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Clinical Portal

A Case Study of User Support in Integrated Hospital Information Systems

Marianne Horn
Thea Christine Steen

Master of Science in Computer Science
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Supervisor: Eric Monteiro, IDI
Co-supervisor: Kjell Isaksen, Objectware

Norwegian University of Science and Technology
Department of Computer and Information Science

Problem Description

IT development have been employed within the health sector as a means of efficiency improvement and better utilization of resources. This has proven to be challenging, and the resulting hospital information systems have tended to be poorly integrated. State-of-the-art suggests that systems must be integrated to increase the information flow and value creation. However, integration of multiple source systems in combination with the heterogenous user groups often situated at hospitals, may lead to an application system which yields poor user support. The students will perform a literature and case study to assess how to enhance the user support of such systems.

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Abstract

The complexity of medical work, the amount of heterogenous user groups, and the large amount of both paper-based and computer-based information systems existing at hospitals, indicate the difficulty of implementing computer-based hospital information systems. Our work is a case study of a system that handles this challenge by integrating a set of source systems in a service oriented architecture. The services and data implemented by its source systems and its architectural service layer is presented through one single portal application system. We have investigated the impact the chosen approach may have on the system's ability to provide efficient user support. Our results pointed to two main challenges; an excessive information load in the user interface, and a general scepticism to paperless information systems among the users. On the basis of our case and literature study we have tried to assess how customization of user interface components and system services, possibly could improve the user support. Our analysis suggests that extended customization should be postponed until the users are accustomed to, and have accepted the usage of, computer-based information systems in relation to the relevant activities.

Preface

This study is done in association with our Master of Technology degree in Computer Science at the Norwegian University of Science and Technology. The thesis is written as a part of our study at the Department of Computer and Information Science, the Human Computer Interaction group.

We would like to thank our principal supervisor, Eric Monteiro, for his patience, wise words and good advices. During our meetings, we have been given useful and intresting advice on relevant topics, earlier work and literature. We would also thank Monteiro for his general support and encouragements throughout this semester. Furthermore, we would like to thank our co-supervisor Kjell J. Isaksen and his company, Objectware AS, for giving us the opportunity to carry out this work, for introducing us to the development project, and for helping us identify a starting point for the thesis.

This work has been very instructive to us. The health and social sector is a very intersting, significant and complex application area of information technology. We are thankful for the hospitality and interest that we have been shown during our visits at the IT department at Rikshospitalet. In particular, we want to thank Per Storjord and Bent Kristiansen for helpful feedback.

Trondheim, June 29, 2006.

Thea Christine Steen

Marianne Horn

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Chapter 1

Introduction

The first computer-based hospital information systems (HIS) was developed to facilitate economical follow-up and management of patient administrative information. The evolution of the fields of technology and medicine has resulted in expansion of the application area of HIS. This has encouraged a shift of the software development focus within the Norwegian health sector towards the core function of hospital enterprises. In the 1980s the Norwegian health and social sector increased and became more costly, resulting in a need for efficiency improvement. Electronic patient records (EPRs) have been implemented as means to improve the exploration of healthcare resources and increase efficiency within the sector [Ell02]. Generally, medical work are characterized by complexity, a huge amount of heterogenous users and professionals, and an unnumbered amount of information systems. These characteristics may be the reasons why implementation of EPRs has proven to be a challenging task [Ell02]. Up until now, medical work has been facilitated by either paper or computer systems. Some work processes have even had both paper and computer support. However, at Rikshospitalet, and many other hospitals, computer-based information systems have often been acquisitioned and developed for individual departments and with an ad-hoc approach. This approach has resulted in a vast amount of diverse, autonomous systems [Loh04]. The general opinion within the field of information system development is that in order to maximize gains, and provide useful support, information systems must interact to a larger extent than previously. Integration of information systems will produce more value to the value-chain and customers of the enterprise [Has00]. Accordingly, the development focus has shifted towards *integration* of HISs. When stand-alone systems are integrated, collections of small and rather homogenous user groups, associated with each of the stand-alone systems, will merge into a few larger and heterogenous user groups of the new integrated systems. This may influence the user support related to these systems.

Several researchers have studied development of systems for large, heterogenous user groups [sta94] [RM02] [Ell02]. They have studied how local variants of systems may emerge when the original standardized system fails to meet necessary requirements. There are suggestions arguing that *customization* of such systems through, for instance, design multiple, parallel variants of the system, possibly could handle conflicting requirements. Some of the theories related to such an approach are described in chapter 3.

1.1 Motivation and Problem Description

Clinical Portal is an enterprise portal developed by and for Rikshospitalet-Radiumhospitalet HE (RR HE) with the goal quoted below.

> *One clinical portal have replaced today's paper journal and offering new and patient related information services to patients, employees, external customers and service providers [Bru04].*

The portal is developed and introduced at Rikshospitalet as part of the strategy of RR HE to become a paper independent hospital [Bru04]. This implies that the portal in the longer term will replace all paper-based information systems at RR HE, including order and retrieval of test results from the laboratories. Additionally, the portal integrates a number of Rikshospitalet's central computer-based HIS to achieve the benefits associated with such system and information integration.

Designing the user interface of application systems resulting from system integration, can be challenging. The set of source systems that are integrated, often has a large scope. Consequently, the resulting application system provides an equivalent amount of functionality and information as all the previously stand-alone systems combined. Simultaneously, the user groups of the stand-alone systems, are merged into one large user mass. Accordingly, there will be a large base of heterogenous, and probably conflicting, user requirements related to the application system. The presentation of functionality and information from multiple integrated source systems, to a large and heterogenous user mass, through one single user interface, may influence the user support of the application system. This possible influence on user support is our focus. We will discuss how theory on developing application systems for heterogenous user groups can be applied to possibly improve user support. This leads us to the following research questions:

- How can the integration of several HISs affect the user support?
- Can application of the theory regarding customization of information systems improve the user support?

- If so, how do various factors influence the degree of customization that realistically can be carried out?

In order to answer these questions we will conduct a case study at Rikshospitalet. In our study, we will focus on the portal pages related to order and retrieval of test results from MBK. A more comprehensive description of our work is given in chapter 5 *Method*.

1.2 Scope

We will restrict our research of Clinical Portal to the portal pages and work processes related to order and retrieval of test results from clinical chemistry laboratory. Our case study regard the dermatological department and the clinical chemistry laboratory at Rikshospitalet. However, during our visits at Rikshospitalet's IT department, we interviewed medical personnel from several other hospital departments, as well as project workers with various responsibilities related to the portal development.

1.3 Related Work

Bente Brevig [Bre06] has conducted an ethnographic study at Rikshospitalet, and evaluated the development strategy utilized in the Clinical Portal project. She concluded with three main challenges; how to get the end-users to participate in the development process, how to deal with how introduction of an information system change the boundaries between departments in regards to responsibility, and how to cope with the changing general conditions given by external actors.

Camilla Berg Lohne [Loh04] carried out a case study at St. Olavs hospital in Trondheim regarding the integration of existing systems at the hospital. She evaluated the advantages and the disadvantages, and concluded that integration, to smaller or larger extent, is necessary. She further stated that the probably best solution would be to keep the old systems, while integrating them with a middleware technology, similar to the portal solution presented in this work.

Gunnar Ellingsen [Ell02] has written a doctoral thesis concerning the design and use of electronic patient record in large hospitals. His conclusions include that EPR can not be a standalone system, but rather interact with the existing systems at the hospital, in order to be a useful contribution. Secondly he states that there are no universal answers, and no simple solutions, to developing hospital information

system. This is to a large extent due to the heterogeneity in in the user group and the complexity of the work processes.

1.4 Outline

This work has four main parts

Part I includes our theory. We begin with a presentation of the Norwegian health sector, along with the IT development at Norwegian hospitals. The second chapter targets information systems in general, and covers the subjects software engineering, human-centered design, computer supported work, and customization of information systems. The third chapter presents integration and portal technology.

Part II describe theory concerning research methods, along with a description of how we conducted our case study, and finally an evaluation of our work.

Part III is the case part. It begins with a description of Rikshospitalet-Radiumhospitalet HE, including the characteristics of the employees and the working environment. The next chapter presents the development of information technology at RR HE, and gives an introduction to Clinical Portal. The last chapter in the case part outlines the "order and results" functionality in detail, and presents the results of our case study.

Part IV includes our analysis, where we discuss our findings at RR HE, and the conclusion, along with suggestions for further work.

Part I

State of the art

Chapter 2

The Norwegian Health Sector and Social and IT Development

In this chapter we will present the Norwegian health and social sector and development of IT within this sector. This is the context of the development of Clinical Portal. We will start with a description of the Norwegian health sector, continue with an introduction to health informatics in relation with the situation in Norway, and finally list some of the major challenges that has emerged through the development of information technology at Norwegian hospitals.

2.1 The Norwegian Health Sector

The Norwegian Ministry of Health and Social Affairs develops and deploys national regulations concerning the Norwegian health and social sector. These regulations can be formulated as strategy plans or programs and reforms that must be followed-up by the actors within the sector.

The Norwegian health and social sector is divided into primary healthcare and specialist healthcare. The *primary healthcare* consists of *fastlegeordningen*(the general practitioners), nursing homes, maternal and child health centers, casualty clinics, and the domiciliary care services [odi]. This part of the sector is governed by the local authorities in the geographic regions of the country. The *specialist healthcare* consists of districts psychiatric centers, anti-drug clinics, rehabilitation units, the ambulance service, specialist physicians, and the hospitals [odi].

2.1.1 Geographical Regions

This section is based on the documentation of the organizational development of the sector in work written by S. Opedal et al. [Nor05]. Since the 1970s the organizational development of the Norwegian health and social sector has been performed implemented by means of three phases. In 1975 the country was divided into 5 regions, each owned by the county municipalities. From 1975 to 1999 the cooperation between these regions was optional. In 1999 the government issued a law stating that the county municipalities was bound to develop health plans for the region, and cooperate with the other health regions [Nor05]. Three years later, in 2002, the responsibility and ownership was transferred from the county municipalities to the state [Nor05]. This was the, so far, final development on the over 25 year old plan to obtain a well organized national health service. The 5 regions in Norway is Helse Nord, Helse Midt-Norge, Helse Vest, Helse Sør, and Helse Øst. These regions concern the northern, mid-Norwegian, western, southern, eastern geographical regions of the country, respectfully.

2.1.2 Hospital Functions

The services offered by Norwegian hospitals are divided into 4 different levels; National, Multi-regional, Regional, and Local. This classification has been introduced to ensure that the most common needs are present at all hospitals, while more rare and expensive treatments are reserved to few, or even just one single national hospital.

National function is defined by the Norwegian Ministry of Health and Social Affairs as the treatment that is only performed at one single national hospital that covers the needs of the entire nation [HF06].

Multi-regional functions are services offered by maximum three hospitals nationally. These functions require expensive equipment and/or specialist competence, and are considered to have a frequency that exceeds the capacity of one single hospital [HF06].

Regional functions involve the treatment of all patients from within a region, whenever these patients are transferred from their local hospital due to lack of equipment, capacity, or expertise [HF06].

Local function is the first instance of health care provider after the general practitioner.

2.2 Health Informatics

This introductory part of this section is based on *Handbook of Medical Informatics* edited by J.H. van Bemmel et al. They use the following definitions of the term *medical informatics*.

> *Medical informatics is the science of using system-analytic tools (...) to develop procedures (algorithms) for management, process control, decision-making and scientific analysis of medical knowledge.*
>
> *- Shortliffe, E.H., The Science of Biomedical Computing. Med Inform 1984; 9:185-93*
>
> *Medical informatics compromises the theoretical and practical aspects of information processing and communication, based on knowledge and experience derived from processes in medicine and health care.*
>
> *- Van Bemmel, J.H., The Structure of Medical Informatics. Med Inform 1984; 9:175-80*

The term *medical informatics*, or, as we will refer to it, *health informatics* is used to refer to the field that intersects that of information technology and the various disciplines of medicine and health care [MH97]. The first term indicates that *medicine* or *healthcare* are the area of research. The second term announces the methodology. The field of medical informatics has both applied and theoretical aspects, and models are developed both in applications and in theoretical activities. It is a multidisciplinary field as it deals with the field of medicine and health care as a whole, done by investigators who come from different scientific disciplines [MH97]. Research in medical informatics aims at the incorporation of knowledge from the natural science, and of special knowledge or clinical experience [MH97]. Through, research practitioners strive for the collection of generally applicable knowledge, so that they may use it in the practical domain of *health care* [MH97]. This can be summarized as follows.

> *In medical informatics we develop and assess methods and systems for the acquisition, processing, and interpretation of patient data with the help of knowledge that is obtained in scientific research.*
>
> *- J.H. van Bemmel, M.A. Musen, J.C. Helder [MH97]*

2.2.1 Hospital Information Systems

Researcher and employee at Rikshospitalet, Hallvard Lærum, defines hospital information systems (HISs) as *computer systems designed to support the comprehensive information requirements of hospitals and medical centers, including patient, clinical, ancillary and financial management* [Lær02]. HIS include information needed for clinical work, but also administrative information to run the hospital as a business [Lær02]. The objective of a HIS is to achieve the best possible support of patient care and administration by electronic data processing [wika]. A HIS can be composed of one or a few software components with specialty specific extensions, as well as of a large variety of sub-systems in medical specialties (e.g. laboratory information systems, radiology systems) [wika]. The next section presents the electronic patient record (EPR), patient administration system (PAS), laboratory information system (LIS), radiology information system (RIS), picture archiving and communication system (PACS); each of which are different kinds of HISs. In addition to these systems, there exists a wide variety of systems to support the range of tasks performed at a hospital. These include specialist systems in the laboratories and other ancillary departments, and AKIS (Avdelingsvise kliniske informasjonssystem), which is support systems especially tailored for local use [Loh04].

2.2.2 Electronic Patient Record

There are many definitions of the object holding the information that earlier were archived in paper-based patient records. Some of the most common are electronic patient record [Ell02] [Nor01] [Nor04], electronic medical record [Lær02], and computer-based patient records [MH97]. The Medical Records Institute define electronic health care records (EHCR) as the general term for the object, and defines automated medical record (AMR), computerized medical record (CMR), electronic medical record (EMR), electronic patient record (EMR), and electronic health record (EHR) as the five different levels of EHCRs [wikb]. Some of the most common are electronic medical record [Lær02], and computer-based patient records [MH97]. Hallvard Lærum describes an electronic medical record as *the repository of clinical information on which health personnel base their decisions regarding health care of the individual patient* [Lær02]. We will use the term *electronic patient record* or *EPR* for short.

2.2.3 Patient Administrative System

The first HISs were developed for administrative and economical purposes and follow-up. These systems held administrative information needed to run hospitals

as a business [Lær02], and are called patient administrative systems (PAS) [Lær02]. When the implementation of PAS is done separately from that of EPRs, the patient identity is normally held by the PAS because PAS implementation typically precede EPR implementation [Lær02]. The PAS can also include selected clinical diagnoses and contact history [Lær02]. Even if there may be an overlap between the content of PASs and EPRs, the two subsets of systems serve different needs; administrative and clinical, respectively [Lær02].

2.2.4 Laboratory Information System

A laboratory information system (LIS) is a HIS that is responsible for receiving, processing and storing information generated by laboratory processes [wikc]. Disciplines of laboratory science include hematology, chemistry, immunology, blood bank (Donor and Transfusion Management), surgical pathology, anatomical pathology, flow cytometry and microbiology [wikc]. LISs are customized to facilitate a wide variety of laboratory workflow models [wikc], and comprise hundreds of tables and critical definitions to build, validate and maintain [wikc].

2.2.5 Radiology Information System

A radiology information system (RIS) is used by radiology departments to store, manipulate and distribute patient radiological data and imagery [wikd]. This kind of application systems comprise of patient tracking and scheduling, result reporting and image tracking capabilities [wikd].

2.2.6 Picture Archiving and Communication System

A picture archiving and communication system (PACS) replaces film archives and other kinds of hard-copy based means of managing medical images [wike]. It provides the capabilities of off-site viewing and reporting, and enables practitioners at various physical locations to use the same information simultaneously [wike]. The decreasing price of digital storage provides PACS with a growing cost and space advantage over film archives [wike].

2.3 The Development of IT in the Norwegian Health Sector

In his dr. scient. thesis from 2002, *Global Research, Local Use*, Gunnar Ellingsen presents the history of the introduction of IT into the Norwegian health and social sector [Ell02]. He states that information technology has for several years been

considered an important means for efficiency improvement in the sector [Ell02]. The former Director of the Center for IT in Health Care (KITH), a publicly owned agency aimed at establishing IT related standards in Norwegian health care, stated the following [Ell02].

> *In the middle 1980s, considerable possibilities for the National Health Service were indicated if the potential in IT was utilized to a much lager extent [Ell02].*

The Norwegian health and social sector have been constantly increasing and more costly [Ell02]. This has resulted in the established different ways to improve the exploitation of healtcare resources the employment of several strategies to improve the efficiency in the sector [Ell02]. The implementation of EPRs in large hospitals been considered as a means to achieve such goals [Ell02].

In 1987, a large research programme focusing on IT in health care and aiming at reforming, was established. Soon the focus of this program was directed towards ERPs [Ell02]. In the action plans established by the Government the two following decades, the expectations to IT and ERPs are still present. The action plan for 1997 to 2000, *More Health for each bIT*, reflects this by the following stated.

> *Experiences show that the employment of IT has considerable potential in freeing time for the health care workers [Nor96].*

In 1995, five national regional hospitals saw that they had common interests in relation to systems for handling patient and administrative information. They agreed to cooperatively develop a common EPR based on one of the existing systems. The result was a national project was called *MEDAKIS*. The goal was that one supplier would implement a common ERP at all 5 hospitals within 1999 [tuiP04].

In 2001, the Government issued a national action plan regarding ICT and the health sector, *Say @!*. In addition to acknowledging the maintaining expectations to IT, Say @! saw IT as a means for inducing changed or new work processes, redistribute power, and quality improvement [Ell02]. The plan concern the preliminary works of employment of electronic interaction to strengthen and enhance the efficiency of the cooperation between the various actors within the sector, enhance the contact with patients and clients, and increase the quality of the offered health care services. The priority areas of this strategy plan was the development of a national health network, electronic interaction, tele medicine, and general public services [Nor01].

