areas, and empirical methods in line with the research objectives of this thesis. First of all, the development and concerns in the area of software engineering are discussed. Further, the Internet and its related techniques are presented as a possible platform and infrastructure for the design of information systems. Then the settings in which the studies were performed are described. Subsequently, an orientation of QFD, the critical incident technique, and ProG is given as background to the methods evaluated in this thesis. Then, the actual use of information systems in the public sector area of health care and the possibility to use information systems as support for inter-organizational collaboration are discussed. Last in this chapter, the research approaches of the case study methodology and participatory action research strategy used in the studies are presented.

2.1 Software engineering

Software engineering was formed as a research area in the late 1960s as a response to repeatedly overrun budgets in software development projects, long delays and even cancelled projects, and poor quality of systems that were delivered (Mills, 1988; Brooks, 1995). Initially, the focus was on the writing of code. Then the focus gradually moved to the design and further to the specification of the characteristics of the systems. These changes represent a focused movement from details to the system as a whole (Alexander, 1997). Two of the targets in software engineering are correctness and usefulness[2]. The first target, correctness, is concerned

[2] *Usefulness* refers to "benefits of use" while *usability* refers to "easy to use".

with getting the system to behave as intended: in other words, to make it behave as the software engineers thought it should; for example, *structured programming* (Dijkstra, 1979) and the *cleanroom* (Linger, 1994) were suggested as approaches towards achieving correctness. Further, major efforts were put into identifying and removing errors, for example, by *testing* and *code inspection* (Kobrosly & Vassilladis, 1998; Vienneau, 1991; Sallade, 1992; Porter, Siy, Toman, & Votta, 1997; Christenson & Huang, 1988). However, it was found that (1) not all mistakes could be eliminated despite careful testing and (2) many corrections originate from changes in the specification, and these proved expensive to correct (Blum, 1991). Therefore, it was found better to ensure that the mistakes were avoided from the beginning (Alder, Leonard, & Nordgren, 1999). Efforts aimed at quality moved from the products to the software development process. Software development processes such as the *waterfall model* and the *spiral model* were suggested (Boehm, 1988). The idea was that a good development process would generate high-quality software. To improve the development process, quality methods, such as Total Quality Management (TQM), were also adopted (Arthur, 1992). However, it has been claimed that they have had limited success, because software, unlike manufacturing, is mainly a development process, not a production process (Basili, 1996). Therefore, Basili (1995) suggested a quality improvement paradigm aimed at reusing knowledge and previous experience in future software projects – a kind of continuing quality-improvement process for software processes. Examples of specific methods and standards for ensuring the quality of software products include the *capability maturity model* (CMM) (Ellmer & Merkl, 1996; Niessink & van Vliet, 1998) and the *ISO 9000* certification program (Ince, 1994).

The second target is usefulness – that the systems should be useful for the users. In other words, the systems should behave as the users wanted them to do. The usefulness criterion required a broadening of the scope during development and the users were seen as a part of the system that had to be taken into account. Examples of specific methods aimed at ensuring the usefulness for the users are *joint application development* (JAD) (Carmel, George, & Nunamaker, 1992) and *Walkthrough methods* (Karat, Campbell, & Fiegel, 1992; Bias, 1991). These methods, however, were not always found sufficient since the users acted in and interacted

within a context. Therefore, it was also found necessary to take into consideration the contexts of use. Further, since the users are not able to explain to the developers what they need or want, it is necessary to capture requirements in the context of the use situation (Suchman, 1987; Suchman & Trigg, 1991; Leonard & Rayport, 1997). The increased understanding of the importance of the earliest steps taken in software development has resulted in a new research area – requirements engineering.

2.1.1 Requirements engineering

A distinction between software engineering and requirements engineering can be seen as software engineering focuses on the solutions, while requirements engineering focuses on the problems. The aim of requirements engineering is to specify what the systems should accomplish without saying how (Siddiqi & Shekaran, 1996). Further, it has been claimed that development of new products, services and software requires that the users are studied in the context of use (Leonard & Rayport, 1997). It is also a fact that "An information system development is an instrument of change, and the larger the information systems project, the greater the number of people in the organization affected by the development." (Warne, 1998, p. 482). The importance of capturing the social aspects of the requirements has been emphasized by several researchers (Goguen, 1993; Goguen & Linde, 1993; Baskerville, 1996). Examples of approaches proposed for these studies are ethnological approaches (Garfinkel, 1967; Mumford & Weir, 1979; Simonsen & Kensing, 1997) and Contextual Inquiry (Coble, Maffitt, Orland, & Kahn, 1995). One concern discussed in requirements engineering is the *requirement traceability problem.* The traceability problem concerns the inability of methods to trace requirements from their origin to design features and vice versa (Gotel & Finkelstein, 1994). Further, in larger information system development projects often many categories of persons are effected by the design and the different categories of people will have different views of what features the systems should have. However, it is not possible to implement all requirements asked for in an information system (Yeh, 1992), Therefore, a prioritization of the requirements must be made so that it is the most prominent features that are implemented (Karlsson, 1998).

2.1.2 Participatory design

An area closely related to requirements engineering is *participatory design* (PD). In PD, the active participation of users in the design is emphasized (Schuler & Namioka, 1993). However, the users' degree of participation and influence on design decisions differs among different projects. The reasons for involving the users in the design process also vary between projects. It may be because of belief in decision-making democracy or because the users are found to be best equipped to discover the problems and design the solutions. PD has been used in different areas of design, e.g., urban planning, workplace design, software design (Reich, Konda, Levy, Monarch, & Subrahmanian, 1996). One direction of user participation in system design was developed in Scandinavia (Ehn & Kyng, 1987). Initially, it was focused on the ability of the blue-collar workforce to influence their work situation by participating in the design of computer systems. It was based on the ideal of "good work" (Sandberg, Broms, Grip, Steen, & Ullmark, 1992). During the continuous development of PD, it has been found to be useful in areas where traditional methods have failed (Anderson & Crocca, 1992). To support the professional designers and practitioners in working together on design, several tools have been developed, such as *future workshops* and *mock-ups* (Bødker, Grønbæk, & Kyng, 1993; Kensing & Munk-Madsen, 1993). The tools should be easy to learn and use so that persons with little knowledge and experience of information systems design can participate in the design, without being dependent on professional developers. PD has also been found useful in the design of information system in health care (Sjöberg, 1996).

2.2 The Internet

Recently interest in using Internet and related technology as an infrastructure for platform-independent information systems has increased (Bentley, Horstmann, & Trevor, 1997), especially since it has been shown that the technology can be used for implementing systems for collaboration, such as information sharing and communication in a cost-effective manner (Korpela, 1998). The Internet is often described as a worldwide network. This is not correct because the Internet consists of many thousands of networks (Mercier & Hembree, 1998). However, describing it as a large number of connected networks is viewed as a

deceptive description. Instead Internet has been defined as: "A set of protocols for data transmission and control, a set of services or utilities, and the people who use them" (Leon, 1994). The most frequently used services on Internet today are electronic mail and the World-Wide-Web (WWW) (Mercier & Hembree, 1998). WWW can be seen as a hypertext platform for multimedia, which builds on the concepts of links that point to, e.g., other documents and data files (Hunt, 1998). Further, WWW can be used to integrate most of the services provided on Internet by its linking concept, for example by "clicking" on links to download a file from a server, to access a bulletin board or to send an electronic mail. A previous disadvantage of WWW was that it did not support interactivity, which was a limitation for several types of applications. However, with the introduction of techniques such as JAVA and JavaScript, this problem has been solved to a large extent (Verhoeven & Warenhof, 1997). Another disadvantage of the Internet is the lack of security, which has been one of the reasons why companies and organizations do not connect their information systems to the Internet (Oppliger, 1995). However, intensive work and research are ongoing to solve these problems, e.g., by developing secure protocols (Oppliger, 1998; Bellovin, 1997).

The Internet's infrastructure for communication and as a source of information has been found to provide many benefits. These advantages, together with the security problems, resulted in many organizations building *intranets*, which are internal Internets. The intranets use the same set of protocols as the Internet for internal communication, but external access is severely restricted. These intranets have the advantage that unauthorized persons outside the organization should not be able to reach the internal information, since it is protected by a firewall (Schuba & Spafford, 1997; Lodin & Schuba, 1998). However, for some enterprises it is beneficial if their partners can reach some of the information on the intranet, and vice versa (Prakash, 1997). The limitations of external access to intranets have motivated *extranets*. In extranets a small door in the firewall is open to parts of the intranet for those who have authority; otherwise unauthorized persons are kept out (Sharp, 1998). The extranets are of interest for integrating the information exchange between different organizations.

2.3 Settings

2.3.1 The public sector

The services the public sector organizations provide differ among countries. The Swedish public sector is known to be relatively large and extensive (Pierson, 1996). It has also been more service-oriented than the public sectors in other countries which have been more oriented towards welfare support (Clayton & Pontusson, 1998). The welfare system in Sweden is general, while in many other countries it is connected to employment. Examples of services that are provided by the Swedish public sector are health care, social services, child care, education, care of the elderly, retraining programs, military defense, police, and other services related to social welfare. The public-sector areas chosen for the studies in this thesis are health care and social welfare. More specifically the studies were performed in primary health care and at a clinic of social medicine. The prototype system implemented was aimed at occupational therapists in Sweden.

2.3.2 Primary healthcare centers

Primary care is the first contact level for patients and in many countries it works as a gateway to the specialist levels of health care. At primary healthcare centers most of the patients' health problems are handled, when necessary by referral to specialists (Mehanic & Rochford, 1996). Due to, amongst other things, economic reasons many healthcare service provided by specialist departments have been moved to the primary healthcare centers (Hirschfeld, 1998). Thereby, primary health care today assigns patient cases that are more complicated than before. To handle this, teamwork and cooperation have been suggested as "the name of the game in primary health care" (Saint-Yves, 1982, p. 233).

For the study of advice seeking patterns, four primary healthcare centers were approached. Two of them had a centralized organization where physicians and nurses received patients from the entire catchment area. The other two had a decentralized organization and consisted of *care teams* (1 physician, 2–3 nurses, 2–3 nurses aides, 1 secretary). The catchment areas were subdivided in that the care teams had the responsibility for geographical sub-areas. The teams had their own

patient reception, equipment, and meeting facilities. A two-person management constellation consisting of a physician and an administrative nurse led all four centers. The primary healthcare centers also had clinical laboratories and physiotherapy departments.

2.3.3 The social medical clinic

Health does not only have a medial (physical) dimension, it also has social and psychological dimensions (WHO, 1948). Social medicine is a discipline that combines the three dimensions. Since 1970 a social medical service has been provided at Linköping University Hospital (Timpka, Leijon, Karlsson, Svensson, & Bjurulf, 1997). Between 1970 and 1997, which included the time for the study presented in paper II, the service was provided by the department of clinical social medicine (CSM). The economic recession lead to the downsizing of healthcare organizations. The CSM was no exception. In 1997 it was reduced to only one team and organizationally moved to be a sub-unit of the Pain and Rehabilitation Center. The studies presented in papers IV and V were performed during this time of reorganization. At the time for all three studies, CSM provided case management based on integrated multi-professional teamwork for patients with multiple problems of a medical, social, and psychological nature. Common patient types were

- persons suffering pain, where traditional treatment methods had been insufficient;
- young people with minor medical problems who had not been able to establish themselves on the labor market; and
- persons with personality disorders and/or with some talent handicap.

There were essentially five types of institutions that referred their clients to CSM: primary healthcare centers, social-insurance offices, occupational-healthcare clinics, employment-exchange bureaus, and social-welfare offices. At the clinic, the first step was an evaluation of the patient's medical, social, and psychological status, i.e. problems and resources. After this an individual plan for investigation and therapy was defined. The aim was that the patients should be able to return to working life or in some other ways achieve an increase in life quality. At the time of the study presented in paper II, the local county council reimbursed all services CSM provided. However, there were indications that the referral

institutions would in future have to contribute to the finances of the services provided, which during the time for studies presented in papers IV and V had become a fact.

2.3.4 Occupational therapy

The concept of using activity for rehabilitation is old. As early as the ancient cultures, for example in Egyptian, Chinese and Greek civilizations, entertainment and productive work were used for recreation (Hopkins, 1988; Dunton, 1947). However, it was not until the late 1800s that modern principles for occupational therapy were introduced as a clinical discipline (Woodside, 1971). Its modern form has its roots in *moral treatment* and was practised first for psychological illness (Kielhofner & Burke, 1983). It builds on a holistic view of humans and focuses on bringing people with disabilities back to productive work through gradual improvement (Peloquin, 1994). The early industrialization and the World Wars increased the need for occupational therapists with specialization in physical disabilities (Hanson Schmidt & Walker, 1992). The term *occupational therapy* did not appear until 1911 or 1914, depending on who should be credited as the inventor, Dunton or Barton, which is still being argued (Bing, 1987). The term *occupation* is defined as *"a behavior which is motivated by an intrinsic, conscious urge to be effective in the environment in order to enact a variety of individually interpreted roles that are shaped by cultural tradition and learned through the process of socialization"* (Burke, 1983, p. 136).

Today, occupational therapists work in most areas of health care, e.g., primary health care, hospital care, and home care (Hopkins & Smith, 1988; Devereaux & Walker, 1995; Harris & Krimker, 1997). In the different areas the aim of their work differs, but the general aim is to optimize people's ability to interact with the environment as they desire.

In their work, occupational therapists also have to deal with emotionally and ethically difficult situations, for instance, reveal bad news to patients and/or their relatives (Barnitt, 1994). Further, the occupational therapists are also challenged to deal with tasks of a more engineering nature such as selection, application, and modification of assistive equipment and living environments (Johnson Taylor, Trefler, & Nwaobi, 1984).

Rehabilitation should, according to modern philosophy, be performed by multi-professional teams (Strasser, Falconer, & Martino-Saltzmann, 1994). However, it has been found that occupational therapists experience stress and pressure in situation of teamwork, since they feel a lack of respect and understanding from other professions (Rees & Smith, 1991). Further, occupational therapists spend only 40% of their working hours on direct patient contact (Fred, 1991). A large proportion of working hours is spent on paperwork, which causes stress and has been described as the major cause for them leaving the profession (Bailey, 1989).

2.4 Quality function deployment (QFD)

Quality Function Deployment (QFD) is one of several quality systems, e.g., Total Quality Management (TQM) (Bergman & Klefsjö, 1994), Statistical Process Control (SPC) (Card, 1994), and ISO9000 (Ince, 1994). QFD is aimed at ensuring customer satisfaction with developed products (Mizuno & Akao, 1994). *Products* can include goods, services, and software. QFD was developed in Japan during the late 1960s and has since been used worldwide in many different application areas (Mazur, 1994). Perhaps it is most known for its use in car manufacturing where several producers use or have used QFD (Akao, 1997). In its general form, the features of the product as well as, for instance, the manufactoring and marketing processes are specified. However, it is common that QFD is applied to the transformation of customer needs to a specification of design attributes, often by using the House of Quality (Hauser & Clausing, 1988).

The expression *Quality Function Deployment* is a direct translation of the Japanese phrase, *Hinshitsu Kino Tenkai.* However, since each of the three Japanese words has more then one English translation, QFD could have been called something else (Cohen, 1995). In fact, it was first called Quality Function Evolution (Akao, 1997). QFD consists of a philosophy, quality tools, and application models. The models work like maps for applying the quality tools so that quality creation processes are obtained. However, before discussing QFD further, the term *quality* must be clarified.

Quality is a general term that has no distinctive definition, for instance in Webster's dictionary[3] eight different meanings are given. Examples are "*degree of excellence"* and "*the attribute of an elementary sensation that makes it fundamentally unlike any other sensation"*, which imply some kind of positive characteristics. However, the question of who will judge whether something is good or not also leaves room for interpretation. Hence, it is a phenomenon that is subjectively judged, i.e. different people have different perspectives when they judge quality.

> *Example of different perspectives of quality: a coffee-maker. Let us assume that it has been made so that it will function for at least 20 years without any service at all. Is this good quality? Let us further assume that the coffee tastes really bad. Will it then matter whether it functions for 20 or 100 years? However, if the coffee tastes good, is the coffee-maker then of good quality? For those who like coffee it is, but for those who do not, the features of the coffeemaker do not matter.*

Several researchers have provided definitions of quality which are related to QFD. To mention a few, Juran, Gryna, and Bingham (1974) claim that quality is *fitness for use* and Deming (1986) that quality is aimed at the *needs of the consumers, present and future.* Bergman and Klefsjö (1994) define quality as: "The quality of a product (article or service) is its ability to satisfy the needs and expectations of the customers". Kano (1995) discusses aspects of quality around three types of customer requirements. The basic requirements are unspoken and required. If they are omitted, the customers become dissatisfied, but if the requirements are fulfilled, they are taken for granted and barely noticed. The performance requirements are expressed explicitly by the customers and the more they are fulfilled, the more satisfied the customers become. Finally, the excitement requirements are not requested, because the customers are not aware of them. As an illustration we can again mention a coffeemaker. A basic requirement is that it makes coffee. This is not asked of a coffeemaker, it is required. Performance requirements include that it is easy to clean and makes coffee quickly. The more these

[3] Merriam-Webster's Collegiate Dictionary, Tenth Edition. Copyright © 1998 by Merriam-Webster, Incorporated.

requirements are fulfilled, the more pleased the customers will be. So, the faster the coffee is ready, the happier the customers are with the coffeemaker. Excitement requirements can be that it cleans itself and that the coffee is ready when the customer wakes up. Requirements tend to start as excitement, become expected performance, and end as being basic. Take for instance an electric bulb. Shortly after its invention, it was an exciting feature of a home to have electric light. For a while it was something that could be used as a positive feature when selling a house. Today it is taken for granted.

In the QFD community, the target group is referred to as *the customers*. In software engineering the target group often is referred to as *the users* (Warne, 1998). Both areas define their target group broadly. Strictly defined, they mean totally different things. In this thesis, users and customers will be used equivalently in a broad sense, which means people and organizations that will be directly or indirectly affected by the design and implementation of the information system or service.

2.4.1 Philosophy

A famous golf player was once asked what had made him the number one golf player in the world and he answered, "*I never took a swing for nothing*". This answer reflects one essential part of the philosophy of QFD. Never design, develop, or produce features of products and services that do not bring any value to the customers. The value to the customers implies, of course, that in the long run quality brings something back to the stakeholders. Another essential part of the philosophy is: *to do nothing wrong does not mean to do anything right* (Braithwaite, 1993) and as Deming (1994) stated that *zero-effects are no longer enough.* In other words, just because a product is perfect technically, this does not make it useful. For example, suppose a teacher suddenly remembers that he has a lesson and on his way to the classroom remembers that he needs a pen to write on the whiteboard with; on his way, he asks a colleague for a pen and gets one; in the classroom he realizes that the pen he holds in his hand is a ballpoint pen. Assume it is an exclusive pen that is technically perfect. But does it bring any value to him? Only if he can trade the pen for a whiteboard marker, not necessarily expensive and technically perfect, but functional. QFD is

aimed at designing value, from the customers' point of view, into products.

Table 1: The QFD tools contents in the three toolboxes.

The seven quality control tools	The seven management tools	The seven tools for planing new products
Histograms	Relations diagrams	Group interviews
Cause-and-effect diagrams	KJ method: Affinity diagrams	Questionnaires
Check sheets	Systematic diagrams	Positioning analysis
Pareto diagrams	Matrix diagrams	Concept checklists
Graphs	Matrix data-analysis	Table-type conceptualizing
Scatter diagrams	Process decision program charts	Conjoint analysis
Control charts	Arrow diagrams	Quality tables

2.4.2 Tools

Several tools have been developed for the practical application of QFD. These have been organized in three toolboxes; *the seven quality control tools* (Ishikawa, 1982), *the seven management tools* (Mizuno, 1988), and *the seven tools for product planning* (Gustafsson, 1996), (Table 1). In the following sections, the QFD tools relevant to the work in this thesis are presented.

The voice of the customer table (VCT)

When asking customers what they need, they will not express themselves only in terms of needs. They will also use descriptions of, for example, problematic situations that they have experienced and technical solutions that they believe can be useful for them. Therefore, *the voice of the customer* must be *cleaned*, so that the actual needs are identified. For this purpose, the *voice of the customer table* (VCT) can be used (Mazur, 1992; Nakui, 1992). The VCT consists of two parts, but in this thesis VCT will refer to the first part. The VCT constitutes an eight-column table; in the first column the expression of the voice of the customers is inserted. Then analyze *who* asked for it, *what* do they want to do with it, *when* do they want to do it, *where* would they like to do it, *why* would they do it, and *how* would they do it. Then the last column for the

customer need can be filled in, hopefully with a correct understanding of the customers' needs. (Table 2).

Table 2: An example of how a VoC statement can be analyzed in the VCT.

The VoCs	Who	What	When	Where	Why	How	The Customer need
I need access to a knowledge support system	Physician	Knowledge	Meeting patients	In the consulting room	Need to know how to proceed	Knowledge support system	Information on how to proceed during consultations

Affinity diagram

It is common that a large number of needs are identified. However, for practical reasons the number of needs must be limited, due to the resulting size of the QFD matrices. The needs can also be at different conceptual levels, which has to be resolved before they are inserted in the matrices. Examples of needs that are at different conceptual levels are *access to information* and *access to clinical information.* The first need incorporates the second one, which means that the prioritization of the technical requirements will be misleading. This is caused by the need *access to information* appearing to have a ranking corresponding to its own ranking plus the ranking of the need *access to clinical information.* Therefore, the needs must be stuctured. To achieve this, the needs can be ordered in *affinity diagrams* (Figure 1), where they are categorized in a bottom-up procedure (Bossert, 1991; Holtzblatt & Jones, 1993). First, the needs are grouped in categories consisting of related needs. If necessary, a need can be split into several sub-needs and duplicates are removed. The needs on a conceptually higher level can function as a name for categories. Then the categories are grouped, with similar categories. In this way affinity diagrams are constituted.

Hierarchy diagram

Another way of displaying the needs and their relationships graphically are *hierarchy diagrams* (also called tree-diagram) (Figure 2). This graphical notation provides an overview of the needs, categories and the relationship between them, which is useful when finally adjusting of them.

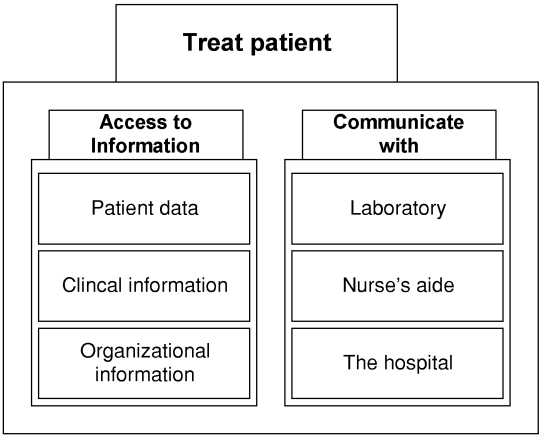

Figure 1: A fictive example of what affinity diagrams can look like.

Matrix

The *matrix* is used to transform the ranking of features in one notation to the ranking of features in another notation, such as the ranking of customer needs to the ranking of technical requirements. The matrix used for this specific transformation is often referred to as *the House of Quality* (Figure 3) (Hauser & Clausing, 1998). The actual transformation is performed by inserting the customer needs to the left in the matrix together with their ranking. The technical requirements are inserted at the top of the matrix. In the middle of the matrix, the degree of how well each technical requirement fulfills each need is inserted, the correlation. The scale {1, 3, 5, 9} is the one usually used. A "9" means that the technical requirement to high degree effects the fulfillment of the need. A "1" means that the technical requirement only has a minor effect on the fulfillment of the needs. An empty spot means that the technical requirement does not contribute at all to fulfilling the need. Then by multiplying the rank of the customer needs with the correlation with the technical requirement and then summarizing each column, the importance of each technical requirement is acquired.

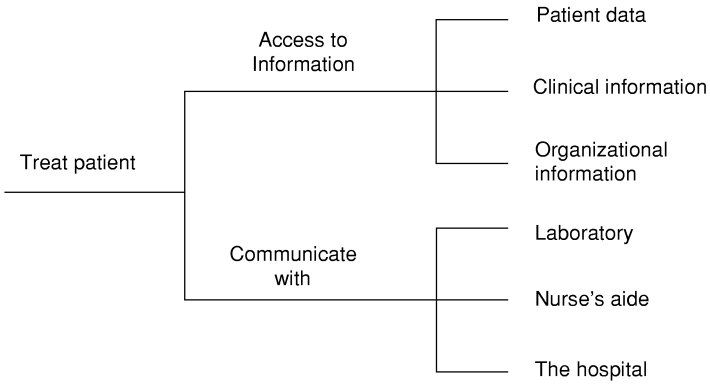

Figure 2: A fictive example of a hierarchy diagram.

2.4.3 Models for application of QFD

Since its introduction, a number of ways, also called models, for applying QFD have been suggested.

The House of Quality

The House of Quality (HoQ) is the most famous tool of QFD and a common way of applying QFD has been just to use the HoQ (Figure 3) (Cohen, 1995). In the HoQ, the ranking of customer needs is transformed to the ranking of the technical requirements. But before the transformation of the ranking of the customer needs, each of them can be adjusted, for example according to how well the competitors succeed in fulfilling the need and the importance of meeting the need for the marketing of the products. After the transformation, the ranking of the technical requirements can be adjusted, for example according to how well competitors fulfill the technical requirements, a target value for how well it should fulfilled, and the difficulties in achieving the requirement.

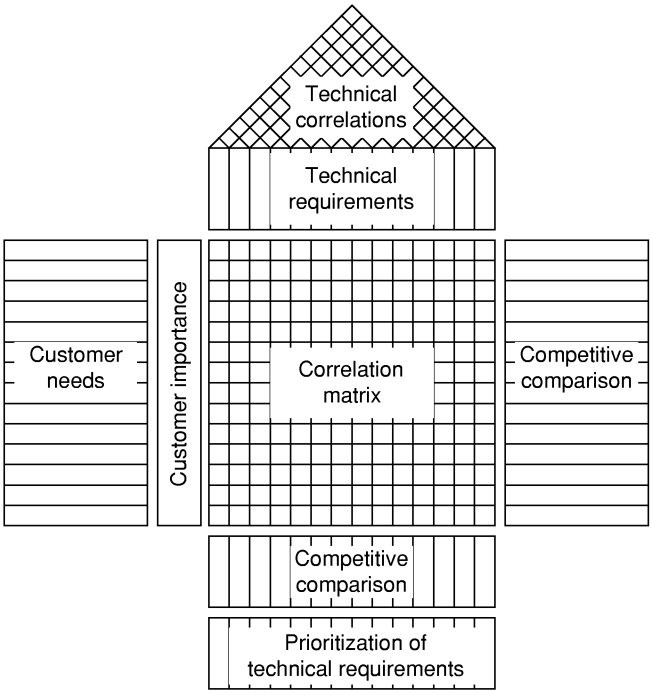

Figure 3: The House of Quality.

To use only the HoQ and claim that it satisfies QFD has been criticized (Zultner, 1995). Much work, it is argued, must be done before applying HoQ, since HoQ works according to the principle "garbage in, garbage out" (Zultner, 1991). Others claim that HoQ can be sufficient and that it depends on the situation (Cohen, 1995).

The four-phase QFD

The four-phase QFD was an early model proposed for applying QFD (Hauser & Clausing, 1998). The idea is to add three additional matrices in sequence after the HoQ and thereby transform the customer needs to performance measures that are transformed to parts characteristics, that are transformed to process parameters, that are translated to product operations. The four phase model has also been applied to software, though slightly modified (Tran & Sherif, 1995).

Software Quality Function Deployment (SQFD)

Even though QFD suits the development of software, it has been claimed that the common and traditional models of QFD, such as the four-phase model, are inappropriate for software development (Zultner, 1988), for instance, since software development has little to do with choosing material and other aspects of manufacturing. However, several different QFD approaches for the design of software exist, which are often called Software Quality Function Deployment (SQFD). SQFD can be a relatively complex QFD model which is combined with more traditional software tools (Zultner, 1988), a customization of the four-phase model (Tran & Sherif, 1995), or just a customized HoQ (Haag, Raja, & Schadke, 1996).

The Blitz QFD

As a response to arguments that QFD takes too long, that the results do not realize what was expected, and that QFD is more than HoQ, Blitz QFD was introduced (Zultner, 1995). In contrast to several QFD models, for instance the four-phase model, the focus in Blitz QFD is on the work done before inserting the needs the HoQ, i.e. the transformation of the voice of the customers to customer needs.

The Comprehensive QFD

The Comprehensive QFD is the most complex and complete model. It can be seen as the total model of QFD, which includes several matrices and the flow the between them (Nakui, 1991). It is aimed at goods of mass production where much planning is required. However, not all of the matrices need to be realized; instead it should be used as a map where the development team select the parts that they find essential to deal with. An alternative description of a comprehensive QFD is the Matrix of Matrices (King, 1989).

2.4.4 Advantages of QFD

Several benefits of applying QFD have been reported, some of them are listed below.

- QFD is an effective mechanism for collecting and categorizing the customers' needs (Moseley & Worley, 1991).