The second action plan, *Te@mwork 2007*, was issued in 2004 as a follow-up of *Say @!*, and is still current. Its regulations concerned further employment of information communication technology within the Norwegian health sector. It emphasizes enhancement of the information flow in the sector and electronic interaction with new actors. Regulations concerning the electronic patient record, electronic messaging and sessioning, continue to influence the portal's formats and implementations of such. Furthermore, the plan also arrange for electronic interaction and cooperation with out-patients, the general public, and pharmacies and other actors involved in the health care. The strategy state that paper must be eliminated, electronic collaboration must be extended to involve all actors in the sector, emphasize on common standards, good information flow between the various solutions, and national circulation of use/application. It also stresses that IT development must be connected with the organizational development, changes in work processes, and new forms of cooperation and distribution of work [Nor04].

A more comprehensive extract of the national action plans can be found in appendix D, for the complete documents we refer to [Nor01] and [Nor04].

2.3.1 Challenges of establishment of IT systems in the health sector

In his dr. scient. thesis, G. Ellingsen mentions that despite a series of heavily funded national and international initiatives, successful establishment of EPRs in large hospital has proven to be challenging [Ell02]. This subsections, including its its subsections, is based on Ellingsen's thesis and the appurtenant papers. The focus of his study was the only very modest success in establishing working EPRs in large Norwegian hospitals in order to explore and explain why things have failed [Ell02].

In the early 1980s the Norwegian health sector experienced a period of relative economic stagnation. Already at this point in time, was IT recognized as a potential means of efficiency improvements within the sector. As referred to above, various projects, strategy programs, and other initiatives have been issued the two following decades to implement IT in the health sector. Implementation of IT in hospitals have several times been initiated in association to organizational changes, such as replacement of paper-based patient journals by EPRs. Many of the IT projects have been very ambitious, but unable to reach their goals. Ellingsen considers both organizational, technological, and social issues as well as

the interwoven relation between these three factors in his analysis of difficulties of EPR implementation.

> *(...) the design and implementation of large-EPRs or other large systems are not merely a technical effort (as argued in Pressman, 1993 and Coad and Yourdon, 1991) [Ell02].*

Ellingsen point to the complexity of large hospitals as one of the challenges of hospital information system design and implementation. The work performed at hospitals is specialized, and is both the work itself and its division has a very complex characteristic. HIS user mass typically consists of heterogenous user groups and professionals that very often are recognized with different agendas and interests. These issues, in addition to the unnumbered amount of information systems, are recognized by Ellingsen as implications of how formidable implementation of an ERP is.

Socio-Technical Networks

The paragraph above indicates that multiple factors influence the success of EPR particularly, and HIS generally, implementation. Ellingsen illustrate the influence these factors, including EPRs, have on each other in terms of network theory. ERPs, information systems, work practices, users, etc constitute a heterogenous network.

> *Infrastructures are heterogenous socio-technical networks, including many networks in which both technical and social actors take part [HL01].*

On this basis, Ellingsen compare design with network maintenance to illustrate that a total replacement of large-scale infrastructures isn't merely a question of replacement. Withdrawing or adding one of the network components, either human or non-human, affect several other components in unforseen ways. Ellingsen states that goals that everybody agree on isn't enough to hold the network together.

> *The network is rather kept together by components and actors that take part in a complex relationship with each other, recognized by negotiations, compromises and shifting allies [Ell02].*

He ends this discussion by stating that this illustrates how and why final outcomes of IT-projects might be hard to predict [Ell02].

Domestication of Implementations

As mentioned above, IT is often employed as a means for organizational change, and there are often high expectations of efficiency improvement, increased collaboration, increased information quality, and increased centralized control [Ell02]. However, actors with such expectations may get disappointed. Ellingsen states that to get a more realistic view of the outcome, one should take the way these systems continously are *domesticated* in hospitals, into consideration [SH92] [Mon98]. The processes, technology and the social practice are transformed in a relationship and enable opportunities of changed practice [Ell02].

Introduction of Standard Solutions

Another issue discussed by Ellingsen the application of standard solutions at various heterogenous locations. Traditionally, uniform and standardized IT systems are considered mechanisms for increased control, efficiency, and quality [Ell02]. Ellingsen emphasizes that standardization efforts should be targeted at a reasonable level. It must strike the balance between the global level's need for increased co-ordination and control and the local level's need for flexibility [Ell02]. Standards are social constructs that come to being through negotiations [Ell02]. Failing acknowledgment of this results in lack of adaption, resistance in use, and temporary validity [BS99]. As mentioned above, IT systems are part of a network or infrastructure that is interwoven. Accordingly, it affects and is affected by the local context it is put into. Work is needed both to agree on the standard and to keep it alive after it has been put into the local context(s) [Ell02].

Legitimatizing for Everyday Work

Ellingsen also points to the work needed to maintain and keep an introduced IT-solution alive in everyday work. Compared with the work associated with the actual introduction with the IT system, the work performed to keep it alive is rather an invisible part of daily routines and work [Ell02]. This work may even be considered as legitimate if it doesn't conform to formal procedures [Ell02]. Accordingly, Ellingsen argues as follows.

> *One has to come under the skin of daily work in order to give input to design [Ell02].*

2.3.2 Critical Success Factors

In her book *Health and nursing informatics* [Rul00], Cornelia Ruland lists a number of factors that are critical to ICT projects' success. These are described in the following below.

Understanding the Organization

A profound understanding of the organization, e.g. a hospital, is crucial in order to obtain a successful system. As most system developers today agree on, and according to the ISO standard 13407 on human-centered development [Int98a], to investigate the target user group(s), environment and organization as thorough as possible, will yield a product adapted to the users instead of the users adapting to the new system. This will lower the learning costs and improve attitudes toward the system [Int98a]. In the health sector, this understanding is particularly important. Health enterprises are complex, and the goals of each single unit (e.g. the lung department) might differ from the goals the management has set for the hospital. Failure to capture all aspects of the organization (to such extent that is possible) will often lead to general miscontent and unintended/lack of usage of the system. The workflow approach [Swe95], emphasizes the detection of both tangible and intangible processes, and the interdependencies between them.

To Unite Conflicting Interests

As mentioned above, a hospital consists of many units, such as laboratories and clinical wards, all which may have conflicting interests with the others in various matters. Nuseibeh et al. state that it is vital to identify and negotiate these at an early stage to avoid conflicts later, when the refactoring costs are high [NE00]. Besides from the pure practical medical aspects, there might exist cultural conflicts, as the occupational groups at a hospital is known for taking pride in their work and their routines. Such a group might not welcome a system they feel contribute to undermine their esteem/position, even if the system improves efficiency/quality in general. However, such a unification is not always possible. We will discuss this further in chapter 3.

Defining the Work

Often when Health Information Systems are designed, the aspects of the work that are easiest to define and standardize (the tangible ones), are the ones that are being emphasized [DM95]. The more diffuse or intangible aspects/activities could easily be overlooked or postponed, as they are much more difficult to model and do not necessarily affect the functional requirements directly. These aspects,

however, are equally as important as the former ones to design a system that fully supports the work processes. New workflow technology target this problem aiming to account for "common sense" actions. This require resources to investigate the work in different user groups, but could pay off in form of a better system, and improved attitudes towards the system due to sense of ownership and contribution.

To Allow Learning

To involve users in the development process is necessary, but to expect people to know what they actually want would be a mistake. Few are sufficiently skilled in information technology to know how the end product should look like. The development process should allow for changes in the requirement specification as the user group become increasingly able to express what they need. Prototyping can be a good way to quickly test concepts, and it is easier for a user with little IT-skills to talk about desired features when having a starting point. Agile methods, increasingly popular development methods, use short iterations and quick prototyping to be able to handle the refactoring that emerge from the changing user requirements.

Chapter 3

Information Systems and System Engineering

This section presents the field of information systems and software engineering. *Information systems* is a term that cover many kinds of systems. For instance, K. E. Pearlson uses the term to refer to the system compromising the three main elements: technology, people, and processes [pea04] in her book *Managing and Using Information Systems*. Most people tend to use the term to refer to the technology [pea04]. The following definition is given by Wikipedia.

> *A system, whether automated or manual, that comprises people, machines, and/or methods organized to collect, processes, transmit, and disseminate data that represent user information.[wikf]*

As this definition reflects, an information system is not necessarily computer-based. We will use the term to refer to both paper-based and computer-based information systems. In paper-based information systems the "what", that K.E. Pearlson reserves to technology in her definition, is related to paper.

3.1 Software Engineering and Techniques

Software is a generic term for computer programs, including systems programs which operate the computer itself, and applications programs which control the particular task at hand [lin]. *IEEE Standard Glossary of Software Engineering Terminology* defines the term software engineering as follows [IEE90]:

> *Software engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software [IEE90].*

Software systems are developed to solve one or more specific challenge(s) or problem(s) encountered by actors in some real world domain. In order to solve the problem, the system must support its users and their work. This requires an analysis of the problem, involving identification of the system requirements voiced by the system's users, customers, and other possible stakeholders influenced by the system. As stated by Hans van Vliet, cited below, if the system isn't accepted by the users, they will circumvent it or state new requirements [vV00]. Therefore, requirement elicitation is a software development activity that should be given much emphasis. Requirements engineering also involves a feasibility study. The objective of this study is to design a solution that is both economically and technically feasible.

The activities of software development are organized into phases. In addition to the phase mentioned above, requirement identification, software development involves design, implementation, and testing. Furthermore, software systems typically require some kind of maintenance after delivery to the customer. The software development phases can be run through in different ways. Accordingly, various process models have been defined. Some of the best-known models are *the waterfall model* and *the iterative model* [vV00]. These models are very much in contrast with each other. The waterfall model is a structured approach. It goes through each of the phases in a strict sequential order preferably only once. The project seldom return to an earlier phases during the development projects. At least, this is not part of the project's progress plan. An iterative development methodology, on the other hand, has an iterative approach to system development. It is organized in a way that allows the development project to go through the process phases, for refinement of the phases' products, several times. The iterative development approach will be described in better detail in section 3.1.2.

3.1.1 Characteristics of System Engineering

This subsection is based on H. van Vliet's introduction to system engineering given in *Software Engineering: Principle and Practices* [vV00]. He presents the following list of essential characteristics of software engineering. He states that these characteristics are always, explicitly or implicitly, present in this kind of engineering [vV00].

- *Software engineering concern the construction of large programs.* Software engineering is not an one-man-job, but refers to a project involving a number of people and span, for more than a half year.
- *The central theme is mastering complexity.* The problem at hand can't be served in its entirety, but has to be split into parts such that the individual

part can be grasped, while the communication between these parts remains simple. This doesn't reduce the total complexity of the problem, but can make it manageable.

- *Software evolves.* Most software model some part of reality. Because reality evolves, the software modeling it must also be allowed to evolve. The costs associated with the software will be incurred after delivery.

- *The efficiency with which software is developed is of crucial importance.* Total cost and development time of software projects are high. Accordingly, efficient methods and tools to are needed to cope with and reduce resource demands.

- *Regular cooperation between people is an integral part of programming-in-the-large.* Work and responsibilities must be distributed, methods for communication have to be set, and so on. The size of the problem yields the need for administration and organization.

- *The software has to support its users effectively.* Users that don't like the system will try to circumvent it.

- *Software engineering is a field in which members of one culture create features on behalf of members of another culture.* Generally, software engineers' have a thin spread of knowledge of the application domain and its culture. This can be a common source of problems.

H. van Vliet states that to support its users, the software's functionality should fit the users' tasks. If the users aren't satisfied with the system, they will try to circumvent it or, at best, voice new requirements immediately. To create the system that is right for the users, and provide them with efficient support, the software engineers should carefully study the users at work. This will help the engineers elicit the users' functional requirements, and address usability and other quality aspects well, such as reliability, responsiveness, and user-friendliness. User interviews, written policies, and the like, can be used to discover the "official" set of work practices. However, it can only to a limited extent teach the software engineers about the users' domain and culture. A crucial question with respect to system acceptance and success is whether the user community actually follows those practices. This question is very hard do answer for an outside observer.

3.1.2 Iterative Development Practice

This subsection is based on P. Kruchten's book *The Rational Unified Process: An Introduction.* Kruchten refers to *iterative software development* as one of the *best*

practices of software development today. He states that it is one of the practices that cope with root causes of failing projects. His basis for referring to the relevant practices as best is that these are applied in industry by successful organizations. The following lists sums up the best practices presented by P. Kruchten.

1. Develop software iteratively.
2. Manage requirements.
3. Use component-based architectures.
4. Visually model software.
5. Continously verify software quality.
6. Control changes to software.

As mentioned above, a project that employ iterative development, go through the software development faces several times. Each of the iterations are considerable smaller than the one iteration associated with the traditional waterfall model. Additionally, each iteration result in an executable release. Kruchten states a number of advantages of developing software iteratively. Serious mistakes are made evident early in the (product) lifecycle when it still is possible to react to them. User feedback is enabled and encourage by the continual development of new releases. This helps eliciting the system's real requirements. The development team's focus is held on the issues that are most critical. Testing performed continously and iteratively in a relation to each phase enables an objective assessment of the projective status. Furthermore, inconsistencies among requirements, design and implementation are detected early. The workload of the team, especially, the testing team, is spread more evenly throughout the project's lifecycle. Lessons learned can be leveraged and the process can consequently be continously improved. The continuous development of releases and results, give the stakeholders in the project concrete evidence of the project's status throughout its lifecycle.

3.1.3 ISO Standards for Usability and Human-Centered Design

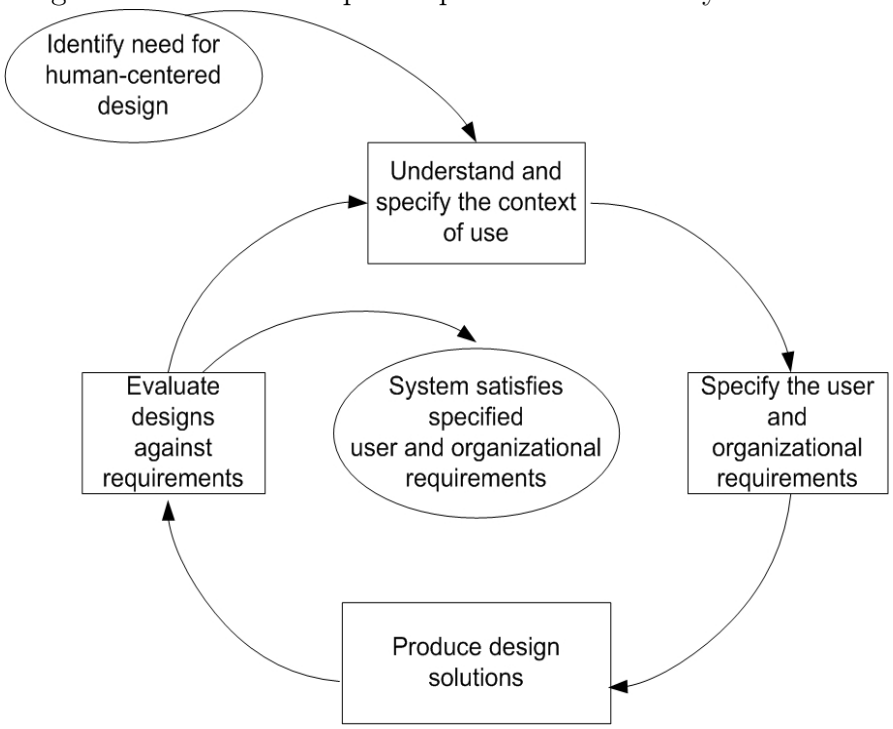
Human-centered design is a software development approach for gaining higher quality of application systems with interactive characteristics. When future users are involved in the software development processes, the resulting systems tend to be characterized by increased usability, improved user satisfaction, and decreased costs associated with user training and support [Int98a]. Usability is defined by *the ISO standard 9241-11* as the follows:

> *Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [Int98b].*

ISO 13407 is a standard focusing on the development of products with high levels of usability. The standard's objective is to be general enough to apply to nearly all human-centered system development methods. Additionally, by being an ISO standard, it guarantees the existence of an international consensus on its validity.

ISO 13407 provides an overview of the process of human-centered design. The standard consists of four parts, each describing one activity in the human-centered development process. The process is iterative, as illustrated in figure 3.1. Accordingly, it goes through all activities as several times for refinement until all identified requirements are addressed satisfactory.

Figure 3.1: The development process described by ISO 13407



The following description is an extract from [Int98a]:

Understand and specify the context of use is important in horde to develop a system that will function well in its environment. The tasks that are to be performed, the characteristics of the users, and organizational issues are all defining the context. When this step is finished, the specification should be approved by the users to ensure completeness.

Specify user and organizational requirements should identify issues regarding required performance of the new system against operational and financial objectives, and relevant statutory or legislative requirements, including safety and health. Furthermore, cooperation and communication between users and other relevant parties must be analyzed, as well as the users jobs (including the allocation of tasks, users well-being, and motivation). Other aspects to look at include task performance, work design and organization, along with management of change, including training and personnel to be involved. Finally, issues concerning feasibility of operation and maintenance, and the human-computer interface and workstation design must be identified.
According to the iterative nature of this process, the requirements should be updated continually.

Produce design solutions A general course of events in a human centered production process would be:

- use existing knowledge to develop design proposals with multi-disciplinary input
- make the design solutions more concrete using simulations, models, mock-ups, etc.
- present the design solutions to users and allow them to perform tasks (or simulated tasks)
- alter the design in response to the user feedback and iterate this process until the human-centered design goals are met
- manage the iteration of design solutions

The idea is to as early as possible match the users' requirements, in order to avoid comprehensive and expensive refactoring later.

Evaluate designs against requirements Evaluation can be used to provide feedback which can be used to improve design, to assess whether user and organizational objectives have been achieved, and to monitor long-term use of the product or system. A rule of thumb is to focus on improving design early in the process, and later, when a more complete model exist, measure whether user and organizational objectives have been achieved. There exists

a variety to perform such evaluation, in which we will not present here. A more in-depth description can be found in [Int98a].

There is a general consensus amongst researchers that end-users should be taken into involved in the development of information systems [RM02]. The topic for discussion is *to what extent* users should be involved. Too many users to elicit requirements from, will consume a considerable amount of resources, while too few users can result in an incomplete requirements specification.

3.2 Computer Supported Work

In this section we want to explore the concept of work, specifically computing work, and how a person interacts with its surroundings (i.e. co-workers, work environment and technology). The section is based on Les Gasser's article *The integration of computing and routine work*.