- Important aspects of a product identified early on are not lost during the development process (Eureka & Ryan, 1988).
- The products developed meet the customers' real needs (Brown, 1991).
- QFD reduces the changes of specification by 30% to 50% and reduces the design time by 30% to 50% (Vasilash, 1989).
- QFD works as a communication device between persons involved in development by graphically showing how the different functions contribute to customer satisfaction (Raynor, 1994).
- Mistakes made in determining requirements and the design are fewer than in traditional methods and therefore fewer changes in the later part of development are required. (Tran & Sherif, 1995).
- QFD can be used to enhance process management, i.e. to direct an organization's efforts towards a primary goal — to meet its customers' requirements (Conti, 1989).

2.4.5 Pitfalls

Applying QFD is not easy and it is even harder to apply it correctly. One of the major pitfalls is to do too much, e.g. that the matrix in the HoQ gets too large (King, 1989). For example, assume that 100 needs are inserted and that 100 corresponding technical requirements are identified. The relationship matrix will then contain 10,000 correlations that must be considered. This work is not only extremely time-consuming, it will also be impossible to get an overview. Further, it can be questioned how much notice the customers will take of how their requirements ranked as number 99 and 100 are dealt with. Probably, if a product solves the five most important needs that the customers have, it can be a "seller". Another aspect which has caused low results in QFD projects is the importance of the *true* needs being inserted in the HoQ, since it works according to the principle of "garbage in, garbage out". The solution here is to listen carefully to the voice of the customers and to interpret it correctly. Another common mistake is that the needs inserted in the HoQ are mixed with technical requirements, which results in a totally meaningless transformation (Zultner, 1995). Applying QFD takes time and costs resources. It must be applied with full commitment and cannot

be seen as a side effort (Eureka & Ryan, 1988). This view may be seen as obvious, but a study carried out in Sweden in 1995 indicated that nearly 80% of the QFD efforts lacked management support and nearly as many lacked the group members' commitment (Bergman & Gustafsson, 1997).

2.5 The critical incident technique

The critical incident technique (CIT) has been proposed as a method for generating useful data from anecdotes (Bradley, 1992). In this way it provides an opportunity to study what works well in practical settings and what does not. The technique reveals elements that can be used to improve a process towards an optimum outcome (Cheek, O'Brien, & Pincombe, 1997; Callan, 1998). CIT was developed by Flanagan (1954) as a technique "for collecting observed incidents having special significance and meeting systematically defined criteria" (p. 327). He defined incidents as "any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act". Further, he defined being critical thus: "an incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effect". The technique was gradually developed during studies at the U.S. Army Air Force, where it was used to improve the selection of pilots and the training programs (Flanagan, 1954).

Flanagan did not provide a rigid set of rules for the use of CIT. Instead, he proposed five important steps: (1) Identify the general aim of the studied activity. This step is necessary to be able to determine what is critical or not; and further, whether the critical incident contributes to achieving the aim of the activity or the contrary. (2) Develop plans for the collection and analysis of data. This step includes determining of who the observers should be and how the information should be acquired. It is necessary that the observers are familiar with the studied activity. (3) Collect data from the observers. This can be done by interviews, focus groups, questionnaires, and record forms. (4) Analyze data. The analysis means identification of the incidents and clustering the incidents into categories with similar incidents. (5) Interpret and report findings.

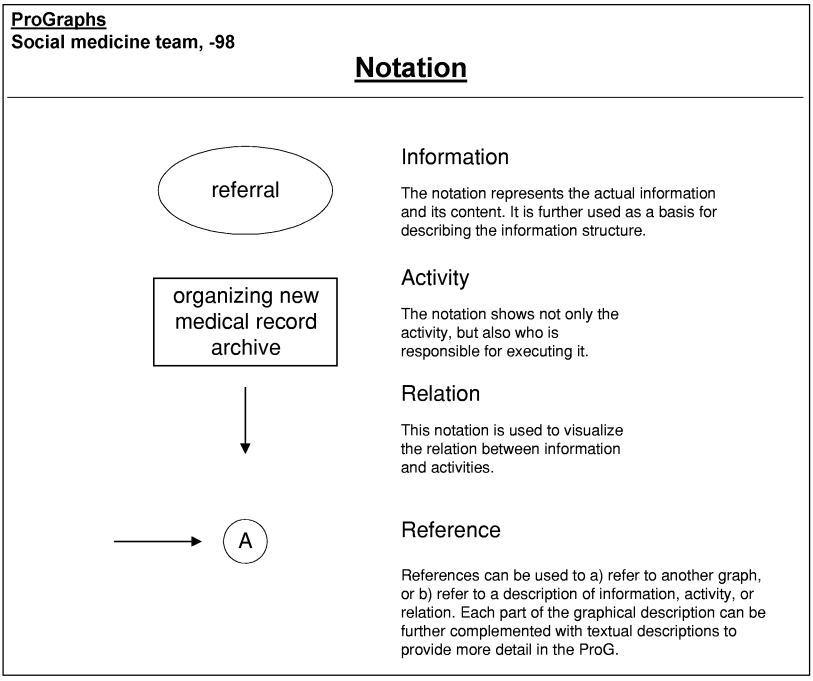

Figure 4: The notation of ProG.

The CIT has been found useful in several different type of settings, e.g. to study the work of nurses (Cox, Bergen, & Norman, 1993), to study the organizational culture and thereby be able to improve efficiency (Dean, 1998), and to discover possibilities for improvement in service quality (Callan, 1998).

2.6 ProG

ProG is a process graph notation developed as a support for enterprise modeling in requirements engineering (Johansson, 1999). Its notation is a development of the notation used for object graphs (Timpka, Westergren, Hallberg, & Forsum, 1997). ProG is intended to be used for the visualization of internal organizational functions, that is processes, activities, and information. The purpose is that the descriptions should be useful as a basis for organizational discussions. For example, it can be used for detection of different perspectives on the enterprise that may be held by different groups or individuals. ProG consists of only four

notations, i.e. information, activity, relation, and reference (Figure 4). A requirement for methods used in participatory design projects is that the notation must be easy to learn. Therefore, the notation has been kept limited to be useful in participatory design projects, so that user representatives can use the notation to describe the business themselves and to understand others' descriptions.

2.7 Information systems in the public sector: the case of health care

Health care is an information-intensive enterprise which is dependent on accurate and often immediate information (Smith, 1996). The care providers spend a large part of their daily work on handling information, which become costly for the organizations (Clayton & Mulligen, 1996). Therefore, large resources have been and still are dedicated to the development of information systems (Lock, 1996). However, the benefits of these systems have been questioned, as it has been claimed that they have not fulfilled fundamental needs in health care, such as the need to communicate with colleagues and searching in medical literature (Bleich, 1998). It has been claimed that for an information system to be used routinely, it must provide the users or the organization with some benefits or the users must gain enjoyment, satisfaction, or status by using it (Heathfield & Pitty, 1998). The clinical information systems must also focus on the individual patients and provide specialized views for different professional specialists (Simpson & Gordon, 1998). Further, the same systems should be used in the whole organization, so that the systems do not put limits on who can communicate with whom (Bleich, 1998). Several different types of information systems have been developed for use in healthcare settings, for example:

- storage systems for clinical patient data, e.g., computer-based patient records;
- systems for diagnosis by image processing, e.g., support for the identification of cancer (Bankman, Christens-Barry, Weinberg, Kim, Semmel, & Brody, 1992; Polakowski, Cournoyer, Rogers, DeSimio, Ruck, Hoffmeister, & Raines, 1997);

- knowledge and information systems which support clinicians in decision making, e.g., in medicine prescriptions (Walton, Gierl, Yudkin, Mistry, Vessey, & Fox, 1997);
- systems for the support of shared care, e.g., intra-professional collaboration where general practitioners collaborate with specialists (Branger, van't Hooft, van der Wouden, Duisterhout, & van Bemmel, 1998); and
- systems that support the development of care organizations, e.g., by supporting organizational learning (Timpka, Sjöberg, Hallberg, Eriksson, Lindblom, Hedblom, Svensson, & Marmolin, 1995).

Using Internet-related technology as an infrastructure for information systems in health care has been identified as an approach to providing cost-effective implementations (Cesnik, McCray, & Scherrer, 1998; Bentley, Horstmann, & Trevor, 1997). Several benefits have been identified, such as the main part of the software being stored in one place, which makes it easier and more cost-effective to maintain (Korpela, 1998). Further, the systems implemented can be designed as *easy to use* and to match the healthcare providers' needs, such as access to information and communication with others from different places (Neame & Olson, 1998). A problem that has delayed development is security (Rind & Safran, 1998). Healthcare is more dependent on secure information systems than many other types of organizations due to the type of information that is handled, for example due to the patient's rights to privacy (Morger, Nitsche, & Teufel, 1998). However, security systems and structures that solve these problems or at least solve them to an acceptable level have been recognized (Masys, Baker, Barnhart, & Buss, 1998). Another feature that arose with the Internet is seen in the patient-supportive systems, for instance patient-to-patient support such as discussion forums and patient knowledge support such as medical databases that are accessible on the Internet. In the discussion forums, people with similar problems can find and support from each other, for example by asking each other questions and sharing their experience by telling "their story". One example can be seen in the Experience Journals that support children with chronic illness and their families (Gonzalez-Heydrich, Bromley, Strohecker, Marks, DeMaso, Ackermann, Gibson,

Shen, & Umaschi, 1998). In medical databases available through the web, patients and others can find information about different kinds of ill-health. Examples of such databases are Infomedica[4] (Swedish), Medical link[5] (Swedish), and the American Health Network[6].

Occupational therapists started to make use of computers in their work in the early 1970s (Lau, 1986). During the following decades, they have used computers for administrative tasks, treatment planning, and patient recreation (Smith, 1986). The recent development of information technology, including Internet, has expanded the possible application areas significantly. Today, organizations supporting occupational therapists provide information via web sites, e.g., Förbundet Sveriges Arbetsterapeuter[7] (Swedish Organization of Occupational Therapists) and the American Occupational Therapy Association[8].

2.8 Inter-organizational information systems

Modern information technology has made completely new connections and cross-boundary collaborations between organizations possible. Information systems used for this purpose are often called *inter-organizational information systems* (IOISs). A technique often referred to in IOIS is *electronic data interchange* (EDI), which can be seen as a structured form of electronic mail (Blacker, 1991). EDI can be used for sending messages such as orders and invoices. The data is formatted according to EDIFACT or ANSI X. 12 standards (Bolisano & Gottardi, 1996). Even though the technical prerequisite for IOIS exists, this introduction has not been unproblematic. It has been claimed that to gain the most positive effects possible from the adoption of IOIS, re-organization methods such as Business Process Reengineering (BPR) must be applied (Finnegan & Golden, 1996). A successful adoption of IOIS has also been shown to be greatly dependent on social issues such as the organizations' cultures and the power relations between them (Premkumar & Ramamurthy, 1995). The tasks must be clearly divided

[4] http://www.infomedica.nu/
[5] http://www.medicallink.se/
[6] http://www.ahn.com/
[7] http://www.fsa.akademikerhuset.se/
[8] http://www.aota.org/

between the actors, so that no competition or mistrust between the actors arises that hinders the collaboration (Christiaanse & Huigen, 1997; Bytheway & Dhillon, 1996). When the right circumstances exist, the organizations have the possibility to introduce IOIS that will increase cost-effectiveness (Clark & Stoddard, 1996). In this thesis, the term *information-systems-supported service* often will be used. Information-system supported service includes IOIS as well as information system support for individual work and teamwork.

2.9 Empirical research methods

To study organizational matters, both qualitative and quantitative research approaches have been used. Quantitative research is aimed at measurements, asking, for instance, how much, how far, and how often, and using a statistical analysis of data. It originates from the natural sciences and the researchers' subjective influences are minimized by the use of well-defined and rigid methods. Further, their beneficial use, for instance in health service research (Speller, Learmonth, & Harrison, 1997), and in software development processes such as statistical control of efficiency of different methods (Wang, Court, Ross, Staples, King, & Dorling, 1997), are well known.

In qualitative research the aim is to discover qualities of phenomena in their contexts (Denzin & Lincon, 1994). For qualitative research, no set of rigid methods, as in quantitative research, are provided. Instead, the methods have the form and character of research directions and guidelines. Originating from the social sciences, several qualitative research approaches are today used in different domains, e.g., software quality process improvement (Badham, Couchman, Little, 1995) and healthcare (Chapple & Rogers, 1998; Green & Britten, 1998). In this thesis most of the studies are based on qualitative approaches. A brief description of the two research approaches employed in the studies follows.

2.9.1 Case studies

Case study methodology is aimed at the investigation of phenomena or units in their real context. It provides a holistic and complete understanding of the situation. It has been claimed that the term *case*

study has been misused. However, a strict case study should follow five steps: (1) choosing the problem to study, (2) planning the investigation, (3) systematically collecting data, (4) interpreting data, and (5) reporting the findings. An important issue is the planning in advance (MacNealy, 1997). In case study methodology six different sources of data collection have been identified: documentation, archival records, interviews, direct observations, participatory observations, and physical artifacts. However, data from more than one source should be used, in a triangular fashion, and both qualitative and quantitative data can be used (Yin, 1994). Case studies have been criticized as being soft and unscientific, for example due to the difficulties in repeating studies and generalizing from findings. As a response to this criticism, Eisenhardt (1989) suggested a nine-step interactive approach to a theory based on case studies. Her objective was to integrate the positivists' view of testable hypotheses into case-study research. Case studies have also been found useful for evaluating methods and tools. For example, a method can be applied, evaluated, and improved in a blocked-subject study in which experience from one case study is used as a study subject in a subsequent case study (Kitchenham, Pickard, & Pfleeger, 1995).

2.9.2 Participatory action research

Participatory action research (PAR) has its basis in social science, participation in decision-making by workers, and the socio-technical framework (Whyte, 1991). An important aspect of PAR is that both researchers and practitioners actively participate in the research process. Although practitioners are encouraged to participate in the scientific process, researchers are ultimately responsible for knowledge accumulation, theorizing, and scientific documentation (Karlsen, 1991). The action research approach differs from other applied sciences in that the researchers "serve as professional experts, design the project, gathering the data, interpreting the findings, and recommend actions to the client organization." (Whyte, Greenwood, & Lazens, 1991 p. 20).

PAR has gained interest within computer science (Kyng, 1994) as by active participation researchers can observe and report from interventions in disciplines not previously studied academically. Researchers can also

use the competence of project members to discover ideas for future actions and innovations.

In all action research, scientific rigor and relevance are central, but sometimes mutually competing, concepts. To avoid interference from scientific instruments in practice settings, rigor is mainly ensured in the interpretation of data by feeding back all inferences to be reviewed by the participants in the study (Greenwood & Gonzales Santos, 1995). Criticism of action research has been formulated in that it does not sufficiently construct and report the background of interventions, which makes it difficult for outside readers to draw conclusions from their outcome (Argyris & Schon, 1989). However, if the interventions and their background are formulated before each step in the study, the laboratory type of controls become irrelevant (Whyte, 1991).

2.10 Summary of the background

The Internet and related technology are considered to play an important role as a platform and infrastructure for the design of information systems used in the public sector (Korpela, 1998; Neame & Olson, 1998). However, proper methods for the design of these new information systems are lacking (Blum, 1991). The philosophy of QFD provides an interesting view on design by its focus on the value of the customers instead of error corrections (Mizuno & Akao, 1994). It also emphasizes the importance of fulfilling the most important customer needs instead of all needs. QFD contains sets of different tools that can be applied in several different ways. However, since there are several different ways of applying QFD, a proper model for applying it in the specific situation of the public sector must be defined. To gain knowledge of information system development as such, case study methodology and participatory action research strategies have been found useful (Kyng, 1994; Kitchenham, Pickard, & Pfleeger, 1995).

Chapter 3
Methods

This chapter presents how the studies were performed and which research approaches were used. Each subheading in the chapter corresponds to one article.

3.1 Communication patterns in public service organizations

The study was performed at four primary healthcare centers. It was initiated by a presentation, during seminars, of the aim for the study to representatives of all professions (physicians, nurses, nurses' aides, physiotherapists, laboratory staff, and secretaries). All professions at the four centers agreed through their representatives to participate in the study provided that individuals were able to withdraw. Extra staff and staff on sick leave for longer than 10 days were excluded from the study. Nine (4%) of the eligible staff members (four physicians, three nurses, one nurses' aide, and one secretary) chose not to participate. All primary healthcare centers were represented among the non-participants.

The data was collected via interviews performed by a research assistant/sociologist. Each interview lasted for 15 minutes and consisted of questions such as "I would like you to say which staff member you would ask for advice if you had a medical problem with a patient." An example of a medical problem is an elderly diabetes patient with a bruised foot. Similar questions were asked for problems in the patient–provider relation and advice about organizational issues.

Subsequently the collected data was coded and displayed using descriptive statistics. The Chi-square test was used to analyze the

association between team and central work organization and differences in communication patterns between professionals.

3.2 QFD for orientation of a healthcare service

The study was performed by interviewing the staff representatives at the department for clinical social medicine (CSM) and representatives from the five institutions that refer clients to CSM, followed by an application of QFD on the interview data (Figure 5).

3.2.1 Interviews with CSM staff

To gain an understanding of how the social medical service was carried out the manager of the clinic and one representative from each profession were interviewed, i.e., a social worker, a physician, a nurse, a psychologist, and a secretary. Each interview lasted 45–90 minutes and questions concerning three areas were asked: (1) overview, aimed at a general description of the purposes, prerequisites and goals of the clinic; (2) appointment and assignment, addressing the profession's work role; and (3) organization, addressing the working situation, considering internal and external prerequisites, such as legitimacy of decision making, communication, and division of labor.

3.2.2 Interviews with the referral institutions

To identify the referral institutions' needs of a social medical service, representatives from each of the five institutions were interviewed. The five institutions were the occupational healthcare clinics, the employment exchange, the local social insurance office, the social welfare office, and primary healthcare. The representatives selected were the persons who coordinated the contact with CSM. Each interview lasted 45–60 minutes and the questions, which were sent to the representative a week in advance, reflected two areas: (1) service use; addressed services used today, services they would like to have today, and services they expected to need in the future. (2) Cooperation with CSM; aimed to pick up attitudes to cooperation.

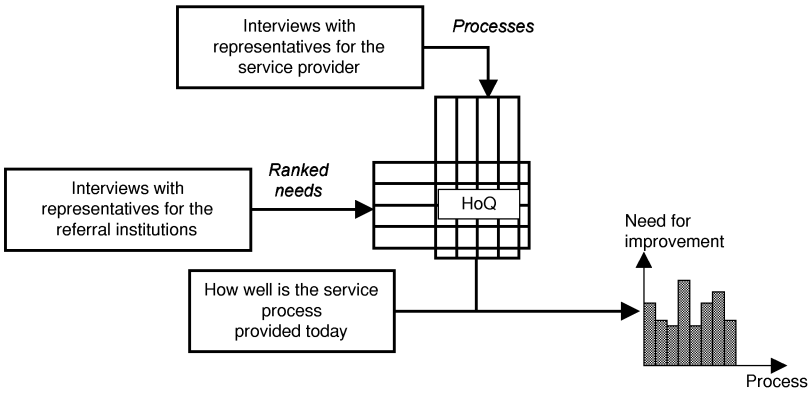

Figure 5: QFD model applied for orientation of CSM.

3.2.3 QFD on the interview results

From the interviews with the representatives, customer needs were identified. The needs were returned to the representatives who were asked to validate and to grade the importance of each of them on a scale from 1 to 5. Each representative was also provided with a list of the needs that the other representatives had identified, and in addition, they were allowed to add new needs to their own lists. Thereafter, the ranked needs were inserted into the HoQ. One HoQ for each referral institution was created.

From the interviews with the CSM staff, processes of their service performance were identified and inserted in the HoQ as design attributes. In the HoQ's relationships matrix the correlation between each customer need and each design attribute was inserted. Thereafter, the prioritization of each design attribute was calculated.

Since this project concerned the orientation of a preexisting service, it was necessary to determine how much each design attribute must be improved. Therefore, the level of fulfillment was calculated as the distinction between the estimation of how well a design attribute must be performed before it could be considered as being satisfactorily

performed, and the estimation of how well it is performed today. These values were called *need of improvement*. To determine how large the need is to improve each design attribute from the referral organization's point of view, the values of the need for improvement were multiplied by the values of importance of design attributes (%) for each design attribute. The results were presented in Need of improvement diagrams.

3.2.4 Experience of using QFD

Data on the experience of using QFD for the orientation of the service were collected through participative observations (see also Hallberg and Timpka (1996)).

3.3 QFD for design of information systems

To customize a QFD model for design of information systems, a blocked-subject case study design on the basis of a PAR was used (Whyte, 1991). The starting point for the development was the Software Quality Function Deployment (SQFD) model (Haag, Raja, & Schadke, 1996), which was theoretical customized, followed by evaluation of its application in two case studies. A project facilitator mobilized relevant expertise from the participating engineering and healthcare organizations. Data was collected by participative observations and taking field notes. In case study II, the data was also collected through interviews with the participating practitioners. The researchers and practitioners contributed interactively by deciding interventions, interpreting outcomes, and suggesting evaluations. The research results were compiled cooperatively and describe the interventions performed. The resulting method, the Medical Software Quality Deployment (MSQD), is based on the findings made during the case studies.

3.4 MSQD: Design of information-system-supported service

To extend the MSQD method to be used for the design of information-system-supported services, it was first customized theoretically based on presumptions that had been reported in the literature (see section 2.8). Subsequently the extended MSQD was evaluated in a case study. In the case study, data was collected through questionnaires and interviews on a regular basis with the participants, video-recordings of design meetings

and demonstrations, and participatory observations by the researchers who noted down their observations.

The case study was carried out in a project aimed at developing the social-medical service. Due to changes in the environment and to economic prerequisites, it was necessary to investigate how the service can be provided more efficiently. The idea was to use information technology to support individual tasks, teamwork, and above all to develop inter-organizational collaboration with the other rehabilitation actors.

3.5 Integration of the extended MSQD and ProG

In the same setting, where the extended MSQD was evaluated, the integration with ProG was studied. The aim of the integration was to study what benefits can be gained and what difficulties will occur when integrating MSQD with process graphs. In the case study, ProG is used as an example of process graphs. The assumption was that since the service is reengineered, benefits of the integration with some kind of process graphs notation would be gained. In this study an approach based on participatory action research methodology was used (Whyte, 1991). All design group members participated and actively contributed to the results presented as experience concerning the integration. Data was collected through taking field notes during the development process and by video-recordings of the design meetings. Findings on the integration, made from transcriptions of the video-recordings and in field notes, were used as input to discussions at later design meetings throughout the project.

3.6 Prototyped network service for support occupational therapists

The design of the prototype was performed according MSQD, where design meetings built on participatory design methods were held (Sjöberg, 1996). The baseline data were collected via a questionnaire based on critical incident technique (Flanagan, 1954), which was sent to all occupational therapists (n = 287) in the county of Östergötland, Sweden (local population 440,000). The occupational therapists were asked, amongst other things, to describe their most recently experienced problem related to a patient-consulting situation. The aim was to identify

problems occupational therapists experienced during their daily work. 185 of the questionnaires distributed were returned.

The descriptions of problem situations were analyzed and transformed to needs by using a voice of customer table, an affinity diagram, and a hierarchy diagram (Mazur, 1992; Holtzblatt & Jones, 1993). The prioritization of the needs were based on, (1) in how many questionnaires the need is identified and (2) how often the respondent stated that the need occurs. The 12 highest prioritized needs were inserted in the House of Quality, to be transformed into ranked technical requirements. The technical requirements were expressed as features, such as *providing information about assistive technology* and *enhancing communication with other occupational therapists.* The technical requirements were transformed in a second matrix to ranked design attributes. These constituted the base of the design specification. The design attributes were expressed as information sources and as tools, e.g., assistive-technology databases and electronic discussion forums.

Based on the design specification, the first prototype of the network service was implemented. The implementation was based on Internet-related service and techniques, such as HTML and CGI-scripts, and on general commercial products.

Chapter 4
Results

This chapter describes the practical and scientific results achieved in each study. The following results are presented:

- the communication patterns of primary healthcare centers,
- the effects of using QFD for orientation of social medical services,
- the experience gained during the development of a QFD method for the design of information systems and their effect on the resulting QFD method,
- a description of the QFD method for the design of information systems,
- a description of the extended version of the QFD method for the design of information-system-supported services and the experience of applying the method,
- the experience of integrating the extended QFD method with a process graph notation, and
- a description of a prototype designed using the developed QFD method.

4.1 The communication patterns at primary healthcare centers

The result of the study showed that in both types of organizations the advice-seeking patterns differed between the problem areas. For organizational advice, primary healthcare center managers were consulted at the centrally organized primary healthcare centers, while staff at centers using team organization more often consulted outside sources.

Medical advice was mainly sought from physicians in both organizational types. Having no one to ask for advice on client communication was more common in the centralized organization. Regarding medical advice, only nurses' aides differed by consulting withintheir own profession rather than physicians. For clients' communication problems, the professions shared an intra-professional advice pattern. The result indicated that if information systems should support the advice seeking patters, intra-professional, inter-professional, and inter-organizational communications options must be considered.

4.2 QFD for orientation of a social medical service

The experience from the study of QFD for orientation of a social medical service was that a limited QFD model, based on HoQ, can be used for orientation of an existing healthcare service. However, the project team found it difficult to extract customer needs from the voice of the customers. Therefore, validation of the identified needs was found necessary. It was performed through a Delphi-oriented method (Jones & Hunter, 1995), i.e. the needs were sent back to the respondents, who were asked to add needs they thought were missing and repudiate needs they thought were unimportant. The validation of the needs was found to increase the accuracy of the identified needs. The HoQ was found both useful for transforming customer needs to service processes and to display a large amount of information in an easy-to-read and compact format (Hallberg & Timpka, 1996).

4.2.1 The design attributes

From the interviews with the personnel fourteen features (Table 3) of CSM were identified and used as design attributes in the HoQ.

4.2.2 Customization of the service

The customer representatives were in general satisfied with the services that CSM provided. However, differences were observed in what the referral institutions expected from the services. Therefore, to please the referral institutions the CSM needed to reorient their service differently towards each referral institution (Table 4).

Table 3: The identified design attribute of the social medical service. (N.I. – Needs for improvement.)

Design attribute	Explanation	N.I.
Client investigation (social, medical, and psychological)	—	-10%
Client therapy (social, medical, and psychological)	—	7,5%
Administration	Includes contact with the referral institutions and administration of patient cases. It does not include personnel administration or annual report.	30%
Reporting	Concerns the reports that CSM sends to the referring institution about the status and progress of the investigation and treatment of the patient.	25%
Capacity	Reflects the number of patients that CSM can handle and the waiting time for a patient to come to his/her first appointment.	50%
Marketing	Distribution of information about CSM's services.	50%
Care	Taking care of the patients, e.g. so that the patients feel well-treated.	0%
Teaching	In clinical social medicine at different levels.	10%
Cooperation	With the referring institution, e.g. about in-duty training.	20%
Research	The research that CSM can perform, based on patient cases.	50%

The occupational healthcare clinics: CSM should improve information about their services. They should also increase the frequency of contacts with the occupational healthcare clinics about how the patient cases progress.

Table 4: The Need of improvement of design attributes for each referral institution. (O.H. – the occupational healthcare clinics, E.E. – the employment exchange, S.I. – the local social insurance office, S.W. – the social welfare office, and PHC –primary healthcare.)

Design attribute	O.H.	E.E.	S.I.	S.W.	PHC
Soc invest	-14,8	-4,2	-9,1	-24,1	-2,3
Med invest	-6,9	-4,2	-5,8	-17,2	-2,9
Psy invest	-6,9	-4,2	-5,8	-27,6	-9,2
Social therapy	11,7	4,5	0,0	7,8	3,5
Med therapy	3,3	0,0	0,0	0,0	0,0
Psy. therapy	3,9	5,8	0,0	7,8	3,9
Administration	7,8	18,0	23,4	10,3	20,8
Reporting	36,9	25,5	16,2	17,2	7,2
Capacity	0,0	36,0	45,5	0,0	51,9
Marketing	60,7	15,0	22,7	77,6	17,3
Care	0,0	0,0	0,0	0,0	0,0
Teaching	4,3	3,0	5,2	20,7	9,8
Cooperation	0,0	4,8	7,8	27,6	0,0
Research	0,0	0,0	0,0	0,0	0,0

The employment exchange: CSM should increase its capacity, e.g., by increasing the staff. They should also increase the frequency of contacts with the employment exchange to let them know how patient cases progress.

The local social insurance office: CSM should offer the local social insurance office a service package based on rapid investigations, but without any treatment. The package should include efficient administration and frequent contacts on the outcome of the investigations or prognosed outcome.

The social welfare office: The high values on *Importance of Design Attributes* of the Investigations and Care in combination with low values on Administration and Reporting indicate that the social welfare office

does not mind if the investigations and treatment take time, as long as CSM takes good care of the client. The social welfare office seemed to be the institution whose needs best matched the service that CSM offered at the time of the study.