Computing work has been defined as *any employment of computer-based information or analyses in the performance of other tasks* [Gas86]. Accordingly, computing is rarely primary work, but rather a tool used to to support the primary tasks. The work takes place in an organization, about which we can say the following:

- Organizations do not have infinite resources, hence the people working in the organization must decide how to distribute the existing resources. This might give rise to conflicts as certain groups might feel prioritized unfair.
- Limited resources also prevent employees to explore all possible alternatives when making decisions, as the real world is too complex.
- All employees do not have the same knowledge. This calls for coordination to have the right competence at the right place at all times.
- *Meaning is created through the interactions among people and groups, and during the process of performing work* [Gas86].

3.2.1 Tasks and Work Processes

Work consists at the basic level of a *task*. Tasks are performed according to an *agenda*, i.e. a plan for what the task is supposed to result in. A task consume *resources*, such as time, money, equipment and so on, and is executed by a person or a group, called *actors*. By being executers, the actors naturally influence the way a task is carried out. Aspects that influence the way a task is performed

include personal skills, beliefs, priorities and power. Additionally, the working environment in general affect the carrying out of the task.

Gasser states the following: *Each task, considered alone, has a place in the larger system of tasks, and has some connections and relationships with other tasks [Gas86].* The connection or relationship between tasks can take form as a *task chain.* A task chain is a collection of sequential tasks that together form the production sequence of a product or event [Gas86]. An absolute definition of a task chain can exist only in theory because the actual execution of the task chain will be affected by the characteristics of each unique situation and intersecting task chains. A *production lattice* is defined by gasser as *a complex, coordinated structure of intersecting task chains.* A production lattice consists mainly of three types of work, primary work, articulation work and computing work.

- *Primary work* directly addresses the agenda, e.g. ordering a blood analysis from a laboratory.

- *Articulation work* is reorganization and maintenance in order to be able to perform primary work.

- An example of *Computing work* would here be to order the analysis through computer system.

Work in general is defined as *a collection of interlocked and coordinated tasks* [Gas86]. An employee has many different roles to play, one for each line of work. These constantly need to be aligned and coordinated.

All the tasks in the production lattice are affected by the surroundings at that particular situation they are performed in. Consistent *alignment* is necessary, of both resources and commitment, to ensure a successful completion of the tasks. It will, however, not be sufficient to align a task only once, due to the changing environment mentioned above. Gasser separates between two types of misalignment of resources. *Slack* is used as to denote an oversupply of resources, whereas *slip* means that are si an undersupply of such [Gas86]. The most common misalignment is slip, which refer to the lack of resources. In most work situations time or money are usual factors [Gas86]. Slip may also occur in association with computer systems. This is referred to by Gasser as *computing slip.* In the case of computing slip the computer system provides insufficient user or work process support. Computing slip and the three ways, stated by Gasser, to cope with it, are described in the next section.

3.2.2 Techniques to Handle Computing Slip

The three techniques to handle computing slip are described below.

Fitting

> *Fitting work is the activity of changing computing or changing the structure of work to accommodate for computing misfit [Gas86].*

Example: A misleading name on a button led to confusion when carrying out a procedure. Changing the name reduced the displaying of error messages significantly.

Augmenting

> *Augmenting work is undertaking additional work to make up for misfit. When adding extra tasks, you also potentially increase the need for articulation work, hence increasing both workload and complexity [Gas86].*

Example: Double checking, e.g. by calling down to a laboratory to verify that they have received an order placed through the computer system.

Working Around

> *Working around means intentionally using computing in ways for which it was not designed or avoiding its use and relying on alternative means of accomplishing work [Gas86].*

Three types of working around are mentioned by Gasser. These are data adjustment, procedural adjustment and backup systems. Gasser's definitions are as follows. Data adjustment is e.g. to deliberately feed the system false input data to obtain a correct result in spite of a flaw in the software. Procedural adjustment means to change the routines, e.g. that a nurse checks test results when no doctor is present, to maintain effectivity. These two techniques require profound knowledge of either the technology or the organization. The last, backup systems, means using a different system to complete the task.

Adaption work require the same coordination and alignment as other work, and thus can accumulate more complex production lattices, as well as consuming resources. Gasser states:

> *The nature of recurrent computing problems that users face depends on how easily they can fit, augment or work around computing, given the contingencies they face, the resources they control, and the place of their work in the production lattice of computing [Gas86].*

Gasser argues that it is not technical details or formal procedures that defines the way computing integrates into primary work, but rather the details of action. This calls for models that capture these details, i.e. shows how people use their available resources to compensate for the misfits in the computing work [Gas86]. Gasser also emphasizes the need for focusing on the working environment when analyzing or designing a system, as concentrating on humans or technology separately will fail to provide a complete picture of the situation [Gas86]. He states as follows.

> *To address the systematic difficulties of implementation and maintenance, we need better to align the social contexts of the people involved so that their interests, agendas, and resources match [Gas86].*
>
> *Without ad-hoc and informal adaption work, computing would break down in many settings - thus its cost is part of the cost of doing business with computing [Gas86].*

3.3 Customization by Implementation of Local Variants

The preceding sections has touched on topics such as iterative development which support human-centered design, and we have presented computer-supported work and techniques used by users to handle computing slip. This section concentrates on the concept of implementing local variants for various groups of users as a way to customize applications systems. The user mass is classified in terms of, for instance, functional requirements. Each user group possess less diversity in functional requirement than the total user mass. Each of variants are well-customized for one of the defined user groups. Accordingly, each of the user groups have their own *local variant*. Global standards, on the other hand, imply one universal standard that are used by the whole user mass. An application with a number of local variants, has an exclusive approach to feature implementation. Each variant implement only those features needed by its user group, and exclude the rest. A global standard, on the other hand, has an inclusive approach. The inclusive disjunction set of features that are addressed as needed by the user groups in the user mass, and that are decided to be allowed for, must provided by one global standard. The implementation of these features reflects the most dominating needs in the total users mass without regards of potential user classifications.

The quality attribute usability, has had an increasing focus the past decades. One motivating factor for designing Information Systems is usually increased efficiency, but history shows that a badly designed system is either not used, or even worse, causes efficiency to decrease. It is therefore apparent that the end-users must be taken into account when developing Information Systems. This is concluded by several researchers [RM02]. End-users, however, are seldom (if ever) a homogenous group, and represents different, often conflicting, requirements. This rises a discussion on the potential need for local variants of information systems, tailored to the various subsets of the total user mass. From a user's point of view, an ideal solution would be a personal, unique system, perfectly fitting his/hers needs. From the managements point of view, this would represent a tremendous cost, as they would have had to make one version of the system to each employee. The extreme opposite, with one standard solution, would represent the lowest development cost. However, if such a system fails to realize expected benefits due to lacking usability, the system would be less profitable than one with some local adaptions to ensure user satisfaction, but slightly higher development costs.

This was the main problem treated by Star and Bowker in their article *Knowledge and infrastructure in international information Management: Problems of classification and coding* [sta94]. They studied the case of ICD, an international categorization scheme for causes of death. They discovered that different countries often had conflicting requirements to such a categorization scheme. Accordingly, there existed a tension between the universal standard and the local variants, but Bowker and Star argues that this conflict should not be solved by imposed standardization [sta94]. Instead, they suggest some extent of local adjustment, but claim that standardization procedures must be tailored to the degree of granularity that can be realistically achieved [sta94]. There is no universal answer to this problem, as each case demands a careful consideration of the level in each individual case. However, both [sta94] and [RM02] present conclusions that could help guide the process:

- Adding more functionality will not necessarily establish universality [RM02].
- It is unrealistic and counterproductive to try to destroy all uncertainty and ambiguity in infrastructural tools [sta94].
- Parallel or multi-representational forms are required when facing incompatible information or data structures among users [sta94].

- The *Occam's razor* means that too few categories will result in information that is not useful, while too many categories will result in increased bias, or randomness[sta94].
- Imposed standards will result in users domesticating the system employment [sta94]. Three variants of such adjustment are fitting, augmenting, and working around, as described above.
- Identifying granularity of the problem, then encoding it in the system where appropriate, would complement existing organizational information processing. [sta94].
- Match the structure of the information system in the 'middle' of the different participant with the mismatch of their information needs [sta94].
- The precondition for being able to balancing the costs in infrastructural information systems in the design process is to follow a *reflexive design process*. This involves designing the system gradually through iterative processes, where the current design is continuously negotiated and costs on different organizational levels are weighed [RM02].

Chapter 4

Integration and Portal Technology

This chapter presents our literature study on system integration and enterprise portals. We will discuss different strategies to system integration, and the challenges associated with it. Furthermore, we will describe enterprise portals in light of our discussion of system integration, and present their distinctive characteristics and qualities. Enterprise knowledge portals will be emphasized as Clinical Portal is implemented to serve knowledge workers, and it may, therfore, be characterized as an enterprise knowledge portal.

4.1 System integration

To integrate two or more objects is defined by the electronic dictionary *Clue* as to combine them in a way that makes them closely linked or form an unit. The online reference book *Wikipedia* defines *integration* as *a process of combining or accumulating* [wikg]. *Enterprise application integration (EAI)*, or system integration for short, is defined by the same reference book as follows.

> *The uses of software and computer systems architectural principles to integrate a set of enterprise computer applications [wikh].*

System integration is used to connect application systems or databases and make them appear as a whole. There are various approaches to system integration. Each of these have their advantages and disadvantages. Some of them are better suited for certain purposes than others. In the following, we will present such approaches and their characteristics.

Many of today's organizations have a system portfolio consisting of several enterprise systems specialized for and distributed on various departments. This kind of systems are developed to support the function and processes of the

specific departments they are deployed in. Their orientation tend to be directed towards the individual departments and their function isolated from the rest of the organization and without much regards for interorganizational processes. Consequently, the organization's data is distributed over a multitude of heterogeneous, often autonomous information systems, and the data exchange among the systems isn't trivial [Has00]. System portfolios with these characteristics yields poor support for intraorganzational processes and the organization's value-chain. Intraorganizational processes must be based on integrated information systems to be effective [Has00]. System integration is involved in the more general transformation of business organizations to streamline, interconnect, and compress the organization's value-chain and business processes [AB91] [Ham96] [KW00]. Their implementation can result in a higher value to the organization and its customers [Loh04] [Has00]. Accordingly, system integration is regarded as a most important factor in the enhancement of intraorganizational processes and cooperation in an organization [Loh04] [Has00]. Monteiro describes the connection between the integration of organizations' work processes and integration of enterprise application systems, or information systems, as follows [Mon03].

> *Poorly co-ordinated and largely independent work processes are integrated in an effort to remove redundant operations, sort out ambiguity, and cut back on secondary, administrative overhead. As the information systems were also initially poorly co-ordinated, it follows from this transformation that they also need to be more tightly integrated[Mon03].*

4.1.1 Architectural Integration

As mentioned above, cooperation or data exchange between systems with an autonomous characteristic can be difficult or even impossible. An approach that can be used in such situations, is horizontal integration of the architectural layers that each of the system units are vertically fragmented into [Has00]. The three architectural layers that Hasselbring suggests integration of are given below.

Business architecture is the conceptual level that defines the organizational structure and the workflows for business rules and processes in terms that are meaningful to the application system's users [Has00].

Application architecture defines the actually implementation of the business concepts in terms of enterprise application. The goal of this layer is to provide the "glue" between the application domain described in the business architecture and the technical solution described in the technical architecture [Has00].

Technology architecture defines the information and communication infrastructure to achieve business requirements [Has00].

Enterprise application integration integrates the business architecture of the systems. This is achieved by some form om message passing [Has00] In this context, standardization of message formats and message content are important issues. *XML* is emerging as the standard for defining the syntax of data structures to be transferred over the Internet [Has00].

At the technical layer, *middleware integration* can be employed to facilitate system integration. This kind of integration is concerned with the syntactical level, while enterprise application integration, described above, deals with both the semantic and the syntactical level of the integration. Middleware integration is a *distributed* approach. The systems that the middleware integrates don't know where the systems they are integrated with, are situated and don't exchange data directly with each other [Loh04]. The middleware is situated between the different systems it integrates to make it possible for them to communicate and exchange data with each other. The great advantage of middleware is that it is independent of programming language and operating system. Resultantly, middleware can integrate systems independently of the suppliers or platforms of the individual systems.

Examples of middleware are *CORBA*, *web services*, *database gateways*, and *transaction monitors*. CORBA and web services are most widely used. *CORBA* stands for Common Object Request Broker Architecture. It is a standard that facilitates procedure calls across a network of application systems, and its objective is to make interaction between systems running on different platforms and consisting of different programming languages, to interact with each other. *Web services* is a concept widely used to realize a *service-oriented architecture* (SOA), which is defined as given below.

> *SOA a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains [wiki].*

This architecture provide a uniform framework to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectations [wiki]. Object Management Group (OMG) characterization of SOA is quoted below.

> *An architectural style for a community of providers and consumers of services to achieve mutual value with the following characteristics [wiki].*

- *Allows participants in the communities to work together with minimal co-dependence or technology dependence.*
- *Specifies the contracts to which organizations, people and technologies must adhere in order to participate in the community.*
- *Provides for business value and business processes to be realized by the community.*
- *Allows for a variety of technologies to be used to facilitate interactions within the community.*

A software development consulting company claims that a middleware and an integration layer on top of the source applications/services are needed to obtain a flexible and scalable SOA [Bek06]. This solution makes it possible to combine selected applications or services into a system consisting of multiple components that can be modified individually to reflect changing user needs and continually be well customized. SOA is a young technology/architecture/concept. It has evolved as a result of enterprises' rapidly changing needs, and high costs associated with development of traditional silo systems into systems that can cope with the modern enterprises' demands on technology.

4.1.2 Strategies of System Integration

There are different strategies to system integration. These strategies are determined by the characteristics of the *sources* and *contents* of the information being integrated [EM03]. The information sources can either be *integrated* or *non-integrated*, while the information content can either be *identical* or *related, but different*. Table 4.1 below present the four types of combinations.

Content/Source	*Integrated*	*Non-integrated*
Identical information	Compability	Redundancy
Related, but different	Ambiguity	Supplementary

Table 4.1: System Integration Combinations

Redundancy - identical information, non-integrated

According to Ellingsen and Monteiro, the abundance of redundant information duplicated in different, non-integrated information sources is a major motivation for the pressure for integration. Traditionally it has signaled potential consistency

or communication problems. However, as pointed out by Ellingsen and Monteiro, redundancy is not necessarily and automatically a problem [EM03]. Redundancy may play a productive role as a principal reason for the robustness of work, because *if one component fails for lack of knowledge, the whole system does not grind to halt [EM03].* Therefore, the pros and cons must be assessed before the judgment on redundancy is passed.

Supplementary - related information, non-integrated

Information is supplementary when it is closely related, partly duplicated, but distributed across different information systems, or even within the same information system [EM03]. A practical illustration of this kind of information is when the different professions attending a meeting about a patient, have different versions of the patient's trajectories. Ellingsen and Monteiro argue that this kind of information plays an productive role in facilitating robust, collaborative work configurations by *establishing shared understanding, allowing local flexibility and performing consistence checks* [EM03].

Ambiguity - related information, integrated

Ambiguity concerns the way technology may be interpreted, conceived of, or used differently by different stakeholders distributed across distinct local situations [EM03]. Ellingsen and Monteiro's discussion on ambiguity concludes that *the benefits are greater than the costs, implying that forcing compatibility by flattening ambiguity is dysfunctional* [EM03].

Compatibility - identical information, integrated

Situations with compatibility of information are those situations where *seamless integration* is achieved. The data formats are equivalent and form identical information that is available across the all the integrated systems.

4.1.3 Challenges of System Integration

Hasselbring presents *distribution*, *heterogeneity* and *autonomy* as the three problem dimensions for system integration [Has00]. These dimensions are shown in figure fig:SI, and described in the list below. System integration aims at reducing these problems, and approach the origo shared by the three, to achieve seamless integration, described above.

Distribution of systems can be "hidden" by proxy services, such as *remote procedure calls (RPCs)*, or *remote method calls (RMCs)* in an object oriented setting introduced by CORBA [Has00].

Heterogeneity between the systems can exist at a technical as well as a conceptual level. Techniques for overcoming heterogeneity are the usage of *common programming and data models*, and *domain-specific standards* for defining the meaning of information to be shared among different organizations. Furthermore, *wrappers* can be used to provide unified interfaces between legacy systems [Has00].

Autonomy of the systems can concern the systems' design, programming models, naming concepts, and so on. The systems may be autonomous with respect to the way they perform and handle communication and execution. Technical autonomy is hard to reduce. Usually, *organizational changes* are required to reduce autonomy [Has00].

4.2 Enterprise Portals

Many of today's organizations have an IT solution consisting of multiple data repositories, and application and information systems. These systems are often purchased separately, deployed departmentally, weakly integrated support, and implemented to facilitate a restricted number of work process. As mentioned above, system integration is often implemented to cope with this kind of situations. We have presented various ways to integrate systems, and various strategies and challenges of system integration. Among these strategies are compatible, or seamless, integration. A portal environment can help ensure seamless integration [Duf01]. It provides the user with a unified interface to functions, features, services, and information that are retrieved from source systems, and tailored for the user's organizational role, and personal responsibilities and preferences. An enterprise portals can be loosely defined as an intuitive user interface put on top of middleware which is integrated to work with the organization's existing infrastructure applications and services [Col03]. It have the potential to maximize the return of investment by leveraging existing systems [Wei01] by making use of the application systems, services, infrastructure, and data repositories that are already implemented in the organization. In the book *Enterprise Knowledge Portals*, Heidi Collins quotes the following definition of enterprise portals defined by Shilakes and Tyleman, Merrill Lynch, Inc. [Col03].

> *Enterprise portals enable companies to unlock internally stored information, and provide users with a single gateway to personalized information and knowledge to make informed business decisions.*

4.2.1 Enterprise Knowledge Portal

An enterprise knowledge portal as a portal that is developed to support and create value for knowledge workers during their working-day [Col03]. As other enterprise portals, it is a collection of technologies and integrated systems working together rather than a single product purchased from a vendor. Knowledge workers are actors *with specific relationships or roles and a defined set of responsibilities as they are engaged in and complete (...) work processes* [Col03]. They use the following decision-cycle.

1. They gather information,
2. do study the gathered information, research and collaborate, and
3. finally they take action on basis of the results of the two former steps [Col03].