Primary healthcare (PHC): CSM should offer socio-medical investigations that emphasize the psychological aspect. They should also try to improve efficiency in administration and increase information about their services. A customized package of services for the PHC should include teaching in clinical social medicine.

4.3 QFD in the design of information systems

During the development of QFD-based method, it was found that in public-service environments, multi-user situations must be considered in the design of information systems. To be able to identify different user categories and estimate their relative power of influence on system design, it is necessary to study the organization. To use this knowledge in the calculation of the ranking of the needs, a matrix (see section 2.4.2) can be used (Cohen, 1995). Further, aspects of collection of the voice of the customers, identification of the needs, limitation of the number of needs, validation of the customer needs, and transformation of the customer needs to design attributes are studied.

4.3.1 Collection of the voice of the customers

Several operational methods for acquiring the voice of the customers (VoCs) are possible. In-depth interviews and CIT-based questionnaires were evaluated in the case studies. The in-depth interviews were found to provide rich information, which made it easier to understand the situation and thereby identify the needs. However, it is not possible to determine directly from the interviews any ranking of the needs. This limitation made it necessary to send the identified needs back to the users for ranking.

Using questionnaires was found beneficial since they give a large number of the users opportunity to influence the design and provide a basis for ranking the needs. However, because the answers were not as detailed as in the interviews and it not was possible to ask the respondents to explain

further, it was found necessary to have the practitioners' insider knowledge to interpret the answers. In other words, understanding the answers of the studied population requires an understanding of the language and formulations of the population. The best approach it was found, was to use both in-depth interviews and questionnaires, since together they provide both a wide and deep basis for determining the users' needs.

4.3.2 Identification of the needs

The users do not express themselves only in terms of needs. It is therefore necessary to identify the *true* needs from the way the users express themselves. In the first case study, the identification of the needs was made by carefully reading through interview transcriptions and trying to interpret what lay behind the users' formulations. In performing this task, the knowledge about the users' workplace gained during the pre-study phase was found advantageous for the interpretation. However, this task was still found difficult. Therefore, to support the process of interpretation, the voice of the customer table (VCT) was applied in the second case study.

The VCT was found useful for clarifying the mixture of users' statements and for transforming them to needs in a straightforward manner. The VCT was found easy to use and user representatives had no difficulty in understanding the work procedure. In this way, the VCT can be used in participatory design projects to bridge the terminology gap between the user representatives and the professional developers of the design team. Although the work on the VCT was time-consuming, the time was found to be well spent when it came to transforming the needs to technical requirements in the HoQ. The VCT should be seen as a key tool for the qualitative analysis of the VoCs.

4.3.3 Limitation of the number of needs

The needs that are inserted into the HoQ must be on the same conceptual level and as far as possible independent of each other. Further, the number of needs that can be inserted into the HoQ must be limited. For these purposes, the needs must be organized, so that a better overview of the needs and their relationships is achieved. The notation of affinity

diagrams was found useful for the sorting, while the hierarchy diagrams were found to provide a better overview of the structure for the final adjustment.

4.3.4 Validation of the customer needs

It is vital that the design is based on the true needs. To enhance correctness a Delphi-consensus-oriented method was used in the first case study. In this methodology, the users are presented with the other user representatives' needs. Subsequently they are permitted to adjust their own list of needs. The Delphi method was found useful for removing erroneous needs. However, it was found to be sub-optimal for confirming that all needs were considered. Therefore, in the second case study, participatory design methods were used for the validation of the needs.

Participatory design was found useful for the interpretation of the needs in the answers given in the questionnaires. The user representatives identified more needs than the others in the design team. The user representatives were also able to clarifying the cause of the needs to the others. In addition, all participants agreed that the time was well spent.

4.3.5 Transformation of the customer needs to design attributes

It was found that the transformation of the customer needs to design attributes directly within HoQ was a too large conceptual step. For this reason, an additional matrix was added, which means that the customer needs are transformed to technical requirements with the HoQ and subsequently the technical requirements are transformed to design attributes in the added matrix. The approach of using two matrices for the transformation was found to be easier. In addition, the HoQ could be used without considering actual software components. In this way, the design work became more innovative. The results of the case studies were condensed into a function of a method, which is called MSQD.

4.4 The Medical Software Quality Deployment Method

The Medical Software Quality Deployment (MSQD) method emphasizes the fact that quality issues, from the users' point of view, are introduced early in the design process. In this way, an information system that brings

value to the users, that should be targeted, can be achieved. MSQD is formed by determining who the users are, collecting and identifying the users' needs, and transforming the customers' needs to prioritized design attributes of the information system (Figure 6). One property of MSQD is that it handles the introduction of needs from multiple customer categories, where the customer categories may have a different level of power to influence the design. MSQD is performed in four phases: the pre-study phase, the data-collection phase, the need-specification phase, and the design phase.

4.4.1 The pre-study phase

The aim of the pre-study phase is that the professional designers should become familiar with the organization and its operations, so that the categories of users and an estimate of their relative influence on the system design can be determined. Further, the designers' understanding of the enterprise is also essential for the work in the subsequent phases. The customer categories are not restricted to include only care providers, they can include any persons and organizations that are affected by or have an effect on the system design. The work is performed by field observations of users' work sites, interviews, and study of documentation, if any, describing the organization.

4.4.2 The data-collection phase

The aim of the data-collection phase is to collect the *voice of the customers* (VoCs). The VoCs is the data that are directly used as the basis for the design. These data are not necessarily expressed verbally or textually by the users, but can also consist of observations made by them or anything else that hints about the users' needs. To acquire the VoCs several different operational methods can be considered, such as, in-depth interviews and critical incident questionnaires (Flanagan, 1954). It is advantageous if qualitative and quantitative data can be combined. The qualitative data provides a deeper understanding of needs, while the quantitative data provides input from a large population of the users and can be used as a basis for the ranking of the needs.

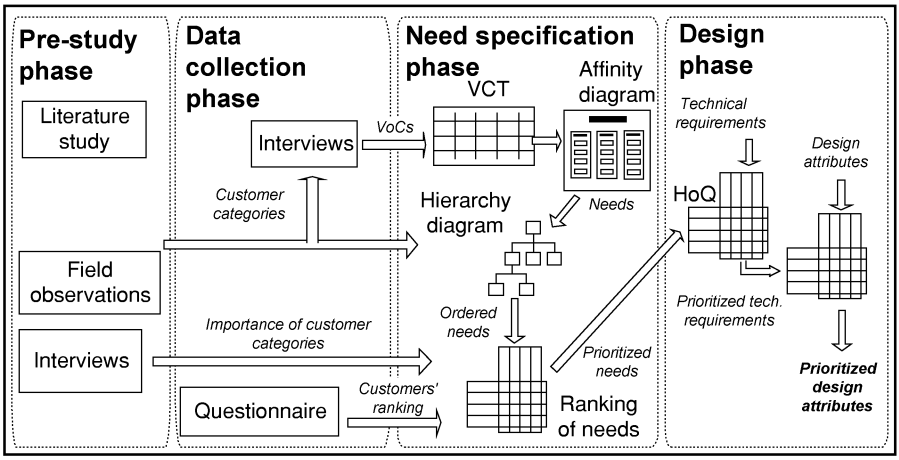

Figure 6: The Medical Software Quality Deployment (MSQD) method.

4.4.3 The need-specification phase

The aim of the need-specification phase is to determine a distinctive set of prioritized customer needs. Since the users do not express themselves in terms of needs, the VoCs must be *cleaned*. This cleaning is performed by using the voice of the customer table (VCT) (Mazur, 1992). Further, to get the needs on the same conceptual abstraction level they are ordered and scrutinized in affinity and hierarchy diagrams. Further, if no foundation for the ranking has been obtained from the collection of the VoCs, for instance by questionnaires, the users are asked to rank the needs. This can be done by asking them to assign a value on a scale of 0–5 to each need, where 0 stands for not important at all and 5 is most important. Another and more precise method is the Analytic Hierarchy Process, where the needs are pairwise compared (Saaty, 1994; Zultner, 1993). The calculation of the ranking of the needs is made on the basis of the estimated importance made by the users and the estimations of the users' relative power of influence.

4.4.4 The design phase

The aim of design phase is to determine the prioritized design attributes. The customer needs and their prioritization are inserted into the House of Quality to be transformed to prioritized technical requirements. Then

prioritized technical requirements are inserted in an additional matrix to be transformed prioritized design attributes. The outcome is in the form of prioritized design attributes that together with further explanatory text about each design attribute function as a design specification.

4.5 MSQD: Design of information-system-supported services

To adopt the MSQD to be used for the design of information-systems-supported services, the following three objectives were considered: user identification, service adoption, and provider involvement. In the new situation of use, where the customers are external to the organization, the number of identified customers can be too large to let all of them have direct influence over the design. Hence it must be determined which of them are sufficiently important to influence the design. Therefore, a graphical tool that supports the identification of customer categories was included (Figure 7).

In the case of inter-organizational information systems, it is stated in the literature that process reengineering is necessary (Finnegan & Golden, 1996). Therefore, the provided services are (re-)designed in compliance with the customers' needs. The information-system-supported service should be designed with the assumption that it is the service that provides the value to the customer and the information systems are tools to provide the service. Therefore, four new matrices were added to the design phase.

It is necessary to structure the scope of the service network early in the design. Further, the redesign of the service provided is a task that is difficult to manage without the providers' competence. Both of these two tasks can be beneficially undertaken with provider participation. Therefore, a design team that includes provider representatives works throughout the entire project.

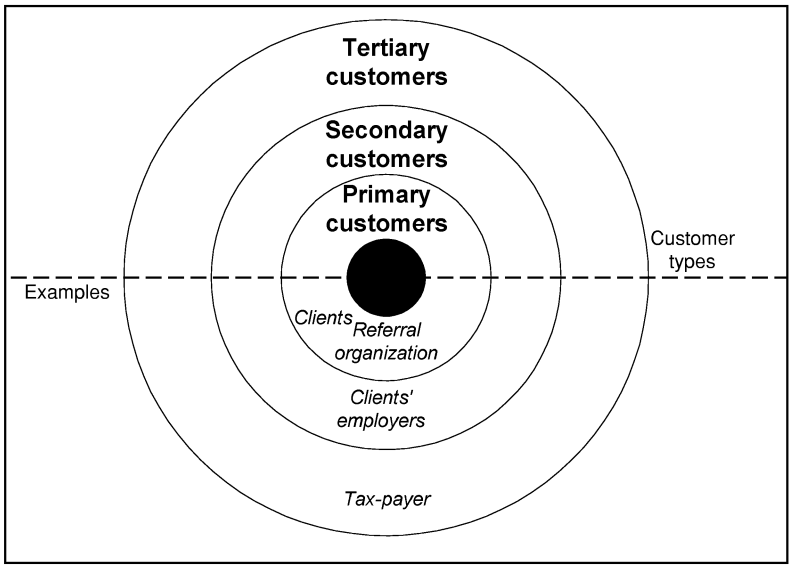

Figure 7: The customer identification tool.

The difference between extended MSQD (Figure 8) and MSQD is mainly in the pre-study phase and the design phase. They will therefore be described in more detail, while the data-collection phase and the need-specification phase will only be superficially presented.

4.5.1 The pre-study phase

In extended MSQD the pre-study phase has three aims. The first aim is to assemble the design team, which should include service-provider representatives, system developers, and group-process facilitators. All professions involved in the service provision should be represented in the design team. The second aim is that provider representatives are given basic information about the method and information systems. Therefore they attend lectures on the method and are given the possibility to use and try it on different types of information systems. The information systems are used with advantage as a natural element in the project work, for example, used to support internal project communication and information sharing. Further, the developers should learn about the providers and their work practice. For this reason they spend time at the workplaces to observe work practice and talk to the practitioners. The third aim is to

determine the customers who should have influence on the design. This is done with the assistance of the graphical tool (Figure 7). First, categories of individuals and organizations that have a direct use or possible use for the service are identified and defined as *primary customers*. Second, the categories of individuals and organizations that have indirect use of the service are identified and are defined as *secondary customers*. Finally, the categories of individuals and organizations that do not belong to the other two categories but are still affected or affect the provision of the service are identified and defined as *tertiary customers*. Then, the categories of customers are preliminarily ranked on a scale from one to ten depending on the extent of the influence on the design they are judged to have. Each of the provider representatives makes his/her own ranking. To improve the correctness of the ranking, a Delphi-oriented method is used (Jones & Hunter, 1995; Duffield, 1993). There, the provider representatives are presented with the other provider representatives' ranking. Thereafter, they are allowed to adjust their own ranking. The final rank is calculated as the average values of the provider representatives' ranking, for each customer. A number of the highest ranked customers categories are selected to have a direct influence on the design. That is, these customers' needs will constitute the basis for the design. In addition, the data-collection methods to be used for each category of customers are determined.

4.5.2 The data-collection phase

The aim of the data-collection phase is to collect the VoCs. For this task, several methods are available, e.g. interviews, participatory observations, different types of questionnaires, and written sources. The use of questionnaires or other quantitative approaches makes it possible to collect data from a large population, which implies that a large proportion of the customers can affect the design and that it can be the basis for the ranking of needs. The qualitative approaches provide a deeper understanding of the customers' situation. Therefore, a combination of qualitative and quantitative approaches is preferable. However, the choice of which methods to use also depends on the customer categories and the amount of resources dedicated to the project. Further, the effort that should be put in the collection of customer data from the different categories is related to the importance of customer categories.