Heidi Collins concentrate on enterprise knowledge portals, and her vision is a working environment that locates and brings together people and delivers relevant information to individuals who need it so that they can take effective action when doing their jobs [Col03]. She states that an organization can take advantage of several knowledge management objectives in an enterprise portal solution [Col03]. The enterprise portals can facilitate localization, learning, capturing, and reuse of information [ibid]. The following list presents necessities of an enterprise knowledge portal.

- Its functionality and content support each step in your work process. This includes the statement clear boundaries that limit and define exactly what can and should be accomplished [ibid].
- It draws the network of people involved in the organization into a common community, and serves as a tool to exchange information and improve the relationship between the organization's employees and between the organization and its customers [ibid].
- The goal of the enterprise knowledge portal desktop is to implement self-service, self-help and self-discovery facilities for its users [ibid]. The users should have the opportunity to continue to use the systems and applications they have experience with. To support such knowledge workers the portal can provide them with two separate benefits. The portal can provide access to information, applications, and interactions in your organization that they are often not aware of or familiar with [ibid]. Furthermore, it can provide a format for these expert users to publish their expertise, be recognized as experts, and be actively involved in improving work processes directly or indirectly related to their responsibilities [ibid].

- It utilizes effective leadership in the process of merging knowledge management objectives with enterprise portal technology to create the enterprise knowledge portal [ibid]. The leadership effort should concentrate on context and content, culture and behavior, process and governance, and infrastructure and environment [ibid].

- It improves communication work processes. Examples of technologies that can be used are instant messaging, audio- and videoconferencing, taking meeting minutes electronically, webcast presentations that are live or requested on demand, and sharing of your desktop in order to allow team members to interact and walk through activities or issues together [ibid].

- Improves the levels of involvement of the employees in understanding corporate objectives and the details of shared processes by letting them express their point of view and provide feedback, identify issues and contribute to change and implementation the solutions to improve them, and enable decision making by encouraging the employees to take responsibility for their actions [ibid]. Employee involvement features include:

  - Gaining employee input through focus groups, customized surveys, or other research tools [ibid].
  - Encouraging employee participation through suggestions and learning trees [ibid].
  - Enabling employee decision making through the enterprise portal and team collaboration [ibid].

In association to enterprise portals, value is created for the knowledge enterprise worker when several loosely defined data sources and work processes are transformed into a single, cohesive electronic workplace [Col03]. Enterprise knowledge portals provide great opportunities for improvement of work processes for employees, customers, suppliers, and partners. Typical properties of enterprise knowledge portals are single sign-on, comprehensive search, application access and integration, personalization, deployment, administration, collaboration, content management, business intelligence, learning, metrics, and security [ibid]. The result is an electronic workplace for knowledge workers to function cross-functionally in well-managed roles and as networks of users [ibid].

Horizontal and Vertical Enterprise Portal

It is useful to divide enterprise portals into two groups according to whether they are *horizontal enterprise portals (HEPs)* or *vertical enterprise portals (VEPs).*

Howard Strauss' and Heidi Collins' descriptions of HEPs and VEPs are given below [Str02] [Col03].

Horizontal Enterprise Portals are often associated with public Web pages that tries to provide their users with all the services that might be useful to them. They include shopping, weather, stock prices, news, search engines, chat groups, horoscopes, and so on. These pages urge you to make their page the page you set as the start page in your Web browser [Str02]. However, enterprise information portals purchased for an organization can also be horizontal. Collins states that horizontal enterprise information portals are generic in nature and cut across the organization, and support information flow, business activities, and processes across your corporation, suppliers, partners and supply chain [Col03]. Whether the HEP is a public Web page or purchased for an organization, it can by personalized by selecting preferred cities, stocks, and news sources, as well as alter the appearance of the Web page, and much more. This personalization is typically held by Web cookies that are stored on your computer [Str02]. Furthermore, public HEPs are financed by advertising that appear on the portal, and their goal is to attract as many users as possible [Str02].

Vertical Enterprise Portals on the other hand, are designed to support specific functions, processes, and applications within the enterprise. Such portal solutions are often associated with packaged applications for enterprise resource planning (ERP), customer relationship management (CRP), sales force automation (SFA), or supply chain management (SCM) [Col03]. VEPs deliver organization-specific information in a user-centric way, as well as all the information HEPs deliver [Str02]. VEPs include alerts, navigation tabs and icons, directories, graphics, and links. Unlike public HEPs, VEPs require user authentication for access. On the basis of the knowledge the portals has of the user, the VEP produces a customized portal page that is tailored to the user who logged on [Str02]. The portal can be customized according to for example what cohort the user belongs to, what role the user has, what projects the user is involved with, how many vacation days the user has taken this year, to mention some [Str02]. Accordingly, VEPs can be customized to the user from the first time he or she logs on, they look quite different for all users, and, of course, the user can personalize the initial portal page, as with HEPs. Additionally, VEPs should include advanced search capabilities and channels [Str02].

4.2.2 Qualities of Enterprise Portals

This section presents the most central qualities of enterprise portals.

Presentation

Presentation involves the visual experience and encapsulates all the enterprise knowledge portal's functionality [Col03]. The presentation of an enterprise portal should provide continuity of the information and features presented to the user, be flexible, allow for intuitive interaction, and easy navigation throughout the portal [ibid]. The structure of an enterprise portal consists of several layers of portal pages. The highest-level pages are used to describe corporate information such as company news, industry news, and specific information about your business and organization [ibid]. The additional content pages are associated to the various functions or work processes supported in your enterprise portal solution. User interface presentation elements found in enterprise portals are the portal banner, the portal menus, personalization, the content page tab(s), the content window(s), the content page, and content-relevant information [ibid]. The collection of services, content, and functionality in the enterprise portal integrates business intelligence, collaboration and communities, managed content, and learning considerations integrated together, throughout the enterprise knowledge portal [ibid]. This provides the users are with proper business context, as discussed above.

Personalization

Personalization is recognized by enterprise portals professionals and experts as one of the most central qualities of enterprise portals [Col03] [Duf01] [Wei01] [Hof01]. The quality offers customization of both content and content presentation to please the individual users' needs and requirements [Col03]. The information retrieval in enterprise portals can be adjusted to the user's role, and usage context [Bol01] [Hof01]. The portal can be personalized to present only the information and applications that are relevant for defining business benefit [Hof01] in a the way that is most serviceable to the user. This quality is often linked with the portal's ability to provide its users with context.

Personalization and roles An enterprise knowledge portal must offer user management and role management to enable personalization of the content it provides [Col03]. Personalization and role features provide a streamlined experience for the user accessing and interacting with the content. These features are focused on access, which depend on the role a knowledge worker is acting in, and the knowledge worker's preferences and responsibilities. An enterprise knowledge portal handle both users and roles, which are two different concepts. A role defines how the enterprise portal is populated with content, and represent the content offered from the enterprise to the user. Personalization, on the other hand,

is a complementary set of features concerning the user's personal organization and preferred presentation of the content made available in the user interface.

Both the enterprise portals content and its presentation can be personalized. Content personalization concerns which content the user want to be presented with in a content window. This is naturally restricted by the access rights of the user's role. The presentation personalization is the definition of how the content is presented in the same window. Heidi Collins states that it is more likely that users will continue to access and use the portal when it provides its users with rich personalization features [Col03].

Content windows in an enterprise portal present short and factual information and provide links to additional background or training knowledge information [Col03]. The information load of the portal pages shouldn't be too heavy because the users may get lost in the page. Heidi Collins suggests the several features to reduce the information load in a portal page [ibid].

Furthermore, the navigation features of the enterprise knowledge portal must be well organized, intuitive, and accurate [Col03]. A site map can be used give a visual presentation of the information that is available [ibid]. It can also be used as a navigation resource, high-level knowledge map to locate information, or training tool that can be used to recognize business process owners and relationships of the information available [ibid].

User Authentication and Personalization of the Portal The enterprise portal user has a record that provides the basis for authentication to the enterprise portal [Col03]. Personalization information is stored in a data dictionary on a server. Accordingly, the users have the same personalized working environment independently of where they are working. The data dictionary typically include definitions of the attributes that compromise each entity, integrity constraints placed on the relationships of the entities, security information regarding the rights users have or what operations a role is allowed to performed on each entity, and definitions of other structural elements associated with identity schema.

Context provider

Context comes from understanding the user and the value of the information sources they seek [Hof01]. Context is provided when the portal integrates business context and meaning with the content of the portal, support work process by providing its users with work flow, categorization, and taxonomy services, and restrict its enterprise meta data repositories to the information that is utilized to

provide meaning and represent the single version of understanding, in addition to integrating the application and information source systems that generate the portal's content and information [Bol01]. Robert Bolds, one of the contributers to the article *Best Practices in Enterprise Portals* in the July/August issue of *KM World* journal, states that to enable the context to be unlocked from the portal, technical requirements that also drive business objectives must be achieved [Bol01].

Role-based content means that the scope of the content provided through the portal to an individual user must be relevant for the user and for defining business benefit.

Task-based knowledge is collaborative information that helps define additional value beyond any particular role.

Quality of context produce proper interpretation of content. The interpretation of content on the basis of quality context produces better decision support, improved workflow and consistent benefits.

Standardization of both information and processes. This can reduce mistakes and result in higher operational efficiency, which is one of the main goals of enterprise information portals.

Unification is the result of all of the above requirements being fulfilled. Unification of the common technology features, the strength of the collaborative nature of the enabling requirements, the integration of knowledge to create context and the interaction of the worker with the portal all combine to produce tangible business benefits.

Integration

As indicated in the last section, portals perform integration along two dimensions. Along one dimension, the portal integrates content from source systems and data repositories to provide its users with a unified and continuous view of its content. Along the other dimension, the portal integrate the personal profiles of the user [Hof01], the business context, and meaning with the content provided by the source systems. Accordingly, the enterprise portal becomes a context provider. This is the key to realizing business value and benefit because it provides knowledge workers with a single personalized interface that facilitates what they do with meaning [Bol01].

The enterprise portal is reviewed as a cohesive architecture that supports a broad collection of features and functions creating a single user interface to information, services, and applications throughout your organization [Col03].

Several integration features can be included in an enterprise portal to provide such architecture, functionality, and features. Some of these include multi-repository support, application integration, process integration, web services, and peer-to-peer computing [Col03].

4.3 Considering User Satisfaction

This section is based on the article *Considering User Satisfaction in Designing Web-Based Portals*, which presents the findings from an usability study of an Indiana University enterprise portal application launched at Indiana University in May 1998 [ZB03]. The authors present various definitions of usability and highlights that virtually all definitions of usability involve user satisfaction. Definitions of user satisfaction tend to focus on whether users like system and find it pleasant to use. The users used IBM's *Post-Study System Usability Questionnaire (PSSUQ)* to rate their satisfaction with the OneStart Portal. The survey suggested the following topics as central in the achievement of user satisfaction in design of web-based portals.

Perceived utility and the extent to which a system meets users' expectations contribute greatly to users satisfaction and to the portal's usability. This emphasizes the need for web-based portal application designers and developers, to fully understand the gap between what users currently have and what they desire in order to accomplish their goals.

Clear and helpful instructions influence user satisfaction positively. Initially, users tend to ignore these features, but when they encounter a problem or difficulty, they quickly returned to their instructions to compare their approach to the suggested one.

Efficiency of use has been suggested by among other [RR86] and [ea98] to increase user satisfaction. This theory is supported by the OneStart study findings a strong relationship between user's efficiency and user satisfaction.

Everything in Place meaning visual design principles for effective proximity, contrast, repetition, and alignment to optimize thir interfaces' organizational appearance [wil94]. In the study users commented positively on the ability to locate information in consistent screen locations, having similar units of information chunked or compartmentalized, and the ability to logically and efficiently scan information.

The Paradox of Information Quantity is caused by portals' intentions to make large amounts of information available to its users without overwhelm-

ing them. Portals should deal with this by excluding irrelevant and rarely needed information from dialogues. Supplementing features and headlines with *More about...* and *Read more...* hyperlinks is used by multiple online papers to let the user obtain additional information if needed, without forcing them to filter out all of the extra details on every screen.

Feedback is important especially to allow novice to become familiar with new systems and reach a state of competency. Participants in the survey that were satisfied with the feedback characterized it as effective and adequate, while those who wasn't satisfied criticized the portals for its lack of meaningful feedback.

Confusing terminology declines the applications usability. Technical jargons and new terms, concepts and words should be avoided. As proposed by Nielsen, the system should speak the users language, follow real-world conventions, make information appear in a natural and logical order.

Part II

Method

Chapter 5

Method

In this chapter we will present theory on method used in this work. Then we will give a description of our work, and the techniques we used while carrying out this Master thesis. Finally, we will evaluate this work against principles of interpretative field studies, as outlined by Klein and Myers [KM99].

5.1 Introduction

The nature of the phenomena to be studied, along with the research questions, will to a large extent determine the research method. A common classification of research methods is between *quantitative* and *qualitative* methods. Quantitative methods *were originally developed in the natural sciences to study natural phenomena* [Mye97]. They are concerned with numbers and measurable numerical data, in order to describe observations and test hypotheses. Laboratory experiments, surveys, numerical methods and formal methods are all examples of quantitative methods. Qualitative methods *were developed in the social science to enable researchers to study social and cultural phenomena* [Mye97]. Examples of such methods are case study, observation, interview, questionnaires, documents and text, and the researchers impressions and reactions. Some researchers argue in favor of a combination of the two classes of methods. Such an approach is called *triangulation*.

A quantitative research methods is used when the researcher wants breadth over depth, and therefore needs comparable, numerical data from a large population. Qualitative research, on the other hand, focuses on depth over breadth, and implies gathering more information from each element in in a smaller population. In our research a qualitative method will be suitable, as we seek an understanding of the relationship between the user, the working environment, and the system. Our

research questions are very much concerned with *how*, hence numerical data will be of less importance than descriptions from the end-users and the developers, and observations of these. However, there are elements of quantitative methods in our work, as our study included observation of the user tests. The user test had the characteristics of an experiment, where the 10 users performed the same sequence of tasks in the portal, while being observed by members of the development team.

5.1.1 Philosophical Perspectives

Both qualitative and quantitative research are based on assumptions about which methods are appropriate, and it is important to be aware of what these assumptions are [Mye97]. Myers argues that for this kind of qualitative research, the most relevant assumptions are those related to the underlying epistemology. Orlikowski and Baroudi [OB91] and Chua [Chu86]has suggested distinction between three different perspectives; positivist, interpretive, and critical, all based on the underlying research epistemology.

Positivist *Positivists generally assume that reality is objectively given and can be described by measurable properties which are independent of the observer (researcher) and his or her instruments* [Mye97]. Orlikowski and Baroudi classified research as positivist if *there was evidence of formal proportions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from the sample to a stated population* [OB91].

Interpretive Walsham defines interpretive methods to be *aimed at producing an understanding of the context of the information system, and the processes whereby the information system influences and is influenced by the context* [Wal93]. Interpretive research assume that knowledge of reality is only obtained through social constructions such as language, consciousness and shared meanings.

Critical *Critical researchers assume that social reality is historically constituted and that it is produced and reproduced by people* [Mye97]. It focuses on conflict and contradictions, and aims at eliminating the causes of alienation and domination.

Our research can be classified as interpretive, since we, as mentioned above, want to analyze the relationship between the user and the portal, exploring what happens when the two interact.

5.1.2 Qualitative research methods

The research method chosen affects the way the researcher collects data. In the following we will briefly present four common qualitative methods, action research, case study, ethnography, and grounded theory.

Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework [Rap70].

Case Study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident [Yin02]. The case study provides ability to cope with various evidence, such as artifacts, documents, interviews, and observation.[Yin02]

Ethnography comes from the discipline of social and cultural anthropology where an ethnographer is required to spend a significant amount of time in the field. Ethnographers immerse themselves in the lives of the people they study, and seek to place the phenomena studied in their social and cultural context [Lew85].

Grounded Theory is an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data [MT86].

We have chosen to do a case study regarding usability of Clinical Portal. Our study has been based on interviews, observation of users in an experiment-like environment, and study of documents. We have to a very small extent been able to observe the employees at RR HE, the end-users, in their natural working environment, due to their busy schedule, and the time limitations of this work. This has given our work less ethnographic character than what possibly could have been desirable, given our research questions.

5.2 Our work

We conducted our case study at Rikshospitalet-Radiumhospitalet HE (RR HE) in Oslo. Our intent was to study the development of a large and complex information system, and the ongoing project *Clinical Portal* matched this criterion, with its 7000 users, wide range of offered functionality, and diverse user groups with conflicting requirements. Our focus has been, as outlined in chapter 1, to

investigate the factors that affect the usability of the system, and discuss these in the light of a possible local tailoring of the system to better match the user groups.

We have been at Rikshospitalet a total of 6 days, divided on 3 visits. Most of the time has been spent at the IT-department, combined with visits at the hospital. We have conducted several interviews, had informal conversations, and observed the user tests of new the functionality described later in this work. The user tests was a combination of observation of the users, and interviews. In the following we will present theory on the techniques we have used, and comment on how we actually used them.

5.2.1 Interview

The purpose of an interview is to obtain rich and comprehensive information about how other people experience their situation [Tha04]. Factors influencing the outcome can be both the interviewer interpreting answers, and the way the interviewee perceive the interviewer and the situation. There can be distinguished between formal and informal interviews. An informal interview has little structure, and can be regarded as a conversation between the researcher and the interviewee where the interviewee can bring forward issues he/she wants to discuss [Tha04]. Formal interviews are structure, and both the questions and their sequence are predefined. [Tha04] state that such interviews are suited when the collected data are to be compared. The questions asked in an interview can be either open or closed. An open question can be initiated with a *how* or something similar to encourage the interviewee to formulate the answer him-/herself. A closed question, on the other hand, is typically initiated with a *when* or *where*, or could be a pure yes/no question.

We have carried out mostly informal interviews with open questions. The reason we felt this was most adequate was due to our lack of knowledge about the domain when we started out. Most of our inquiries have therefore been of an explorative art, where it is important to have the flexibility the informal interview provides. The more structured interviews were conducted in connection with the user tests. The experimental characteristic of the user tests, gave us the possibility to collect data of a slightly more quantitative nature, in order to back up our qualitative data.