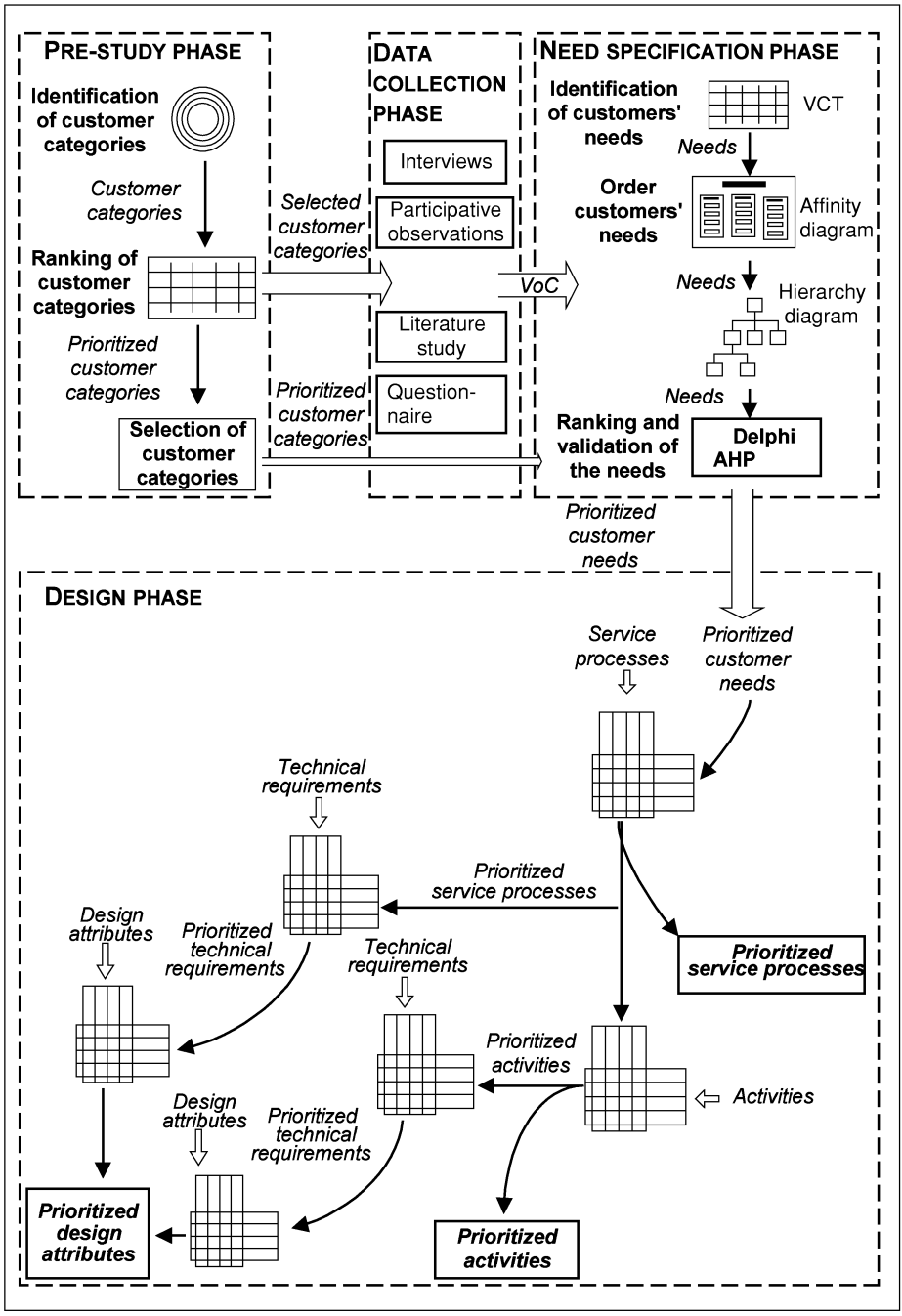

Figure 8: The modified MSQD for design of IOIS.

4.5.3 The need-specification phase

The aim of the needs-specification phase is to determine a manageable set of mutually independent and ranked needs. To transform the VoCs into a manageable set of needs the voice of the customer table (VCT), the affinity diagram, and the hierarchy diagram are used.

4.5.4 The design phase

The aim of the design phase is to determine the services' characteristics and design attributes of the information systems that support the services. The first step is to transform the customers' needs to service processes by the use of the HoQ. The second step is to define the individual service provider's work by transforming the processes to activities in a second matrix. The activities are building blocks, which put together in a specific order constitute a service process. To achieve a specification of the information system, both the service processes and activities are separately transformed into technical requirements in different matrices. Then the technical requirements are transformed into design attributes. The design attributes that originate from the service processes are of a more general character than those that originate from service activities. Meanwhile, the design attributes transformed from the activities support the actual work practice. The outcome is the design specification of an information system that supports the delivery of the specified service through supporting the inter-organizational collaboration, the internal teamwork, and the work of the individual providers.

4.5.5 Findings

The instrument describing the customers' relationship to the service provider, introduced in the pre-study phase, was useful for analyzing the service network, especially for generating customer categories to the service at the second and third levels. The identification of needs from the VoCs was found to be more difficult than in the original MSQD case. The two main reasons for this were that the provider representatives in the design team did not deal with their own VoCs. For this reason, several formulations appearing in the VoCs were difficult to interpret. This problem limited the possibility for the provider representatives to validate the needs. The second reason was that the background knowledge held by the organizations about each other and their view of

the service consumers (e.g., patients and clients) varied to a large extent. These two findings indicated that it could be beneficial or even necessary to include representatives from all involved service organizations in the design team when designing an inter-organizational information system. It was also found that the number of customers who can have a direct influence on the design cannot be too large, since the number of needs has to be limited. Hence, if a customer has been judged to have a relatively low level of influence, his/her specific needs will be sorted out later in the process anyway.

The initial phases of the project were found to be time-consuming. According to the method, the focus in the early phases should be on non-technical issues, e.g., one's own enterprise and the customer needs. The provider representatives sometimes found this approach confusing, since they looked forward to the introduction of computers. Hence they occasionally started to discuss possible technical solutions. The discussions were directed back to the topic by the facilitator. However, the solutions discussed were noted for use in the design phase. Nothing indicated that the graphical notation should result in any difficulties in the PD-based work. Instead, it was found useful as an arena for communication and documentation. In addition, it facilitated keeping the focus on the objective of the work.

4.6 MSQD integrated with ProG

The integration of the extended MSQD with the ProG was applied as follows (Figure 9).

4.6.1 ProG: Description of the present service processes

ProG is used to describe the service provided, according to service processes, activities, and information flow. These descriptions are used to create a common understanding amongst the design team members of how the service is performed at present.

4.6.2 MSQD: Data collection and need specification

The voice of the customers is collected and transformed into customer needs according to extended MSQD. The needs are also ranked according to MSQD.

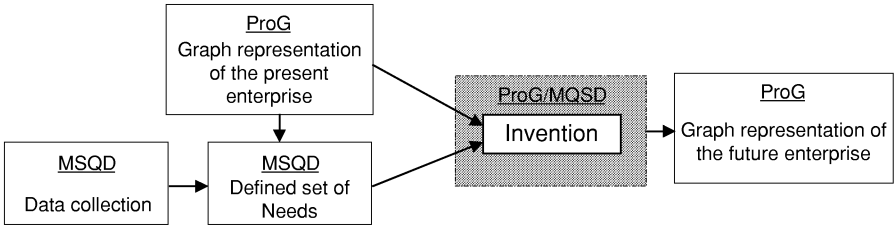

Figure 9: The integration of MSQD and ProG.

4.6.3 MSQD/ProG: Invention

The identified needs are inserted into the HoQ. Then the ProG descriptions are used to identify processes, activities, and technical requirements that correspond to the identified needs. The identified processes are inserted in the HoQ, and the ranking of needs are transformed to ranking of processes. Then ranked processes are inserted into a second matrix and then transformed into ranked activities. The ranked processes and the ranked activities are inserted into separate matrices, all according to extended MSQD. There they are transformed into ranked technical requirements. These requirements are determined using the graphical presentation of the enterprise in the ProG as a support. Thereafter, the technical requirements are transformed into design attributes following MSQD.

4.6.4 ProG: Describing the future

Based on the outcome of the extended MSQD, according the ranked processes and activities, a new graphical description of the service is constructed using ProG. These are used to visualize the redesigned service. Together with the outcome of the MSQD, the "new" ProG descriptions constitute the design specification.

4.6.5 Experience from the integration

Three major benefits of the integration were identified. The first benefit was that the ProG worked as an interface to MSQD by providing an arena for discussions about the provided services. The discussions supported

the identification of processes and activities that can be used as input to the design phases, in MSQD. The second benefit was that the ProG worked as an organizational memory. This meant that *tacit knowledge* collected in the organization can be used in the design of the new workflow. The third benefit is that the ProG visualizes the outcome from MSQD by describing how providing the service *should* be performed.

The greatest difficulty experienced concerning the integration of the ProG notation was that in ProG it is not necessary to clearly determine the difference between processes and activities. At the same time this task is a prerequisite to be able to use them in MSQD. The activities must be as independent as possible and on the same conceptual level to be comparable.

4.7 Computer network service for occupational therapists

The prototype computer network service for occupational therapists is accessed by the use of a web-browser. It was constructed on three levels reflecting the organization of Swedish healthcare: (1) the individual/team level, (2) the regional level, and (3) the national level (Figure 10). The levels are autonomous and each level has its own starting page. These starting pages are called main pages.

The main pages contain indexes of links to tools and information sources. At the national level, it also provides a space for advertisements and a small bulletin board. The bulletin board is dedicated to small messages, for instance, announcements of conferences and new literature on occupational therapy. At the personal–local level the main page works as the occupational therapists' entry point to the rest of the system with links to the other two levels. A description of the specific purpose of each level follows.

- The personal–local level supports the occupational therapists' individual and team-oriented patient work. It also provides access to information that is related to the work organization and processes at the care unit.

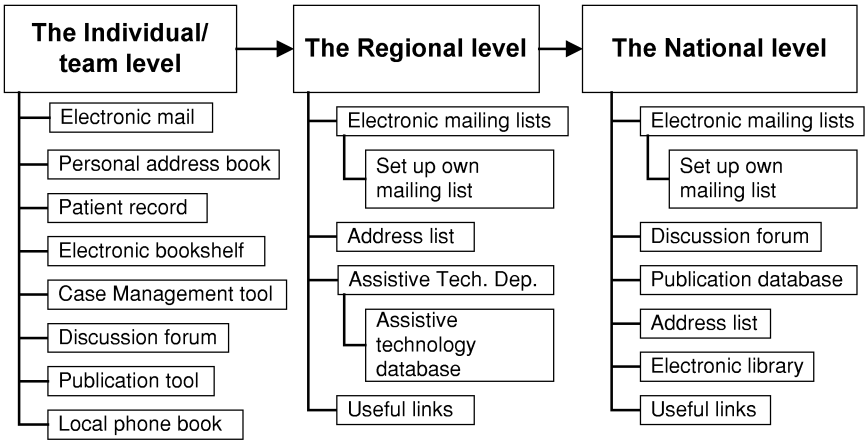

Figure 10: The main structure of the prototype and the content of tools and information sources of the three levels.

- The regional level supports communication between the occupational therapist, other healthcare professions, and external organizations related to healthcare in a county. At this level there is one instance for each region. In Sweden, due to the healthcare structure, the regions naturally due to the healthcare structure, correspond to the provider organizations. Since each region has its own instance at this level, the level can be adjusted according to the regional requirements.
- The national level provides a forum for discussion and exchange of knowledge for Swedish occupational therapists. The level is mainly exclusive for the occupational therapists.

Chapter 5
Discussion

The work presented in this thesis is motivated by the public sector's striving to become more efficient. Worldwide the public-sector organizations have struggled with economic and efficiency problems (Pierson, 1996; Rafuse, 1995). To attend to these problems, responsibility for the use of resources has often been decentralized to local service-provider organizations (Clayton & Pontusson, 1998). The local organizations have, in their undertaking to become more effective, applied different kinds of quality improvement efforts and introduced information systems (Werner, 1988; Lock, 1996; Tien, 1998). However, the benefits in relation to the costs of implementing quality improvement programs, such as TQM and audits, have been questioned (Taylor, 1996; Berger, 1998). Further, the positive effects of information systems used in public-service organizations today are still disputable since they have been found not to meet existing needs and not to be economically defensible (Bleich, 1998; Vimarlund, Ljunggren, & Timpka, 1996).

The main objective of the thesis is to explore methods for the design of information systems and information-system-supported services in the public sector. To do this two initial studies were performed to explore the selected areas of the public sector, healthcare and social welfare, by studying the advice-seeking patterns of professional communication at healthcare units and by studying the effects of using Quality Function Deployment (QFD) for orientation of a social-medical service. Next, the experience gained from the studies was used to develop a method based on a QFD model for software design. The resulting method is called MSQD. It enables the design of information systems and services that meet the users' needs. The possibility of integrating this method with

process graphs for visualization of a business was explored and found useful. Finally, an information system was designed with the method developed and implemented as a prototype in order to illustrate how modern information technology can be used to support public service providers. The remaining part of this chapter will begin with a discussion of the need for orientation of a public service, with the argument that it is important to consider whose needs the service should meet. Thereafter, issues concerning the design and use of information systems in the public sector will be discussed, in which the need for information systems in public services is argued for. Then, MSQD will be discussed: how it works compared to other methods, the benefits of MSQD, why it is beneficial to combine QFD and PD, and the limitations of MSQD. This will be followed by a discussion on the limitations of the study and how it could have been performed differently. Thereafter follows a discussion on how the result, MSQD, can be generalized beyond the scope of the thesis; that is, the possibility of using MSQD in the private sector. Finally, future work and the possibility of expanding MSQD will be discussed.

5.1 Orientation of services

One possible way to improve the quality of the services provided by an organization is to ensure that the services offered are in line with what the users' require and want (Werner, 1988). From the study of the orientation of the social-medical service, it is evident that there is a need for quality improvement of this type in the public sector (Paper II). The clinic, used as the study site, had for a long time carried out quality programs (Timpka, Leijon, Karlsson, Svensson, & Bjurulf, 1997). These programs were, however, directed towards the patients. Meanwhile, the referral institutions, which decided whether the clients should be sent to the social medical clinic or elsewhere, were not taken into consideration. In a dynamic environment, this can result in a service not meeting the needs of the referral institutions and as a result they will stop using the service. It can be argued that this kind of public service should be adjusted to meet the patients' interests and not to the referral institutions. However, since the local managers of public services have received the authority and responsibility to deploy the resources, they have to look to the

interests of their organization and may only use services that meet these. If the referral institutions stop using the service, the patients will not have any benefit of the service, independently of how well it meets the patients' needs. Therefore, this kind of service must attract other public service providers.

A problem in the case of the clinic social medicine was that there was no measurement that indicated how satisfied the referral institutions were with the provided service. An example of this kind of indicator of customer satisfaction in the private sector is the cash flow, which varies depending on the customers' choice. In other words, competition can force providers to become cost-effective. The concepts of public competition and mix-market have been suggested for creating competition effects (Saltman & von Otter, 1992). However, the benefits of these systems were counterbalanced since the savings obtained had to be spent on marketing (Freeman, 1998; Saltman & Figueras, 1998). Despite the lack of success of these models, the demand for the service organizations to be cost-effective remains (Clayton & Pontusson, 1998). However, it is not necessary for service units, at least not small service units, to use major quality improvements approaches.

The study presented in paper II shows that it is possible to use a small and relatively easy-to-use quality tool to improve public services. However, in the later studies it was found beneficial to add the voice of the customer table, affinity diagrams, and hierarchy diagrams to support the identification of the needs (Paper III). The notation not only supported the process, it also benefited the documentation of the user data and the design decisions taken. The compact form in which the information is documented and the overview it provides make it possible to communicate the information to the stakeholders. In the social-medicine case, the manager of the clinic used the notation to present clinical-social-medical services to hospital management. Further, for several of the service processes that were recognized, a need for improvement in information systems can be used to accomplish this. For example, in the administration support for co-authoring of reports to the referring institutions will decrease the time of the writing. In reporting, it is possible to save several days by using computer-based communication instead of ordinary mail for the exchange of documentation with the

referral institutions. For marketing the clinic, the Internet provides opportunities at a relatively low cost.