5.2.2 Observation

Observation means that the researchers are present in the situation together with the informant (the object of study), and gather data by systematically observing him or her [Tha04]. Thagaard also states that it is an advantage to be familiar with the domain, to prevent unnecessary interruption to inquire about the the informant's actions. Creswell [Cre03] has defined four different roles the researcher can undertake. These are summed up in table 5.1. A researcher should always announce his or her presence and role [Tha04] where possible, i.e. open observation. However, there might be situations where this is not possible, such as observation of the queue system in a grocery store, where the researcher has no contact with the observed objects.

	Hidden	Open
Participating	Complete participant	Observing participant
Not participating	Pure observer	Participating observer

Table 5.1: The four observation roles proposed by Creswell [Cre03]

We got to observe the users during the user tests of the new "order and results" functionality. We took on a role as participating observers. Our agenda was well-known to the research objects, but we took no active part in the test, which was conducted mostly by the user alone. The only interference was by the test leader, which read the tasks to be performed out aloud. The fact that each user was to complete a given set of tasks, gave us a basis of data with a more quantitative character, with which to support the other data. The tests were recorded with a tool called *Morae* [mor], which records both voice, video of the user, and all actions performed on the screen. This tool provided us with a rich basis of data to analyze on afterwards.

An overview of our work can be found in table 5.2

We have through contact with the developers gathered information on the general terms for development, and the history of the project, whereas with the clinicians, we have mainly focused on the order and results functionality. We have chosen this particular problem from several reasons:

Date	Activity
09/02/2006	2 interviews with developers
10/02/2006	3 interviews with developers and user contacts and visit at the hospital
16/02/2006	Observation of 5 user tests
17/02/2006	Observation of 4 user tests and 1 interview with person at the IT-department
27/03/2006	2 interviews with developers
28/03/2006	2 interviews with personnel at the IT-department and 2 interviews with clinicians at the hospital

Table 5.2: Overview of our work at RR HE

- The problem is a well-known one amongst developers of hospital information systems, and has proven to be a difficult one to solve in a satisfying way. Main reasons for this are the conflicting user requirements, and that it is difficult to make the process feel more efficient than a paper-based solution.

- The project group was developing this functionality at the time, which made it possible for us, through the user-tests, to have more contact with the end-users than what we would have had otherwise. This is due to the short period of time we had to complete this work (5 months), and the very limited extra time the medical personnel has in their daily work that can be used to contribute to studies like this one.

- We feel many of the issues concerning this problem can be generalized to be regarded as valid for the whole portal, and possibly even other, large systems with heterogeneity in the user mass in other domains.

We are connected to the project at RR HE through future employment in a consultancy firm, in which constitutes a large part of the development team. This factor have possibly influenced us in two ways. Firstly, we might have had a closer relationship with the developers, on the basis of us being future colleagues. The way we have received information, and what they have told us, might be influenced by the fact that they knew we were developers/IT-skilled. On the other hand, it might have jeopardized our objective role as researchers, and made us careful not to be too critical towards the project.

We have tried to be as objective as possible, with the starting point to identify aspects that can lead to a portal that is as usable as possible. We have at all times focused on what is realistic to carry out, given the limited resources of both project team and end-users. For example, we think that our limited time doing

this case study, and being in contact with the end-users, realistically reflects the conditions on which requirements elicitation must be executed, and decisions must be taken. On this basis, we feel that the conclusions we draw in this work are both attainable and close to reality, and made on the amount of information that is realistic to have obtained from a developers point of view.

5.3 Evaluation of our work

In this section we will evaluate our work with the case study according to the principles of Klein and Myers [KM99]. As recommended in the article, we will only elaborate on those we find relevant to our work.

5.3.1 The principle of contextualisation

> *The contextualization principle requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged [KM99].*

We have outlined the history of RR HE, with a special focus on the development of information technology. There is also a description of the organization and working environment, along with a brief introduction of the external actors. This will be done in order to create an understanding of the motivation for initiating the CSAM project, and the way it has been developed.

5.3.2 The principle of interaction between the researchers and the subjects

> *The principle of interaction between the researchers and the subjects requires critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and participants [KM99].*

The users at RR HE are generally suspicious when it comes to information technology. We have a technical education, which might have been an advantage when communicating with the development team. At the same time, we would probably have been left with a different result if we had had medical expertise instead. At the hospital everybody was always very busy, and this lack of time combined with the general attitude towards IT, might have had a negative influence on their attitude towards us.

5.3.3 The principle of abstraction and generalization

> *The principle of abstraction and generalization requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action [KM99].*

Although our study only have included a subset of the functionality of the system, Clinical Portal, we feel our conclusions could be generalized to be valid for the whole portal. The reason for this is that the functionality we have chosen, is a functionality that is utilized with a high frequency, by all the various departments at the hospital, and by all various roles at the hospital. This, we think, is sufficient in order to point to differences in needs between both departments and roles.

5.3.4 The principle of suspicion

> *The principle of suspicion requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants [KM99].*

As mentioned in the last section, our close contact with the developers might have affected the conduction of this case study. However, we have attempted to take on the interpretive role, and analyze the situation as neutrally as possible. Even still, it is inevitable to avoid our background completely, and our conclusions probably show some signs of this.

Part III

Case

Chapter 6

Rikshospitalet-Radiumhospitalet Health Enterprise

In this chapter we will give an introduction to *Rikshospitalet-Radiumhospitalet Health Enterprise (RR HE).*

6.1 Rikshospitalet-Radiumhospitalet HE

Rikshospitalet University Hospital was founded in 1826 [Rik05], and is closely related to the University of Oslo. It is one of the largest health enterprises in Norway, providing advanced patient care, research, education, and consultations at an international level. The hospital holds expertise in nearly all medical areas, and has in addition top competence in the fields of cardiac medicine, transplantation medicine, neurology and pediatrics. As of 1. January 2005, Rikshospitalet was merged with Radiumhospitalet [HF06], a specialist hospital treating cancer, hence expanding its range of expertise

6.1.1 Key Figures

RR HE employed 7646 people in 2005. This number includes almost 700 physicians, 2000 nurses, a number of medical secretaries, bio-engineers, radiologists, and other occupational groups [HF06] [Rad06]. The hospital treated approximately 304.000 patients in 2005, from which 50.000 was in-patients, 46.000 was day patients, and 208.000 was out-patients [HF06].

6.1.2 The History of Rikshospitalet University Hospital

This susection is based on information retrieved from Rikshospitalet's Internet Site [Rik05]. The history of Rikshospitalet University Hospital started in 1824 [Rik05], when king Oscar I decided that the already existing military hospital "Garnisonsykehuset", should be turned into an educational, civilian hospital. The official opening year was 1826[Rik05], and the hospital was constantly extended with more buildings and departments. In 1883[Rik05] the hospital was moved to Pilestredet as a result of increased needs, but the new establishment was under-dimensioned from the beginning. After about fifteen years the number of hospital days was twice the amount of what was predicted when the hospital was planned. Rikshospitalet continued to gradually evolve, and over the decades several new buildings were added. In 1988[Rik05] the Norwegian government decided to plan a new Rikshospitalet from scratch, in order to provide the country with a more unified and efficient hospital. The existing Rikshospitalet at the time was a mixture of old and new buildings, and the establishment suffered from the fact that it had been developed building by building, without an overall plan from the beginning. The new hospital at Gaustad in Oslo was finished in 2000[Rik05], and was built to cope with the complex and compound treatment processes of modern medicine.

Rikshospitalet University Hospital was appointed regional hospital for Helse Sør in 2002. It was in addition made responsible for parts of Akershus and Østfold in Helse Øst, due to its size and location. This means that Rikshospitalet admits large amounts of patients from two health regions, as well as some patients from the rest of the country. More information on the various levels of hospital functions, from national to local, can be found in the next subsection. For an overview of the distribution of Rikshospitalet's patients, please see figure 6.1. The complete list of the national functions offered by Rikshospitalet can be found in table B.1 in B. All functions reflect the focus areas of Rikshospitalet.

6.1.3 Organizational Structure

As of 2005, Rikshospitalet University Hospital was reorganized in order to benefit as much as possible from the merger with Radiumhospitalet. Even before this merger, Rikshospitalet was a distributed hospital, hence the idea of one clinical department spanning several physical locations was not new. Besides the main establishment at Gaustad and Montebello (Radiumhospitalet), RR HE has departments at the Gjøvik, Geilo, Bærum, Nordagutu and Kristiansand [HF06]. The structure of departments are presented in figure 6.2.

Figure 6.1: Percentage of hospital days divided on the 5 health regions

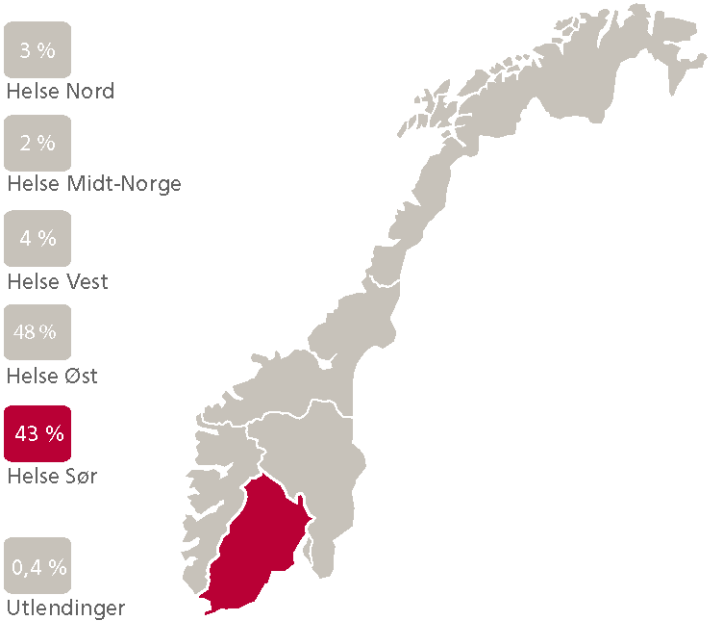
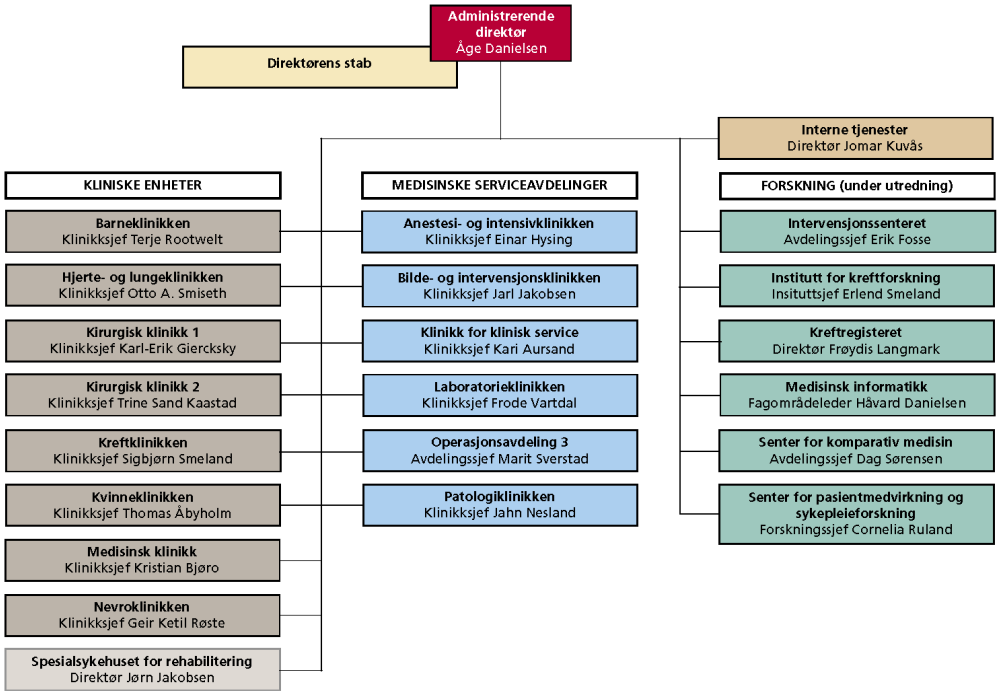


Figure 6.2: The departments at Rikshospitalet-Radiumhospitalet HE



6.2 Characteristics of the Hospital

In this section we will call attention to the characteristics of the users and their context at Rikshospitalet that affect the need for customization of Clinical Portal. In chapter 9 we will analyze the need for customization of the portal on the basis of this sections, as well as our results.

6.2.1 User Heterogeneity

As mentioned earlier, the portal is implemented at Rikshospitalet to provide health care personnel with computer support to do activities and decisions in associated patients and patient treatment. However, the health care personnel is a heterogeneous group. This can make the development of an information system to support their work processes quite challenging. A health care employee are related to primarily one of the health care occupational groups; physician, surgeon, nurse, medical secretary, and so on, and work at one or more departments. Rikshopsitalet's departments are presented in figure 6.2. The occupation of the health care employee, his/her department belonging, and his/her working experience are some of the variables that influence his/her area of responsibility at the hospital. These variables combine into a large number of possible job descriptions and areas of responsibility being distributed on the health care employees at Rikshospitalet. The number of variables that determine the job description and area of responsibility of a health care employee at Rikshospitalet, indicates the high degree of diversity in the characteristics of the health care personnel.

6.2.2 Division of Responsibility

As reasoned in section 6.2.1, there can be diversities in the job descriptions of two employees even if they both belong to the same occupational group, or to the same departments. For instance, can two nurses working at two different wards have different job descriptions. As mentioned in last subsection, this diversity is caused by the number of variables that determine the employees job description. However, certain aspects of job descriptions can be quite universal. For instance, can only physicians or doctors make decisions regarding patients and their treatment. Doctors are expensive and a scarce resource. The number of doctors is restricted to 700 distributed on 50.000 in-patients, 46.000 day patients, and 208.000 out-patients [HF06]. Consequently, doctors mainly concentrate on decision-making

regarding patients' treatment, and leave as much as possible of the carrying out of the prescribed care and office work to less expensive and less scarce resources. Accordingly, performance of some of the treatment, medication, follow-up, and so on, is delegated to nurses, which count 2000 in number [HF06]. The higher number of nurses results in considerably more nurses than doctors per patient. Consequently, the nurses can give each of her/his patients more attention and closer follow-up. He/She can assist the doctor responsible for the individual patient, and provide him/her with details on the patient's progress. To reserve as much of the doctors' and nurses' time to patient care and treatment as possible, the medical secretaries are responsible for most of the paperwork and office routines. Among the tasks delegated to the medical secretaries are completion and administration of test requisitions.

The division of responsibility described above makes the doctor the decisioner as well as the practitioner of the more advanced patient treatment. The nurses assist the doctors in patient treatment and follow-up, and the medical secretaries are responsible for assistance of the doctors and nurses in association with paper work and office routines. However, the doctor responsible for the patient being treated, must control and approve of the work done by the nurses and medical secretaries. This yields the following roughly structured and described chain of events associated with treatment of a patient. The chain is often repeated a number of times depending on the patient's treatment and progress.

1. The doctor reads information about the patient and possibly reference books, depending on his/her needs, and examine the patient.

2. The doctor make a decision regarding treatment, or follow-up, of the patient.

3. The medical secretary does paperwork associated with the doctor's decision-making.

4. The doctor approve of the medical secretary's work.

5. Treatment is performed by doctors and his/her assisting nurses,

6. and documented by the medical secretary on the basis of the doctor's wishes.

7. The doctor approve of the medical secretary's work.

8. The chain is possibly repeated.

6.2.3 Dynamic Roles

Furthermore, each member of the Rikshospitalet's health care personnel can be associated with multiple departments. The competence held by one single nurse, doctor, or another health care employee, can be needed in several departments. This causes the employee to move around between these departments. Within each of the departments, he/she may have different job descriptions and associated responsibilities. This results in the possibility of dynamic relations between the each of the employees at Rikshospitalet and their characteristic. The logic associated with such dynamic relation is complex, but still very relevant for information systems to allow for.

6.2.4 User Focus

Health care personnel tend to emphasize patient care and inter-human work processes. They want to spend their time examining, treating, and helping patients, or discussing issues and cooperating with their colleagues in order to increase the quality of the services that the hospital offer. Many of the health care employees may even have chosen their occupation on the basis of the desire to work with people. These facts, in combination with the lack of resources, in terms of time and personnel results in a possible impatience among the personnel when working with ICT systems. Their focus is on the patient, and they don't want to spend time in front of a computer. The health care personnel at the hospital may accordingly be challenging to please.

6.2.5 The Users' IT Experience

So to speak all the users who participated in the users test had experience with applications in the Microsoft Office-package. We lack confirmation from only one of the participants at this point, but there is reason to belive that also this users has experience with such applications. Beyond this, all the participants have extensive experience with using application and information systems specific to their departments. Among the systems mentioned in this context are PIMS, DocuLive, RIS, SwissLab, PAX, and EROS. For instance, nurses are used to using EROS. This system present its users with test results one by one, which is the way most useful to nurses. Consequently, many of the employees at Rikshospitalet are used to systems that are well customized for their particular responsibilities, work process, and needs.

Furthermore, the users were quite experienced with the Internet. All of them stated that they make use of online money banks, while some of them uses e-commerce,

please see Appendix A. Even some users make use of online reference books. Experience with online money banks and e-commerce is particularly relevant IT experience because such applications are often structured in the same way as the applications in Clinical Portal. This structure may be described as a path or step-wise structure. Experience with this kind of applications may make it easier for the portal users to grasp the logical relation between the portal pages in an portal application.

6.2.6 Working Days and Environment

As indicated by the figures in section 6.2.2, time and personnel are scarce resource of great value at Rikshospitalet. At the emergency unit where seconds be what distinguishes life from death for a patient. The mean waiting time at Rikshospitalet anno 2004 was 87 days [Bru04]. The long waiting lists results in high working pressure on both the health care personnel at Rikshospitalet. The management constantly tries to make the treatment process even more efficient to save resources and shorten the waiting-lists. The personnel's time is distributed over as many patients that, in proper conditions, is possible without hindering the hospital's ability to yield high quality of service to its patients and their relatives.

6.2.7 Cross-Functional Processes

Many of the patient care related processes at the hospital involves several departments, as well as health care employees with different occupations and responsibilities. Cross-functional cooperation is needed to yield the best possible care to the patients. Accordingly, the hospitals departments need support for exchanging information and data with each other. This requires integration of the various departments' infrastructures. Simultaneously, the user interfaces, the system presents to the users at the various departments, must be customized for the needs of these individual departments' users.