5.2 Information systems for the public sector

The level of skill required in working life is increasing, as well as the need for teamwork and cooperation between organizations for problem solving (Roman, 1991). However, when a service is provided by teams, cost-effectiveness is dependent on all members knowing what the other members do and what they can contribute with (Ulschak, 1988). This need of awareness also applies if the team members are located in different organizations. Therefore, the service providers will constantly need to be able to access information, client information as well as information to increase their skills. Naturally, information systems can provide the tools required for handling the increased need for access to information.

5.2.1 Design of information systems in the public sector

Today, the technical prerequisites for information systems that meet the needs in the public sector are available (Korpela, 1998). Still, information systems in use have failed to meet existing needs (Bleich, 1998). The problem has been to determine what is needed and how these needs can be met by information technology (Heathfield & Wyatt, 1993). It has been claimed that the traditional design methods used are insufficient, the early phases in particular have been found to be weak and these are the most critical for successful design (Denning & Dargan, 1996; Timpka & Johansson, 1994; Blum, 1991). This situation indicates the need for methods that identify the features of information systems that meet existing needs. Since not all needs can be realized in the implementation of information systems (Yeh, 1992), it is necessary to prioritize so that the needs that are the most urgent for the users are met.

5.2.2 The prototype computer network service

The prototype computer network service for occupational therapists exemplifies how needs of public service professions can be met. The local/team level illustrated how an information system can play an important role in integrating the professionals into the teamwork, for example by understanding what the other professions do for the clients.

Several parts of the systems illustrate how service providers can be helped. First, the case-management systems can decrease the time spent on searching for client data and increase the information sharing in provider teams. The necessity of information systems to gain the best out of teamwork has been recognized (Makin, Cohen, and Bikson, 1996). Second, the publication databases and the bookshelf provide professional knowledge, that is, the publication database contains information about how to proceed in cases and the bookshelf for how other professions work. Third, the electronic mailing lists make it possible for the service providers to reach each other, relatively quickly and easily. They can use the mailing lists to send requests for assistance or information that they are in urgent need of. In the study of the occupational therapists (Paper III) communication with other occupational therapists was found to be one of the most important technical requirements. The reason for this is that many occupational therapists work in settings with few or no colleagues of same profession. The same is often the case for people of other professions in multi-professional teamwork settings. For effective teamwork, it is important that each individual contributes to the teamwork with their unique professional competence. A danger is that only working with people of other professions causes a loss of one's own professional identity. Therefore to strengthen professional identity, it is important to have ongoing contact with persons of one's own profession. The network service illustrates how this problem can be solved, by providing access to virtual colleagues in the form of electronic mailing lists and discussion forums (Worth & Patrick, 1997).

5.2.3 The use of Internet in the public sector

The use of Internet technology for communication and information sharing has gained interest in public-sector organizations (Bentley, Horstmann, & Trevor, 1997) since it has been recognized as a potential platform-independent infrastructure for information systems that better meet needs at a relatively low cost (Korpela, 1998). However, the Internet has also become a popular and effective forum for spreading information to the public or to specific groups of the public. Examples of the former include the availability of governmental information on the web as well as general health information. Examples of the latter include information to specific groups which can be found on the web-sites for

occupational therapists and web-sites for persons with different kinds of ill-health such as OncoLink for cancer (Benjamin, Goldwein, Rubin, & McKeena, 1996). There are also design difficulties for this use of Internet. For example, what information does the target group need, what information does the provider want the public to have, and how can this information be best provided. MSQD can be directly used for this type of design. It can be assumed that the need for methods for this purpose will increase since the use of Internet as a media for spreading information to the public probably will increase with the rising number of households that have access to Internet.

5.3 MSQD: QFD for design of information systems

QFD has proved to be an appropriate support for the design of products that satisfy the customers, this is, that meet the needs of the customers (Mizuno & Akao, 1994). This property and several other benefits of QFD (see section 2.4.4) are of interest when designing information systems and services for public-sector organizations. However, there are several different ways of applying QFD, which is illustrated by the many different models that exist (Hauser & Clausing, 1988; King, 1989; Nakui, 1991). The general QFD models, for example the Comprehensive QFD, are too extensive and other more limited QFD models are less appropriate for the development of information systems (Zultner, 1988). Moreover, it has been found that QFD models often need to be adjusted to the situation of use (Herzwurm, Schockert, Mellis, & Ahlemeier, 1998). The most common way of applying QFD is to use just the HoQ (Cohen, 1995). Therefore, the starting point of the development of a method for the design of information systems in the public sector was a QFD model for software design (SQFD), based on a simplified HoQ (Haag, Raja, & Schadke, 1996). The selected model has several similarities with the model applied to the orientation of social-medicine service (Paper II). By applying and evaluating a theoretically-customized version of SQFD in case studies, it was further developed in a stepwise fashion. In this way the tools and approaches that do not function optimally could be exchanged and new ones could be added to support tasks found to be desired. Below, the advantages of MSQD are summarized; naturally some of the advantages will coincide with the contributions presented further on in this chapter. Limitations are discussed in section 5.4.

The unique advantages of MSDQ are that (1) it combines the critical incident technique, an effective way of collecting the voice of the customers, with QFD's ability to transform those voices into design solutions. (2) The combination of QFD and PD means that the social issues of the information systems can be considered in a straightforward and coherent design. (3) The use of PD also means that users in the design team can validate partial results during the process. (4) It supports participatory design of inter-organizational information systems. These results mean that the providers have the possibility to influence the design of services that effect their working conditions. Further advantages of MSQD are:

- It supports how a set of user needs from the voice of the customers can be determined. Here, the voice of the customer table (VCT), affinity diagrams, hierarchy diagrams, and participatory design play an important role.
- It transforms ranked user needs, via technical requirements, to prioritized design attributes. When desired, prioritized service characteristics can be determined on the basis of the ranked user needs.
- The ranking of the design attributes illustrates the features of the information systems that are the most important for the users. In this way, the systems can be made less complex by excluding features of the systems that do not add any value. Further, since the information system supports the current work procedure of the users, they will find it easier to learn to use and benefit from the systems. This is of importance for the acceptance and the success of the system, since if a system is to be widely used, it must provide benefits to the users (Heathfield & Pitty, 1998).
- The notation of the matrices displays the needs, the technical solutions, and their relationships in a compact way which is easy to overview. In other words, it provides back and forward traceability between needs and design attributes, a feature that has been lacking and thus viewed as a weakness in several other methods for information systems design (Gotel & Finkelstein, 1994).

- Several categories of users can be attended to and given different levels of influence on the design. This can be useful in, for example, computer-based patient records, where physicians, patients, and unit mangers can all be given influence over the design, but not necessarily at the same level.
- The notation enhances multi-professional design discussions, including representatives from different target groups. It also assists a design team to focus work on design. This support for communication in the team was most evident when using the VCT.
- The graphical notation provides a stable way of documenting the design processes and decisions taken. This approach implies that knowledge gained during one project can be reused (Tran & Sherif, 1995). For example, if an information system is designed for one public-service unit, then in the design of an information system for a similar unit, it is likely that at least some of the needs are the same. Even though the needs are prioritized differently, the correlation factors to the technical requirements will be the same and can hence be reused.

5.3.1 Relation of MSQD to requirements and software engineering

A software-engineering process has traditionally been divided into four phases: the requirements specification, design, implementation, and testing[9]. Several approaches for software development extend over all four phases: the waterfall model and the spiral model are the best known (Boehm, 1988). Even though they have existed for a long time, several researchers have noted the lack of their success (Blum, 1991). The reasons put forward for this problem are the lack of connection between the designers' actions and the concerns of the users, and that the focus has been on the efficiency of the machines instead of human needs (Denning & Dargan, 1996).

A more recent approach is action-centered design which focuses on the human and business activities. An example of this kind of method is

[9] There are several other ways of dividing software-engineering processes.

Action Design (Timpka, Sjöberg, Alendahl, Johansson, Rauch, & Nyce, 1993). In Action Design, as in other action-centered design approaches, different types of graphical notations, such as ProG, are used to gain an understanding of the users and/or the business activities. This activity is performed together with the users. Subsequently prototypes can be used to validate identified requirements. MSQD has many similarities with the action-oriented design approach. They both start in the human and business activity, and focus design on the breakdowns and problems in these activities. Several action-centered design approaches include notations for describing the actual situation. MSQD also includes the notations for transforming the descriptions of existing needs into design solutions.

Besides the software-development process models, there are several methods and tools used for more specific tasks. Some tools are used in more than one phase, but then with slightly different objectives. Because, MSQD in its present form is devoted to the requirement specification and the design phases, it is of interest to compare the tools and methods for these phases. Prototypes can be used in both the design and the requirement specification phase. In the design phase, prototypes are used to evaluate the design, which is done by letting user representatives and/or design experts explore a prototype constructed by professional developers. Walkthroughs and heuristic evaluations are methods that can be used for this evaluation (Nielsen & Molich, 1990; Karat, Campbell, & Fiegel, 1992). The outcome is used to improve the design. In the requirements specification phase, prototypes are used to explore requirements by letting user representatives participate in the building of prototypes. For this purpose, Software rapid prototyping and PICTIVE (Muller, 1993) have been proposed as useful approaches. The major difference between the two is that software rapid prototyping is based on consulting participation while PICTIVE builds on consensus participation. However, using prototyping as an approach for requirements means that some assumptions have been made in advance. One assumption is that a system is needed. In the case of PICTIVE this is illustrated by asking the users to “Think through what you want the systems to do for you.” (Muller, 1993, p. 217). This approach will limit the resulting product, since by asking the users what features they want in an information system, they will only be able to state features that they

believe can be provided, which correspond to the *performance requirements* in the Kano model (Kano, 1995). However, even they do not know how information systems can meet their needs: they know what problems they have. In fact, they are specialists on problems and breakdowns that occur in their work. Therefore, the first source for the design of an information system must be based on the users' actions in their real environment (Leonard & Rayport, 1997). In this way an information system that exceeds the users' expectations can be designed (Kano, 1995).

An approach taking its starting point in the gathering of the user data is contextual inquiry (Coble, Maffitt, Orland, & Kahn, 1995). However, no ranking of the needs is performed and the approach ends in the requirement specification phase. But, as Holtzblatt and Jones (1993, p. 207) noted, QFD can be used to transform the needs into technical requirements. Applying contextual inquiry and transforming the collected data into technical requirements by using a limited QFD model, as Holtzblatt and Jones propose, work in a way similar to MSQD. However, one of the strengths of MSQD is still lacking, the use of VCT to interpret the voice of the customers. In fact in our study the VCT was found to be the most useful tool of MSQD since it assisted in purifying the mixture of statements containing needs, problems, and technical solutions in the voice of the customers and to transform them into customer needs in a straightforward manner. In MSQD it is the process itself that leads to the members of the design team gaining an understanding of the users' needs and how they can be met in the design. This knowledge is important when selecting amongst design solutions.

As discussed earlier (in section 5.2.1) it is, unfortunately more or less as a rule, impossible to fulfill all the requirements asked for in the implementation of information systems (Yeh, 1992). Therefore, it is necessary to prioritize between the requirements so that it is the most important ones that are implemented. There are several methods to prioritize software requirements, such as the analytical hierarchic process and bubblesort (Karlsson, Wohlin, & Regnell, 1998). However, it can be argued that applying these prioritization methods to the technical requirements is insufficient since, if the professional designers do it, they will have little opportunity to judge the users' prioritization correctly and

if user representatives perform prioritization, they have little opportunity to relate the technical requirements to their work situation. Therefore, since it is the users who judge the quality (Bergman & Klefsjö, 1994), they are the ones who should perform the prioritization and it should be done in terms of their everyday work language. Subsequently, the ranking can be transferred to the technical language of professional designers by using the House of Quality.

It has been claimed that applying QFD requires that the whole design team is trained in using QFD (Karlsson, 1998). However, it can be argued that applying any kind of method requires some amount of training, whether it is to prioritize between two requirements, participate in a brainstorming session, or use VCT to interpret user data. The results from the case studies presented in this thesis indicate that the QFD notations were not difficult to use or understand, rather the contrary. In the case studies presented in this thesis only one to two persons involved in the design team had applied QFD before and several of the participants were user representatives who had no experience of information-system development. Still, only a limited time was required to explain the work procedure. It is my belief that the success of projects like these case studies is dependent on the facilitator's understanding of the philosophy of QFD and the ability to explain it to and motivate the participants. That the tools used in MSQD do not require excessive training is also important in another respect. User representatives who are given a large amount of training are alienated from those whom they represent and their ordinary work, which means that the more trained they are in performing design, the less their value in representing the users (Muller, 1993).

Davis (1994) states that the most important principle of software engineering is quality, but that the quality aspect is also a dilemma, because the different groups involved in the software process judge quality differently. In MSQD, too, the aspect of quality is central. However, in MSQD and in QFD this dilemma does not exist because the quality of the product is judged by the users. It is they who will pay for the product, use it, and evaluate its use. Therefore, every effort made in the design process must aim at achieving higher quality from the users' point of view. Nevertheless, the technical quality is far from unimportant,

but cannot dominate over the users' view. It would be like saying, "Ok, we have an information system that works well, let's see what it can do for the users". Instead, in MSQD, the saying is "the users have these needs, let see how we can exceed their expectations with an information system". The notation of MSQD displays how the technical qualities contribute in meeting the users' view of quality. In this way the developers' efforts, for instance in creating correct code, can be concentrated on the parts of the system where the users notice it. The cases where different users hold different views on quality can be handled in MSQD.

5.3.2 MSQD: More than just QFD

Most of the tools and approaches included in MSQD originate from QFD. However, other tools and approaches were included: the critical incident technique (CIT), the Delphi consensus approach, and participatory design (PD). The CIT was introduced as a complement in the collection of the voice of the customers (Flanagan, 1954). In CIT the data can be collected in several ways; in MSQD questionnaires are used, since both quantitative and qualitative data can be collected from a relatively large population of users. In this way the questionnaires can be used for the ranking of the needs. There, both the numbers of respondents who have related to a problem and how often they stated that they experienced it can be used for the ranking. However, the answers are not as detailed as in the interviews and the respondents cannot be asked to fill in or explain a statement if something is found unclear. Hence the questionnaire answers are more difficult to interpret without insider knowledge.