Furthermore, there is a need for support of situations where various users with different preferences are cooperating and viewing the same user interface, for instance, during a meeting involving users from several departments, representatives from various occupational groups, or both.

Chapter 7

Information Technology at Rikshospitalet

In this chapter we will outline the development of information technology at Rikshospitalet. The objective of the chapter is to provide the reader with an understanding of the motivation for implementing Clinical Portal and the context of its development and usage. First we will briefly describe the situation as it was 10 years ago. At this time action was initiated to make the hospital less paper-dependent. Then, we will present the development over the past ten years, and finally introduce development project and Clinical Portal. The chapter is based on interviews with representatives from the IT department at Rikshospitalet as well as project workers working on the *Clinical Systems All Managed (CSAM)* project. This project team consists of system developers hired from Objectware AS and Oracle. Additionally, the chapter is also based on documentation about the product and the project that we have been given access to, and Bente Brevig's master thesis on the portal and the development project at Rikshospitalet [Bre06].

7.1 The Paper-Based Patient Records

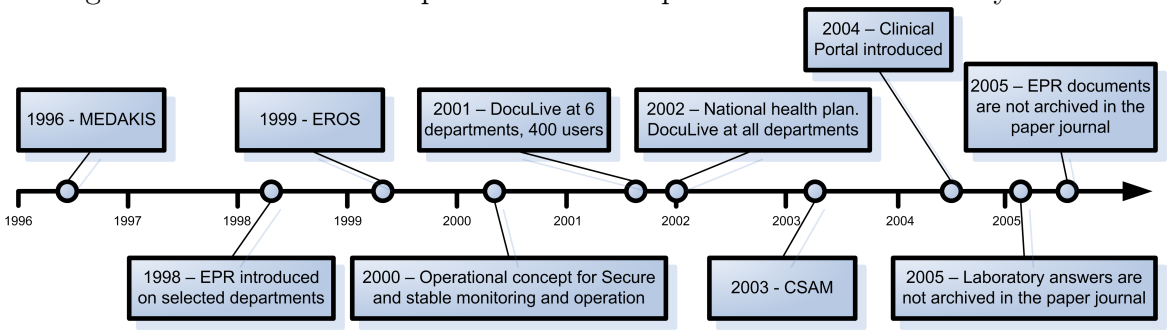
Before the implementation of electronic patient records (EPRs) at Rikshospitalet, patients' medical records was completely paper-based. Patient information was available on paper-based archives only. This made it difficult to keep the record consistent when patients were transferred between both wards and hospitals, and often had one record at each location. Furthermore, it could impose a safety risk, due to lack of availability of the paper documents in emergency situations, or incomplete information as a result of failure to coordinate all records of one patient [Bre06]. A lot of resources was spent on paperwork and administration in association with exchange and coordination of the patient records. Like other

enterprises within the Norwegian health and social sector, the management of Rikshospitalet recognized that information technology could increase the hospital's efficiency [Bre06]. Rikshospitalet had increased their focus on treating multi-subject diagnoses, and the treatment of such diagnoses required cooperation and, accordingly, increased information flow, between the hospital's various functions and department. Consequently, one of the reasons for implementing ERPs was to improve the information flow between the hospital's departments, and provide better support for cross-functional processes at Rikshospitalet [Bre06].

7.2 Ten Years of IT Development

This section presents the IT development at Rikshospitalet over the past ten years illustrated in figure 7.1.

Figure 7.1: The IT development at Rikshospitalet over the last ten years



1996: The MEDAKIS project was initiated [tuiP04]. It was an effort to implement an Electronic Patient Record (EPR) system at all the regional hospitals, and Siemens was chosen supplier. The product, DocuLive, was a system meant to deal with and store all information held by traditional paper records.

1998: An ERP pilot project involving three departments was initiated. Full implementation in only a few departments combined with no implementation at the others, resulted in a very small user mass [tuiP04].

1999: A system for electronic laboratory answers called EROS was implemented. Because the paper record still was the only official, the results continued to be printed out and stored together with the patient paper record record [Rik04].

2001: DocuLive was implemented in six departments. However, this involved only 400 users, approximately 10 percent of the employees [tuiP04]. Limited resources prevented further roll-out at Rikshospitalet. Additionally, Siemens failed to deliver on time.

2002: The national health plan regarding information technology in the Norwegian health sector from 2001, *Say @!* [Nor01] initiated a new strategy at Rikshospitalet. DocuLive was now rolled out to all departments of the hospital. The focus was on basic, rather then full, functionality [tuiP04].

2003: The initiative CSAM was established in order to create one common work interface towards the 160 production systems that existed at the time [Rik04]. Rikshospitalet's system portfolio consisted of 1200 to 1300 systems. The technological framework was finished the same year.

2004: Early 2004 Clinical Portal was introduced, first at the Thorax department, the Pediatric department and the Medical department, later at all departments at the hospital. The portal was at the time integrated with DocuLive and patient administrative systems (PAS) in order to provide EPR functionality, and offered in addition laboratory results from various laboratory systems.

2005: Electronic laboratory results replaced paper results, and was hence decreasing the growth of the paper journal. Even still, the laboratories often delivered results on paper in addition to electronic answers, but these were usually just thrown in the garbage at the receiving wards, and was under no circumstance stored. The work of the project team was concentrated around new functionality, regarding electronic ordering of tests from the clinical chemistry laboratory.

7.3 Clinical Portal

Clinical Portal is based on the *Clinical Systems All Managed (CSAM) framework*, and it is the implementation of the framework tailored for Rikshospitalet. The framework support integrated information flow, and manage information systems and infrastructure [Bru04]. The architecture of the portal is not tied to the various source systems at the hospital. Each of the systems can be individually decoupled from the portal architecture and replaced by a new one. In this way, the portal is prepared to future changes and evolution of the technology. Additionally, the integration architecture implements database queries across the various source systems in order to fetch, present and collocate the needed information to the

end-user. An introduction to the functionality and architecture of Clinical Portal is given below, and an in-depth description of the *order and receive test results* functionality can be found in chapter 8.

7.3.1 Characteristics of the Portal

Clinical Portal offers its users a coherent and integrated view of information and functionality fetched from the portals underlying systems and infrastructure. The objective is to simplify processes and workflow. The portal is implemented as part of Rikshospitalet's strategy to become a paper independent hospital. The goal is that all patient data and health information will be digitalized and available through the portal within 2007. Better operation, higher availability of information systems, and a digitalized, integrated information flow shall facilitate process development at the hospital. This strategy shall turn information technology in general and Clinical Portal a value-creator at Rikshospitalet.

History of the Portal

Rikshospitalet's system portfolio has involved hundreds of enterprise application systems and associated data stores. These systems have been developed for, and implemented in, various departments at the hospital. Many of them are deliver by suppliers that continually extended their own system's functionality and quality to intentionally oust other competing suppliers' systems from Rikshospitalet's system portfolio. This resulted in many of the systems overlapping each others area of responsibility and acting highly autonomous, which made data exchange between them difficult. Rikshospitalet experienced a steady growth in paper production, but no storeroom for all the paper being produced. Furthermore, the Norwegian Ministry of Health and Social Affairs' strategy plan demanded that patient records should be made electronically available. Something needed to be done, and this *something* turned out to be the development of the CSAM framework and implementation of Clinical Portal at the hospital.

The first versions of Clinical Portal are already rolled out and in use at Rikshospitalet. It is deployed in all the various clinical departments and replace all the systems at these departments. Accordingly, the portal is a general system that will be used by all the clinical departments and user groups/roles.

A Vertical Enterprise Knowledge Portal

As described in chapter 4, the term *portal* covers a range of different kinds of informations systems. A portal can be an Internet page, that provides you with

links to other Internet pages that you encounter during your daily round of Internet surfing while drinking your morning-coffee. On the other hand, a portal may practically be your personal computer desktop at work. It provides you with all the information, facilities, and application systems that you need to have an effective day at work. Portal experts tend to agree that portals provide its user with a unified and personalized interface to underlying source systems and information and assist the user in his or her decision making or work process.

The properties of Clinical Portal agree with the definitions of a enterprise portal given by Heidi Collins [Col03]. The portal provides its users with an intuitive user interface with a whole lot of middleware integrated to work with the existing infrastructure applications and services at Rikshospitalet. It enables Rikshospitalet to unlock stored information, and provide users with a single gateway to personalized information and knowledge to make informed business decisions.

Clinical Portal require user authentication for access, and deliver organization-specific information in an user-centric way. It is tailored to the users needs from the very first time the user logs on because knowledge of the user's access rights, role, department belonging, and so on, is already implemented in the portal prior to the user's first sign-on. Furthermore, the user can personalize the portal to better satisfy his or her personal needs. These properties of Clinical Portal makes it a typical *vertical enterprise portal*.

The portal can also be characterized as a knowledge enterprise portal as it is developed to support knowledge workers to make their work processes more effective, facilitate cooperation, communication, and information exchange. This is reflected in Bruun's presentation of the CSAM framework's [Bru04].

As mentioned in chapter 4, portal technology make it possible to define various user groups and roles, and tailor the portal for the needs and preferences of the individual users. But with what granularity shall these user groups be defined? And what effects does this have on the portal's implementation of work process support functionality? This will be discussed in our analyses, but first we will present Clinical Portal's work process support as it is today. This will be done in the following sections.

7.3.2 Computerized Work Process Support

As mentioned earlier, the objective of Rikshospitalet's implementation of Clinical Portal is that the portal shall fully replace paper journal, and offer new and

patient related information services to patients, employees, external customers, and service providers [Bru04]. The implementation of the portal shall facilitate process development and paper independence at the hospital. Many of the processes performed by health care personnel have been based on paper journals, documents, and forms. Complete paper independence demand the transformation of these into processes performed on computers. Accordingly, the portal has to implement services and functionality that can support these processes in the same way, or better than, paper-based facilities. Information overview, order and retrieval of test results, and planning and follow-up of patients are among the services given most emphasis by Rikshospitalet and Clinical Portal development project. Our study is limited to services associated with order and retrieval of test results, and patient information overview.

Services associated with order and retrieval of test results, and the patient overview picture, will be used by various user roles situated in different departments at the hospital. The various roles have different needs, and the various departments have diversing routines, for order and retrieval of test results. The order and retrieval of test results can be seen as a trade in services. The test performer and analyst is the service provider, and the person ordering the carrying out of the test is the client. Test orders to MBK can be written by the client and sent directly. Order of a test taken by the radiology department often requires that the client and the service provider are engaged in a dialog to conclude what kind of test must be taken. The diversity in routines for test ordering is one out of the many reasons why computerized support for order of test results is particularly challenging to implement. We will restrict our study to order and retrieval of test results from MBK.

The actors involved in ordering of MBK laboratory tests have been using paper-based *checkbox forms*. The results have been received in an application system, called EROS, or written on paper and put in the client's mailbox. The routines for paper-based order and result retrieval are both effective and well-incorporated into the involved actors' working days. Doctors and nurses can complete the checkbox form virtually blind folded. This makes it very challenging for the portal to improve the efficiency of the health care personnel in association with the completion of the checkbox form. As stated by a doctor involved in the development of Clinical Portal, the portal must support all its users' total working day. It must increase the efficiency of both the individual health care employee, and the hospital as a unit. A portal should to be its users' *computer desktop*, or *customized, personalized, adaptive desktop* as H. Strauss names it [Str02]. This means that the portal must implement all the functionality and provide all the information required by its users

and their work processes, so that they don't need other systems or paper-based information during their working day [Str02]. H. Strauss states the following.

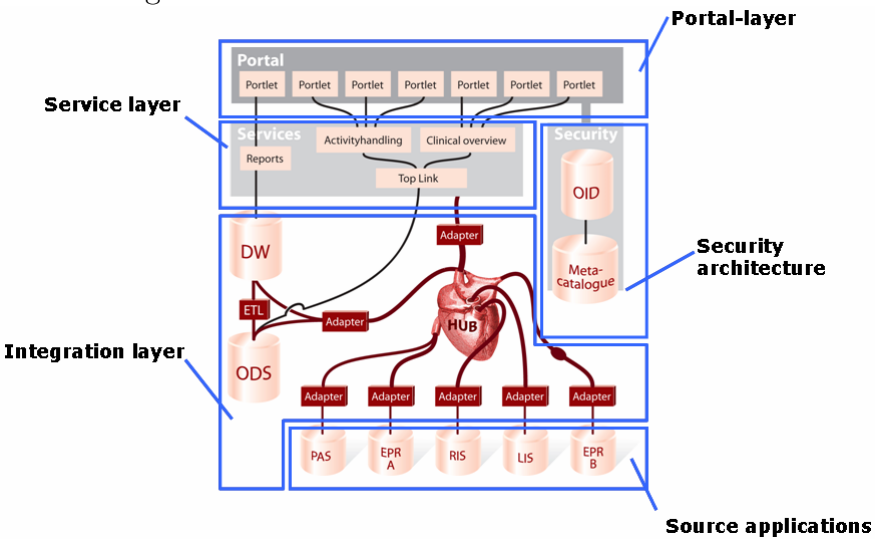
> *It should be the application that appears first on your screen and in most cases should replace everything else on your computer desktop. From a user point of view, the portal will become the computer [Str02].*

7.3.3 The Architecture and Technology

The objective of Clinical Portal is to be an entry gate to all the electronic information used by the health care personnel at Rikshospitalet, and to provide the user access to functionality and information offered by the portal and its source systems [BHR03]. This subsection presents architecture and technologies employed in Clinical Portal. It is based on documentation we have received from Rikshopsitalet's IT department [BHR03] [Lot05] [Kri05a] [Kri05b] [Odd03].

The layered structure of Clinical Portal consist of a portal layer, service layer, integration layer, security architecture, and the underlying source application systems. This structure is illustrated in figure 7.2. The following subsections presents these layers, architectures, and source application systems in the CSAM framework.

Figure 7.2: The architecture of Clinical Portal



Access to	System	Example
Clinical documentation	DocuLive	The previous epicrisis of the patient.
Patient administration	PIMS	Who is currently in-patient/out-patient.
Clinical chemistry	NetLab	Creatinin, HB, electrolyte.
Pharmacology	NetLab, (Miclis)	CyA-concentration.
Immunology	NetLab	Rheumatological marks.
Microbiology	Miclis	Cultivation and resistance.
Pathology	Sympathy	Biopsy, cytology.
Radiology	RISWeb	UL abdomen (results).

Table 7.1: The source systems

7.3.4 Source systems

As mentioned earlier, the hospital's system portfolio involved a large amount of systems before the framework was developed. The historical development projects and purchases of systems have various financing models. In some cases they have been intended for the entire hospital, but in most cases they are departmentally oriented [Bru04]. Consequently, the different departments at the hospital use various autonomous systems. Furthermore, the systems are delivered by multiple suppliers, that had been focusing on expanding the coverage of their own monolithic system [Bru04].

The field of health informatics has an impressive size in constant evolution. The systems and technology of health informatics will continue to change and evolve with same pace as the medicine disciplines [Bru04]. The solution adopted by Rikshospitalet is modifiable in respect of the future evolution in health informatics, the number of users, and amount of data. Furthermore, the utilization of implemented systems at the hospital save resources.

Table 7.1 present the source systems of Clinical Portal, what the various systems provide access to, and examples of usage of these systems.

7.3.5 Integration Architecture

The integration architecture is responsible for the integration of different source systems, and arranges for communication and cooperation between these and the service layer of the solution. The integration architecture deliver information and process oriented services to the service layer, which make these useful the portal

presentation layer. The portal layer provides the portal user with a coherent view of patient information. As mentioned above, the source systems are developed by and purchased from multiple vendors. This can make integration increasingly challenging because the systems may use different standards and protocols for communication.

7.3.6 Security Architecture

The security architecture is responsible for the implementation of the security requirements of the portal. In association with Clinical Portal, requirements concerning identification, authentication, authorization, and privacy are given much attention since portals are built especially to handle variations in user groups and their access rights.

The security architecture offers single sign-on and identity management. The authorization of users is based on the user's role and context of the sign-on. The users are given unique usernames to identify themselves when using the portal, and they authenticate themselves by aid of a password. The authorization of users provide the users with access to information and functionality. This is controlled by giving a group of users unique access rights on a portlet level. The user groups and the individual users are stored the OID illustrated in figure 7.2 [Lot05]. The users' password are encrypted by aid of the *Hash algorithm* [Lot05]. Each user group contains a list of those members belonging to group, and a group can be a member of another group. The architecture is modifiable to be implemented on different organizational levels, locations, regions, and nations. Identity management is based on the *Novell technology*.

7.3.7 Service Layer

The service layer and architecture focus on unique process oriented functionality. It provides services with various complexity and influence on the organization's routines and processes.

The service layer is placed between the portal layer and the integration layer. It offers components which give access to integrated information from the different source systems. New functionality developed will also belong to the service layer. This functionality include activity handling and specialized views. In the layered software structure, the services offered by the service layer are distributed between two modules called *reports* or *top link*. The top link is further structured into one module handling *activity handling* and one handling *clinical overview*.

7.3.8 Portal Layer

The portal layer is the top-layer in the layered software structure of the clinical portal. The portal layer uses HTML and SQL/PL portlets, user interface templates, page templates, cascading style sheets, dynamic pages, and database access technology in its implementation of the user interface. The interface consists of multiple portlet implemented channels. The channels provide the user with a coherent view of information form the source systems, and direct access to and activation of underlying application systems.

Clinical Portal's functionality and services are distributed on five desktops; *My Desktop*, *Patient Desktop*, *Clinical Desktop*, *RH Portal*, *My Journal*. Each of these desktop have their own user groups and services. The first three desktops provide support for work process at the hospitals. The two remaining are desktops for actors external to the portal. *RH Portal* is the extranet of actors in the Norwegian health sector. *My Journal* is meant for the hospital's patients.

Each portal pages contain a number of portlets that are organized on the basis of page templates. The page templates ensures that the pages provide its users with an unified and continual interface in terms of organization of portlets, colors, and user interface components. The portlets are fetch and present services and information by use of the services provided by the service layer.

7.3.9 Log On and Off

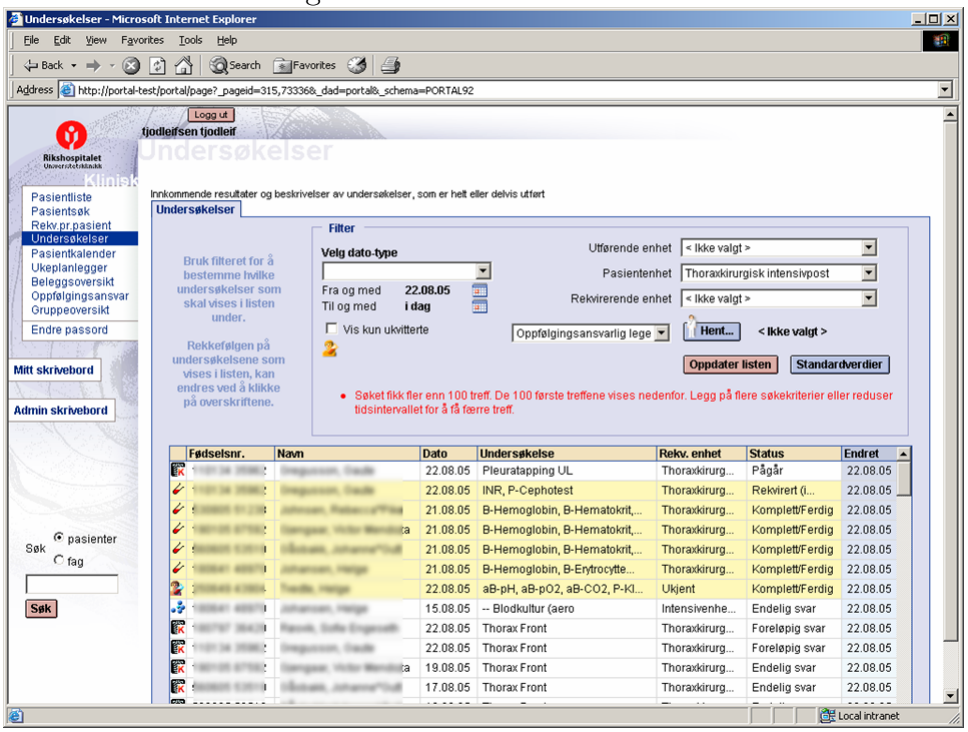
Clinical Portal provides its users with *single sign-on*, *context-based log on*, and *role-based access*. When the user has logged on to the system, he or she can access information and use services offered by all the source/production systems in the portal without additional sign-on to these systems. The user will stay logged on as long as he or she uses the system actively. If the user is inactive for 30 minutes, he or she will be logged of the system, and has to perform an additional sign-on. The context-based log on see to that the user is brought back to the context he or she was situated before the log-off was issued.

7.3.10 Filtration Functionality

Filtration functionality is implemented for lists in the portal. This is an example of a personalization feature and a mechanism for handling the information load in the portal pages. This functionality is implemented in association with, for instance, a list in the Clinical Desktop for presenting all the tests and examinations ordered for the patients that the (clinical) user is responsible for. The portal page presenting

this list is shown in figure 7.3. The user can change the settings for the filter to tailor it according to what he/she is looking for. The list's can be filtrated regarding to date, the performing unit, the patient's unit, requisitioner, and according to whether the result is signed or not [Kri05a]. The filter's settings are memorized by the portal. Accordingly, the settings of the filter will be as the user last sett them, when he/she return to the same page after accessing other pages. The laboratory sheet in the Patient Desktop, which will be described in detailed in chapter 8, has a similar functionality. The user can turn the presentation of notifications of alarming laboratory test results on and off. The settings of the laboratory sheet follows the user in the same as the filtration settings. The filter and laboratory sheet are examples of what Heidi Collins, cited in chapter 3, refer to as content personalization [Col03].

Figure 7.3: Filtration of Lists

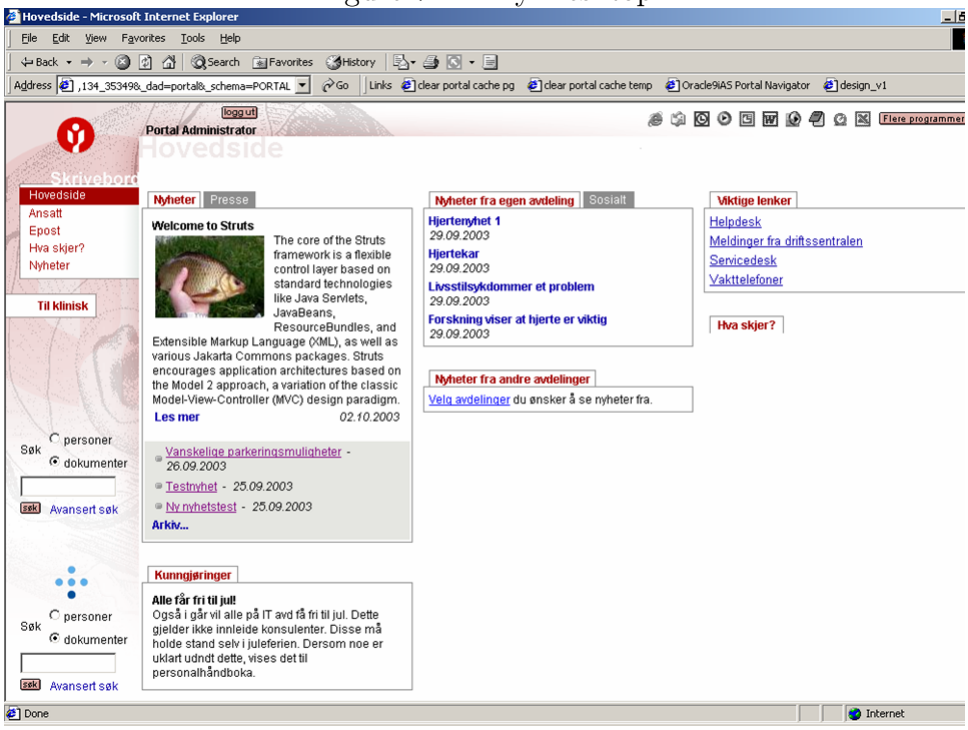


7.3.11 My Desktop

When the users logs on to Clinical Portal for the first, she is brought to My Desktop. A picture of My desktop is shown in figure 7.4. All the pages at this

desktop are red, and the menu at the left side is used for navigation in My Desktop, as well as to the Clinical Desktop.

Figure 7.4: My Desktop



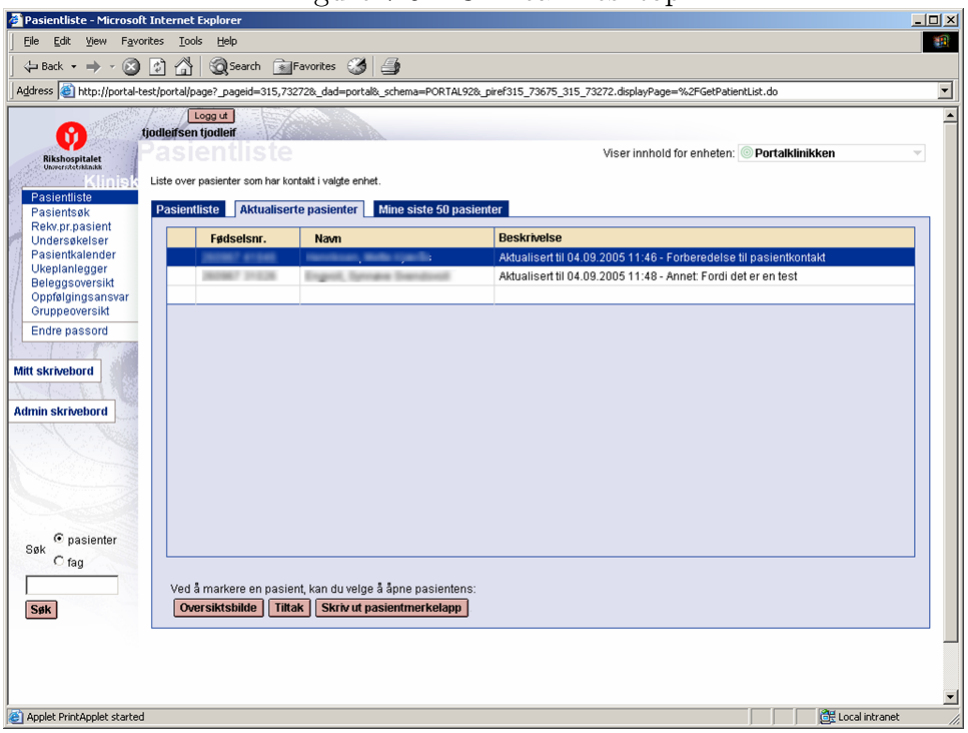
This desktop is for personal use, and presents the user with information and services related to her role, department, and working community at the hospital. It contains announcements, news, and scientific literature, and can launch non-clinical applications, such as Microsoft Word, Excel, and Internet Explorer. The list below shows the desktop's information structure.

- Employee related information and services
- E-mail
- Profession and Skills/Knowledge Management
- Current events
- News
- Personal Space

7.3.12 Clinical Desktop

Clinical Desktop provides the user with medical information. The user enters this desktop from My Desktop with a role, and the content of the desktop will be adjusted to this role and the user's department belonging [Kri05a]. To enter the desktop the user must be a *clinical user*. A clinical user is defined as health care employee that use Clinical Portal in order to do activities and decisions in relation to patients. A user that is associated with multiple departments can choose which department's information he/she wants to view [Kri05a]. Figure 7.5 shows the a picture from Clinical Desktop.

Figure 7.5: Clinical Desktop

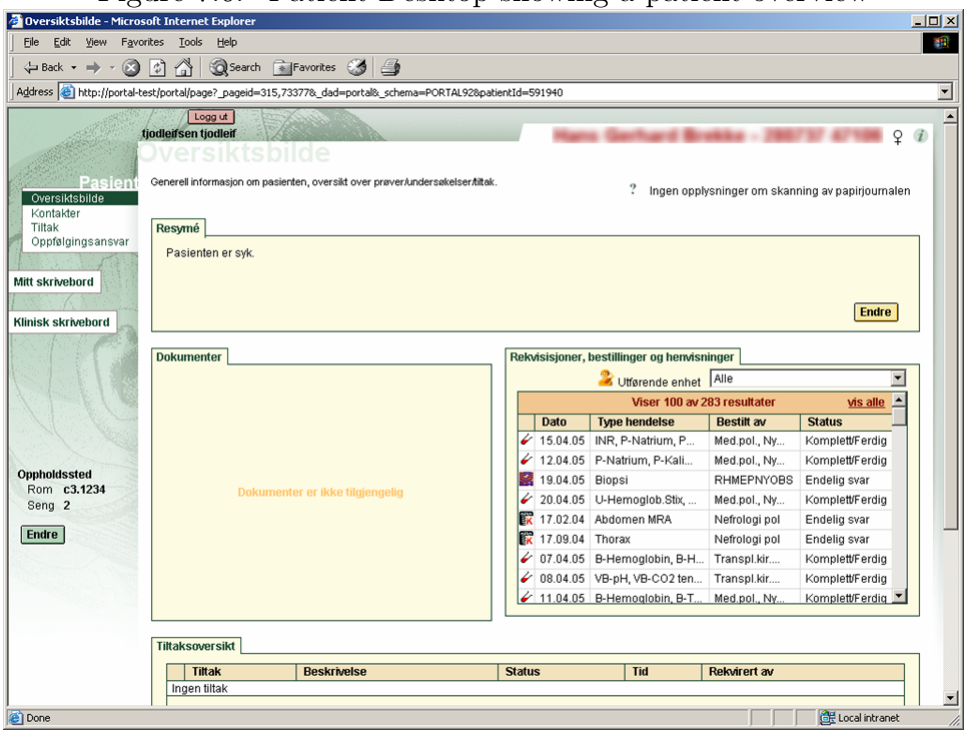


In Clinical Desktop the user can perform searches in scientific literature and the patient list associated with the user, transfer and take responsibility for and make patients topical, order test from laboratories, view results from such tests, and plan and follow up patient actions.

7.3.13 Patient Desktop

When the user chooses to perform an action on a chosen patient from the Clinical Desktop, he/she is taken to the Patient Desktop [Kri05a]. This desktop provides the user access to information about and functionality for handling individual patients. The pages in Patient Desktop has a mutual background color, and the patient's name, national identity number, and sex is continually shown in the upper right corner. The user can navigate within the patient related pages, and to the two other desktops, with the menu at the left. Figure 7.6 shows a screen shot from this desktop. The page depicted in this figure is called the *patient overview picture* provides the user with an overview of the information held by the different source systems about the patient.

Figure 7.6: Patient Desktop showing a patient overview



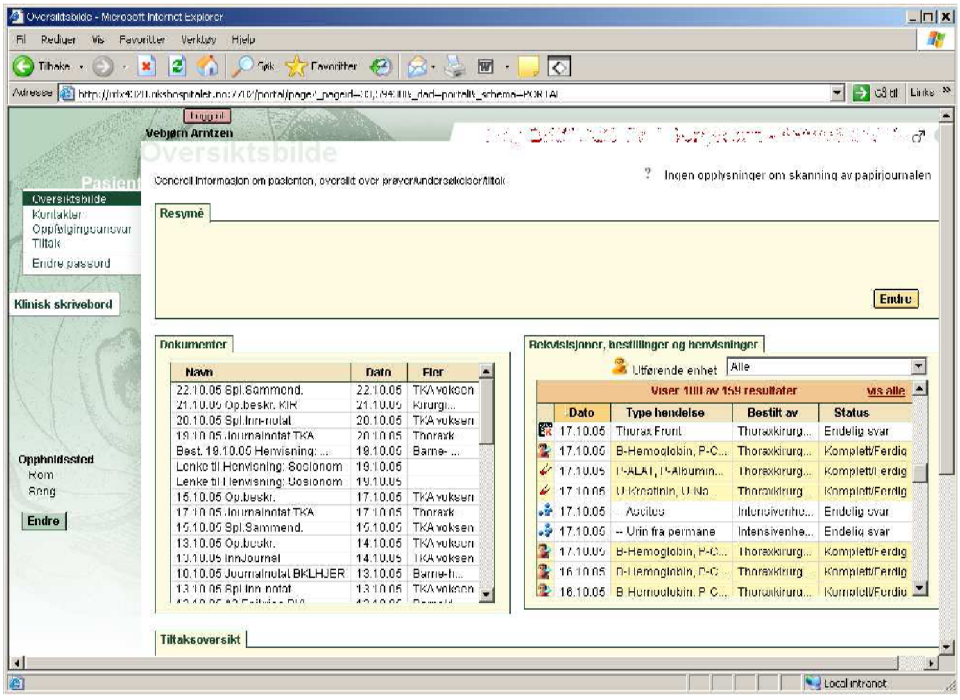
In the patient overview picture the user can search for patient, and retrieve information about the patient from the source systems and have them presented in a coherent and complete fashion as shown in figure 7.6. The user can retrieve detailed information by selecting the portlet with the channel showing the content

of interest. The patient overview picture shows the patient's general personalia, a patient resumè, patient journal documents, requisitions, and actions that are planned or performed for the patient.

Furthermore, Patient Desktop gives the user access the laboratory sheet. *The laboratory sheet* presents the results from laboratory analyses of tests on the patient. The user can view the results in a table, print the sheet, view both requisitions and test results individually, and the test results marked in a graph.

The desktop also provides the user with functionality for planning of patient treatment, and follow up of incidents and the treatment. Planning involves placing orders for patient related actions, treatment, and tests to be performed. Follow-up is related to access to patient all kinds of patient information. This provides support for decision-making regarding further treatment of the patient.

Figure 7.7: Clinical Portal



Chapter 8

Order and Results

This chapter describes Clinical Portal's functional support for ordering of tests performed by the clinical chemistry laboratory and retrieval these tests' results. It will also present the working context at Rikshospitalet in terms of working environment and work processes. We will refer to the clinical chemistry laboratory by the name used by Rikshospitalet, the development team and the portal. That is *MBK* which stands for *medical biochemistry*. When we refer directly to a component in portal pages, for instance, a button or a tag, we will use the Norwegian name that is used in the portal page preceeded by the English translation in parentheses the first time the component is referred to. The various desktops of the portal will be referred to using the English name as done in chapter 7.

8.1 Order Tests From MBK

As mentioned earlier, Clinical Portal provides the user with functionality for ordering tests performed by MBK. This functionality is intended to replace the paper-based system used at the hospital today. The paper-based system for ordering tests from MBK is based on the checkbox form presented in appendix C. Medical secretaries' and physicians' deployment of the paper-based system is described in the subsection 8.1.1. The portal implements its own version of the form in the *Patient Desktop*. The checkbox form implementation involves of three steps called *Valg* (options), *Detaljer* (details), and *Oppsummering* (summary) distributed over three portal pages, and functionality for both *registration of orders*, *drafting*, and *planning of future orders*. The portal pages are presented in the subsection 8.1.3. The objectives defined by Rikshospitalet for Clinical Portal's checkbox form implementation are given in the list below [Kri05b].

- Quick completion of order of test from the clinical chemistry laboratory.

- Easy to get an overview of, and choose from, the analyses that the clinical chemistry laboratory offers.

- Easy to add and remove analyses from a package or self-defined orders.

- Leave room for future implementations, where more information is included e.g laboratory manual and supplementary information per analysis.

The subsections of this section are based on interviews and observations of users. As mentioned in chapter 5, it was impossible for us to observe the functionality for ordering test results in use at the hospital because it was not implemented in the hospital's wards and departments jet. Consequently, we have to relay on interviews with the users. In our discussion of results retrieval we will limit our focus to laboratory sheet in the Patient Desktop. The reason for this limitation is, as mentioned in chapter 5, that we was informed by representatives from the development team that this functionality was especially challenging to implement in an user-friendly way because of the heavy information load in the laboratory sheet. The laboratory is rolled out in some of the wards at the hospital, which made it possible for us to its usage in practice. Our discussion this functionality is therefore based on user observation and user interviews carried out at the users location.