The Delphi consensus approach was first introduced to validate the customer needs identified (Duffield, 1993). For this purpose it was found useful in removing incorrect needs, but it can be questioned whether it contributes to the identification of missing needs. However, the Delphi consensus approach can be used for validation of partial results, for example the ranking of the importance of customer categories in the extended version of MSQD. Instead, to establish a set of true needs, PD approaches were introduced. Through PD the users are given the ability to influence the design of the information systems.

5.3.3 MSQD: A QFD model influenced by participatory design

To our knowledge MSQD is the first attempt to combine the Scandinavian tradition of participatory design (PD) with a Japanese quality process, QFD, for designing information systems. The basic philosophies of QFD and PD have several similarities; for example they put the users' needs before technical quality and they both strongly emphasize the importance of the developers understanding the context of the use situation. However, there are also several differences between the two. In QFD it is the producer who has the responsibility to see that the product fulfills the needs of the customers, whereas in PD the producers, that is the professional system developers, share this responsibility with the users. Further, in QFD the overall objective is to develop products that bring benefits to the producer, e.g., by selling more of the product (Mizuno & Akao, 1994). Therefore, the focus is on the ones who pay and the ones who decide on purchasing. These groups should be highly satisfied so that they choose to buy the product. Meanwhile, in PD the democratic issues are central and it is the direct users who are in focus (Sandberg, Broms, Grip, Steen, & Ullmark, 1992). Their right to participate in the decision making about their own work situation and work-life quality is emphasized. Despite these differences, the findings presented in this thesis suggest that the two approaches have much to gain from each other. For example, in QFD it is of importance that the developers have an understanding of the users and the use situation. In PD projects the developing team includes experts on these two topics, namely the user representatives. Further, the importance of capturing the social aspects of the requirements has been emphasized (Goguen, 1993). This is a core issue in PD that could be beneficially adopted in QFD. On the other hand, PD has seldom been committed to time and budget frames (Carmel, Whitaker, & George, 1992), while reducing the development time has been claimed to be one of QFD's benefits (Vasilash, 1989). QFD can increase the focus of work on the design tasks in PD projects and provide coherent design processes which make the requirements traceable. Hence, PD and QFD can benefit by taking inspiration from each other.

5.3.4 MSQD: Information systems design and service reengineering

It has been claimed that better efficiency can be gained by the introduction of inter-organizational information systems, but it requires reengineering of the service processes (Finnegan & Golden, 1996). To meet the prerequisites for design of inter-organizational information systems, the design phase in MSQD was extended with four new matrices to determine the service processes that best match the needs. However, extended MSQD is not limited to the design of information systems that only support the inter-organizational part of providing the service. The information system can be designed to support the whole service process, which also includes support for individual work as well as teamwork. The rationale for including provider representatives in the design team is that these are better equipped to segregate the actors in the environment towards which the service should be directed and they contribute to the redesign of services. An additional reason is that they should be allowed to affect their work situation. However, the results show that the provider representatives were not better able to interpret the voice of the customer for the external users than the developers even though they had long experience of collaboration with the organization selected. This conforms to the findings in Paper III that extensive insider knowledge is required to interpret the voice of the customers. Further, the result shows that it will be necessary to involve representatives from the other organizations involved in the work if the full potential of using PD is to be utilized.

5.4 Limitations of MSQD

The numerical operations used in the transformations in the matrices can give an illusion that the prioritization of the design attributes is exact, for example that a design attribute that reached the prioritization level of 50 is twice as important as one that reached 25. However, the numerical operations performed in the matrices are not mathematically valid, since values on the ordinal scale are multiplied. Therefore, the ranking of the design attributes should be seen as indicators. That is, design attributes that achieve 50 are more important than one that achieved 25. However, at least theoretically, it is possible to make the calculations mathematically valid (Shaw, 1997). For example, the analytical hierarchic process can be used to perform the ranking of the ranking

inserted a matrix as well as the size of correlation values on a relative scale. This approach would still require an extensive amount of work combined with the difficulties of determining how large a correlation is relative to the other correlations. Further, the strength of the notation can give an illusion of the resulting design attributes being the absolute truth and that the members of the design team have limited influence on the design result. However, the notation is only a support for the design team and several subjective decisions have to be made. Most obvious are the correlations and the design solutions. But it is also the case that some needs and activities should not, or cannot, be met by an information system. Then those activities have to be sorted out from the design work. Further, the notations just point out which features of an information systems meet the major needs of the users and the people involved in design have to know what to do with this knowledge.

The present MSQD ends when the design attributes have been determined. By adding further matrices it is possible to transform the design attributes further to determine code objects or functionality of the code (Lamia, 1995; Zultner, 1988). When it comes to the view of the user interface, this is more difficult. Attempts have been made to use QFD for user interface design (Barnett, Arbak, Olson, & Walrath, 1992), but not to point out where, for instance, a scroll-bar or a window should be placed on the screen. Thus, QFD can be used for determining how functionality should be handled by the user interface, but not what the user interface should look like. Further, MSQD does not include any measurement for the consideration of economic aspects such as, for instance, weighing the cost of different design options; neither are any tools for performing risk analysis included.

Despite these limitations, MSQD has its advantages in the support for the design of systems and services so that they meet the users' needs. This feature, that many other methods seem to lack, is perhaps the most important feature of a method when the design is aimed at products of high quality.

5.5 Limitations of the studies

The studies performed are limited to the Swedish public sector in the areas of healthcare and welfare organizations. This is a limitation, but to apply QFD requires that the professional designer has a relatively broad knowledge of the domain for the application. For this reason, it is not possible for one researcher to facilitate QFD projects in different domains during the scope of a thesis. However, nothing indicates that MSQD would not work in other areas of the public sector. However, to prove this generality MSQD has to be applied in those areas. Further, the case studies in which MSQD was developed were aimed at general information systems. However, no reasons can be foreseen as to why MSQD could not be used for the design of more specific systems, for instance a case management system, since QFD has been used for a wide variety of applications, such as the development of cars (Mizuno & Akao, 1994), determining network capacities of telecommunications (Brown & Harrington, 1994), wine and beer production (Mazur, 1994).

QFD is well-known and used worldwide, while PD has been developed in Scandinavia. Some preconditions for PD have been the laws regulating worker participation in decision making when introducing information systems. This culture dependency can be a dilemma when applying MSQD in a cultural other than the Scandinavian one, a culture not used to such participation.

The case studies have been performed in a sequence where each study has influenced the subsequent one. The approach means that no comparative studies have been performed within similar settings and with similar prerequisites. This limits the possibility of making comparisons between the case studies. Even though this would have been beneficial if it had been done, it is a trade-off with the limits imposed when writing a thesis.

Despite this limitations, the studies presented here are a first step in exploring methods for the design of information systems and services which focus on meeting the users' needs. The findings indicate that using QFD combined with PD, as done in MSQD, are promising avenues for the future.

5.5.1 An alternative approach

The results presented in the thesis are based on empirical studies. An alternative approach to the development of the MSQD method could have been to base the development on theory, for instance, by determining important characteristics of methods and tools in design of information systems and services in the public sector and then theoretically searching for appropriate methods and tools based on the required characteristics. Two main reasons for the selection of the empirical alternative are (1) the spirit of action research in the environment in which the work has been performed, and (2) the lack of scientific studies performed in the area of QFD, especially concerning the use of the tools.

5.6 Generalization

Generalizing the results within the scope of the thesis has already been discussed (see section 5.5). But it is possible to discuss the potential for generalization beyond the main objective of this thesis, i.e. applying MSQD to the private sector. For the design of information systems and services it will probably work well. However, it can be considered that in situations of competition, the aim of production is not necessarily a "perfect" product; instead the aim can be to outshine the competitors. This is also in line with the pure QFD spirit; it is sufficient to beat the competitors, which can be illustrated by an anecdote told by Glenn Mazur, a leading QFD expert.

> *Two boys were walking in a forest, when suddenly a hungry bear appeared. One of the boys opened his bag and pulled out a pair of running shoes and started to put them on. The other boy said, "Are you nuts? You can never outrun the bear." To which the first boy replied, "I don't need to. It is enough if I outrun you".*

In MSQD these issues of making comparisons with competitors are not included because the aim has been to design the information system that best corresponds to the users' needs. However, in the case of a competitive situation, it can be beneficial to use an HoQ that includes the parts needed for comparing the design with competitors' products (Cohen, 1995).

5.7 Contributions

The research contributions of this thesis are divided into main contributions and additional contributions.

5.7.1 Main contributions

The main contributions of this thesis are centered around the Medical Software Quality Deployment (MSQD) method, which contributes to research and practice in the design of information systems and information-system-supported services in the public sector. The objective of MSQD is that the information systems and services thus designed will meet existing needs. The users who the needs are collected from can be individuals inside the organization and/or external individuals and organizations. The MSQD method further contributes to the areas of;

- Information-system design by displaying how ranked design attributes can be obtained from the voice of the customers, so that the information systems include the features that meet the most important needs of the users.
- Inter-organizational information-system design by providing a method for specifying the service and an information system that supports the service based on the existing need for the service.
- Requirements engineering by providing a notation that makes the requirements traceable, gives priorities to the technical requirements, and displays how the requirements can be extracted from the users' voices.
- Software engineering by supporting the transformation from the need notation into the design notation; in other words, bridging the gap between the problem space and the solution space. Further, the information processed and decisions taken are documented in a compact and easy-to-overview format.
- Participatory design by introducing of a graphical notation that supports the design team in focusing on the design tasks and helps structure the communication within the design team. Further, the extended version of MSQD suggests ways for the traditional ideas of participatory design to be used in the design of inter-organizational information systems. Thereby social aspects of all

service providers will be regarded at an equal level in the design of the delivered service as well as in the information systems that support the delivery.

- Quality Function Deployment by providing a QFD model aimed at the design of information systems and information-system-supported services in the public sector. Further, the results show that participatory design can be used within QFD. In this way the social aspects of the users can be regarded in the design. Another benefit of using participatory design methods in QFD projects is that they can be used to validate the interpretation of the voice of the customers. It is also shown how the critical incident technique can be used for the collection of the voice of the customers and how Delphi-oriented methods can be used for validation of partial results.

5.7.2 Additional contributions

The additional contributions in this thesis are as follows:

- The description of the advice-seeking patterns contributes to the area of understanding and improving public services. The visualization can constitute the basis for support of the optimal function by steering the advice-seeking patterns.
- The orientation of the social-medical services contributes to the area of public services. This is done by displaying which type of social-medical services the different referral organizations want and which parts of the actual social medical service have to be improved to better suit the needs of the referral institutions.
- The customized QFD model contributes to the area of quality improvement of public service provisions. This is done by showing how a relatively easy-to-use QFD model can be used as tool for improving a public service according to environmental needs and demands.
- The prototype computer network service contributes to the areas of information systems design and use in the public sector by exemplifying what information systems for public-service professions based on modern information technology can look

like. The prototype illustrates how in reality low-cost information systems, based on modern information technology, can support public-service professions. More specifically, the prototype contributes by illustrating how problems related to the occupational-therapy profession can be met by information systems.

5.8 Conclusions

The main contribution of the thesis is the MSQD method for the design of information systems and information-systems-supported services in the public sector. Advantages of MSQD are that it focuses on the users' needs and supports the transformation of needs into features of information systems and service. The graphical notation provides documentation of the design processes, the information handled, and the decisions taken. In this way, traceability of the needs to the design attributes and vice versa is obtained. Further, it supports user participation by providing an arena that enhances multi-professional discussions. The possibility of user participation means that the social aspects of the users can be regarded in the design. MSQD can handle several different categories of users who have different levels of power of influence on the design. In the extended version MSQD, together with process graphs, is used for the participatory design of inter-organizational information systems.

The prototype network service, designed with MSQD, illustrates several possible ways of how public-sector professions can benefit from information systems by using low-cost technology and by supporting communication and the sharing of information. The MSQD applied to the design of information systems and services can help organizations to achieve increased internal and external effectiveness. Hence, it can contribute in the striving of the public sector to become more efficient. Hopefully, the results presented in this thesis will contribute to the design of better and more useful information systems for the public sector. Although MSQD will not help in designing the fastest system with the best-optimized code or with the best looking user-interface, it can support the design of information systems that fulfill the expectations of the users and bring "broad smiles" to their faces.

5.9 Future work

Three areas for future work will be discussed: further evaluation of the actual MSQD, the continued development of MSQD, and the use of Internet and related techniques as a platform for inter-organizational collaboration in the public sector.

5.9.1 Evaluation of MSQD

Further evaluations of MSQD are desirable, both concerning its use process and the outcome. For this, MSQD needs to be re-applied in similar settings with similar objectives, and the experience from these studies should be compared with those presented in this thesis. One evaluation of the outcome has been performed so far. This was the evaluation of the prototype network service for occupational therapists (Hallberg, Timpka, & Vimarlund, 1998). The next step for the evaluation of the outcome of MSQD is to evaluate the prototype of the information-systems-based social-medical service.

5.9.2 The continuing development of MSQD

MSQD of design of Inter-organizational information systems

A first attempt to use MSQD for inter-organizational design is presented in this thesis (Paper IV). There, MSQD is used to reengineer one organization's service to better fit in with the needs of other service organizations involved with the same client cases and design the information system that supported this new service. The objective for the next extension of MSQD is to use it for the development of a service that extends over organizational borders and for the design of information systems that support this service provision. Therefore, the next step is to invite representatives from all involved organizations to participate in the design team. Here, participatory design will become an increasingly more important issue. In relation to this, the questions of who are the customers and who are the key-customers of the public service need to be further considered.

The technical input

In MSQD a large effort, supported by several tools, has been made on determining the needs. However, to generate the technical solutions, both

technical requirement and design attributes, no tools are included in MSQD. To support this, it is possible to use solution-generating approaches from PD, such as future workshops or PICTIVE (Kensing & Halskov Madsen, 1991; Muller, 1993). An additional possibility is to use TRIZ, which has recently been gaining much interest in the area of QFD (Domb, 1997). TRIZ originates in Russia and is a method where innovations are engineered and the solutions can be generated in a systematic way.

MSQD for design of security system

One of the major problems with information systems in healthcare is the security issue. Even though much work has been done, more is required. The possibility of using MSQD for determining the most important aspects of security systems will be explored. One possibility is to develop a separate module to the current MSQD that highlights the security issues that must be taken into account on the basis of the design attributes which gained the highest rank.

5.9.3 Information systems for public service

One area where the features of the information systems based on Internet related techniques should have a large potential is information sharing, communication, and coordination of client cases between organizations in the public sector. It has been claimed that inter-organization collaboration and information systems, when the circumstances are right, produce large economic benefits (Clark & Stoddard, 1996). How this collaboration and these information systems should be formed are areas for future study.

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