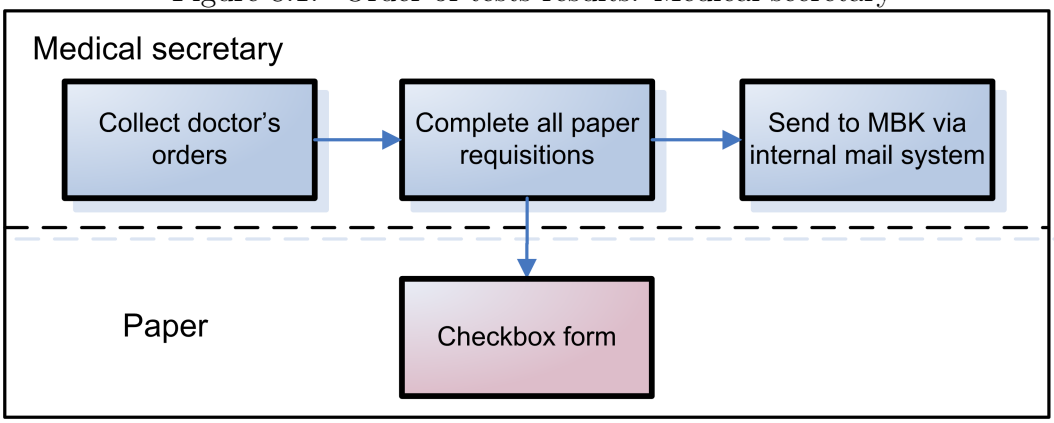
8.1.1 Usage of the Paper-Based System

We will describe the process of ordering from two points of view, physicians and medical secretaries. This is a relevant distinction because these two groups represent those who give orders, and those who carry out orders, respectively. Furthermore, we will also highlight some of the differences that exist between various departments.

The Medical Secretary

Figure 8.1 is an illustration of the tasks carried out by the medical secretary at a ward with in-patients when he/she orders tests to be performed by MBK.

Figure 8.1: Order of tests results: Medical secretary



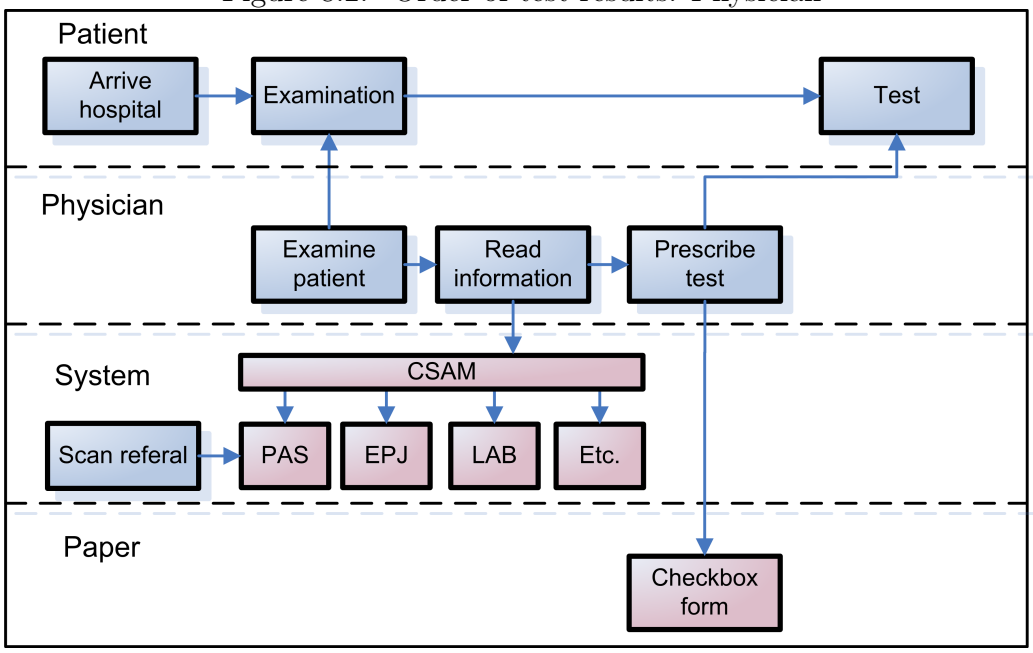
As described in chapter 6, the medical secretary is usually carried out for ordering tests on the basis of a physicians wants at the clinical departments. At the departments with out-patients it is normally the physician who carries out this task. Below we have outlined how a medical secretary order a test from the MBK as described to us by employees at the dermatological department. This process is performed after the doctor has visited the patients at their beds and made notes on further treatment and needed analyses. The doctor has left notes, or marked checkbox forms, regarding needed analyses in the patients' file at the patients' beds.

The secretary starts with going out to the patients' beds and collecting all the notes made and forms filled out by the doctor regarding needed analyses. Back at the office, he/she completes one checkbox form per patient with the patient personalia, information about the requisitioner, details about his/her wants, and so on. He/she can retrieve information about the patient from the portal, which fetches this information from the systems PAS and DocuLive. The doctor might have written the orders directly into an checkbox form. Generally, the requested analyses are written down on the a piece of paper called *kurven*, which means *the curve*. In these situations, the medical secretary must mark the wanted analyses in the checkbox form. When the form is completed, the secretary sends all the requisitions to MBK through the intern mailing system at the hospital.

Order Tests: Physician

Figure 8.2 is an illustration of the tasks carried out by the physician at an out-patient department when he/she orders tests to be performed by MBK.

Figure 8.2: Order of test results: Physician



In chapter 6, we described how the physicians are responsible for prescribing treatment of patients. It is, as stated above, usually only at the out-patient department doctors are carry out the ordering of tests themselves. In other departments the doctors only give orders, and the carrying out of the ordering is left to nurses or medical secretaries. Doctors' standard procedure for ordering tests results from MBK is outlined below. Our description is based on our interview with an employee at the dermatological department.

Prior to or during the session the physician might need to read information concerning the patient, his/her condition, and the sessions agenda. This kind of information was earlier distributed among separate source systems. Today (March 2006) it is available through the portal. The physician starts the session with interviewing and examining the patient. He/she then considers the patient's history, condition, and progress on the basis of the interview, examination, and information about the patient retrieved from the portal, and prescribes further treatment. The physician might enter notes regarding his/her decisions into the system during the consultation. Given that the patient's condition requires more tests to be taken, the physician writes the order for tests on the (paper) checkbox form and gives it to the patient. Then the patient him-/herself takes the form to MBK's visitor's laboratory. When the consultation is over, the physician enters

his/her findings from the interview and examination of the patient, as well as his/her decisions regarding further treatment, into the portal. The physician might read a dictate to his/her secretary, who enters these into the portal for the him/her to save the his/her time.

8.1.2 Discussion of the Paper-Based System

There are many issues that influence the efficiency of this paper-based system. The issues presented to us by the users as well as representatives from the IT department at Rikshospitalet are highlighted and discussed in this subsection.

Several wards have special profiles with MBK analyses. These profiles denotes a set of analyses often prescribed jointly. One example is the TKAX, which is designed for transplanted patients at the thorax surgical department [Bre06]. This solution saves time when filling out the checkbox form as only one check mark is needed. The form has four of these profiles as standard, in addition there are three blank spaces. These can be used to order any known profile. The form is read electronically by a text-recognition machine.

A strength of th paper-based system is the way the checkbox form's structured. As mentioned above, the analyses are grouped into profiles or packages on the basis of which analyses are normally ordered jointly. The most common analyses are present on the checkbox form, and when combined with the blank spaces, it is a powerful and flexible tool for efficient test ordering. This makes it possible to mark and select several analyses in one move and saves time for the person completing the form. Furthermore, the checkbox form consists of only one A4 format page. This provides the user with a manageable information load and a manageable number of choices and performances in association with the individual orders. This structure makes it possible for the person who is completing the form to do this within a few seconds. Efficient routines is imperative for health personnel. Physicians have a tight schedule because of the number of his/her patients and must be very efficient in his/her work. The medical secretary carry out their described process for the patients in their ward up to several times a day. Only a few seconds added to the time it takes to complete each of the forms will accumulate to considerable additional time spent each day. As described in chapter 6, time is a scarce resource, and this additional time is time that the health personal don't have.

As mentioned before, the main reason for implementing the portal is to reduce the paper load at the hospital and, in the longer term, make the hospital paper independent. The ordering of test results produces a lot of paper. MBK receives

approximately 200 000 requisitions a year. In the paper-based system, all of these requisitions are written on paper, yielding 200 000 sheets of A4 format sheets. Apparently, the paper production of the hospital can be reduces significantly if the requisitions could be ordered electronically through Clinical Portal.

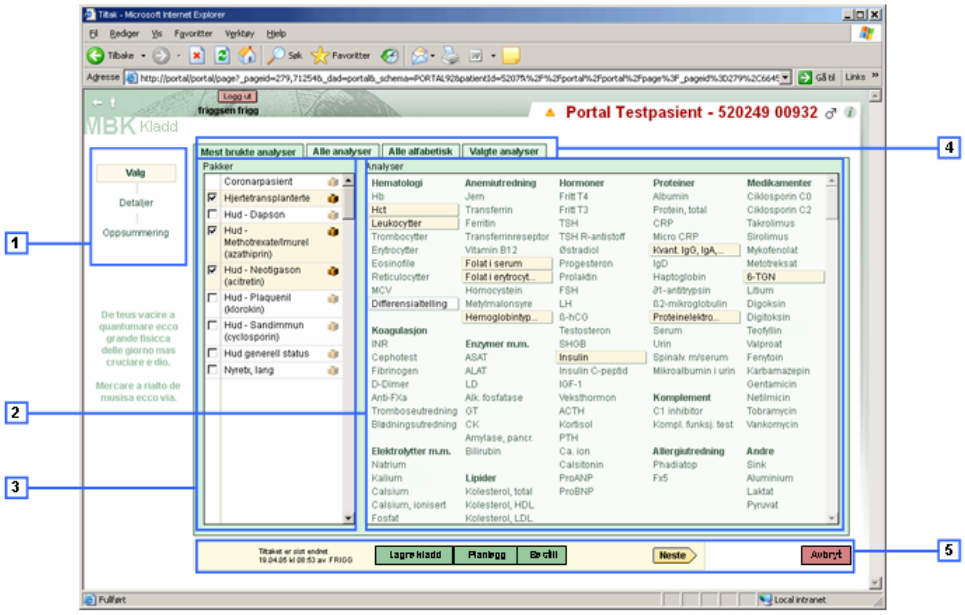
8.1.3 Clinical Portal's Checkbox Form Implementation

This subsection and its subsections present the portal's implementation of the checkbox form. Section 8.1.3, 8.1.3, and 8.1.3 present the three portal pages that constitute the checkbox form implementation. Section 8.1.4 present users' comments and response to the implementation.

Options: Register Wanted Analyses

Figure 8.3 present a sketch of the portal page that constitute the first step of the checkbox form.

Figure 8.3: Register wanted analyses



The portal page that the figure 8.3 illustrate support the selection of test analyses to be ordered from MBK. The interface consists of the following parts:

1. **Navigation Path** gives the user a presentation the logical relation between the three steps that the implementation of the check box form consists of. It highlights the user's current location. Each of the alternatives in the path, *Valg* (Options), *Detaljer* (Details), and *Oppsummering*(Summary), reflect one specific step in the process of test ordering. Furthermore, the feature facilitates quick and simple navigation. If the user presses one of these buttons, he/she will take the user to the corresponding step.

2. **Analyser** (Analyses) consists of the 100 most ordered individual analyses, sorted by category. When the user touches an analysis with the navigation arrow, the analysis' full name and the test material for this kind of analysis is shown.

3. **Analysepakker** (Analyse packages) shoes the analysis packages, or profiles, mentioned in chapter 8. When a package is chosen, the corresponding analyses are highlighted in the *Analyser* (Analyses) box. If the package contains an analysis that is not among the most common analyses, it will still appear in the *Analyser* (Analyses) box.

4. **Tabs** indicate other possible views of the available analyses. *Alle analyser* (All analyses) shows all analyses sorted by category, *Alle alfabetisk* (All alfabetical) shows all analyses in alphabetic order, independent of category, and *Valgte analyser* (Chosen analyses) shows only the analyses already chosen by the user.

5. **Buttons** lets the user choose between 5 alternatives: *Lagre* (Save), *Planlegg* (Plan), *Bestill* (Order), *Neste* (Next) and *Avbryt* (Cancel).

The user can selects analyses by choosing a package of analyses from the list of analysis packages, or choosing individual analyses directly from the list of analyses. When the user has selected the wanted analyses, he/she can proceed to the next portal page, *Detaljer* (Details), by pressing the *Neste* (Next) button, or choosing *Detaljer* (Details) in the menu at the left side of the page.

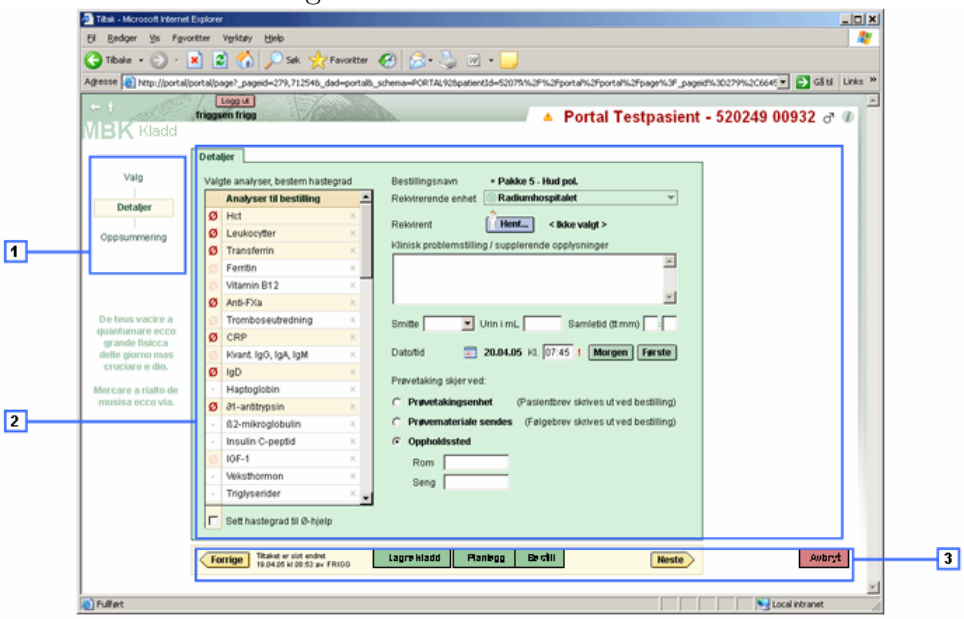
The status of the order is indicated by the headline in the upper right corner. If the user presses the button *MBK Kladd* (Draft) the draft, the order's status is changed to *MBK Planlagt* (Planned). He/she can send the requisition by pressing *Bestill* (Order). Then the *Oppsummering* (Summary) page will be shown. If all the required data is registered for the order, the status of the order will be changed to *MBK Planlagt* (MBK Planned) or *MBK Sendt* (MBK Sent), respectively. If the user presses *Avbryt* (Cancel) or *Planlegg* (Plan), he/she will be taken to context she was in when he/she entered the checkbox from. Furthermore, if the user

pressed *Planlegg* (Plan), the requistion's status is changed to *MBK Planlagt* (MBK Planned), and the requisition will be put into the patient's activity plan and the responsible doctors list of examinations in the *Clinical Desktop*. The user can't change its status back to *Kladd* (Draft) when it has been set to *MBK Planlagt* (MBK Planned) or *MBK Sendt* (MBK Sendt).

Details: Set Order Details

Figure 8.4 present a sketch of second portal page and step in the checkbox form.

Figure 8.4: Set Order Details



1. **Navigation Path** identical to the one described above.

2. **Detaljer** (Details) shows all the selected analyses, with a possibility to mark them as urgent. In the middle of the page, there is an area reserved for entering other details about the order, such as time, responsible person, and so on. The empty space at the far right is left open for future use.

3. **Buttons** identical to the ones described above.

This page is used for registration of the order's details such as urgency and requisitioner. The user can define how urgent the individual analyses are by

selecting the Ø-symbol. A dark red Ø indicates that the analysis is set as urgent. The user can register all the analyses as urgent by marking the checkbox below the list of analyses. Furthermore, the user can define a new requisition name if she has composed the set of analyses that constitute the order herself. He/She is also asked to specify the requisition unit, requisitioner, and the remaining details as can be seen in the sketch.

The user can navigate back and forth in the cross form path by pressing the buttons *Forrige* (Back) and *Neste* (Next). When the user can proceed in the cross form path by pressing the *Oppsummering* (Summary) in the left-side menu, or by press the buttons *Lagre* (Save), *Planlegg* (Plan), *Bestill* (Order), or *Neste* (Next). This will bring him/her to the *Oppsummering* (Summary) page sketched in figure 8.5.

Summary: Confirm and Send the Order

Figure 8.5: Send the order

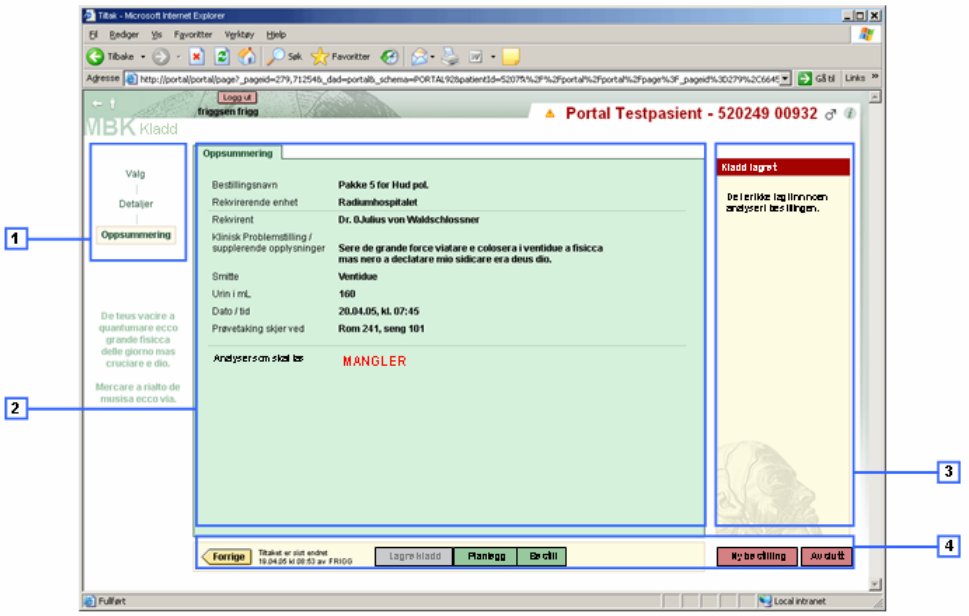
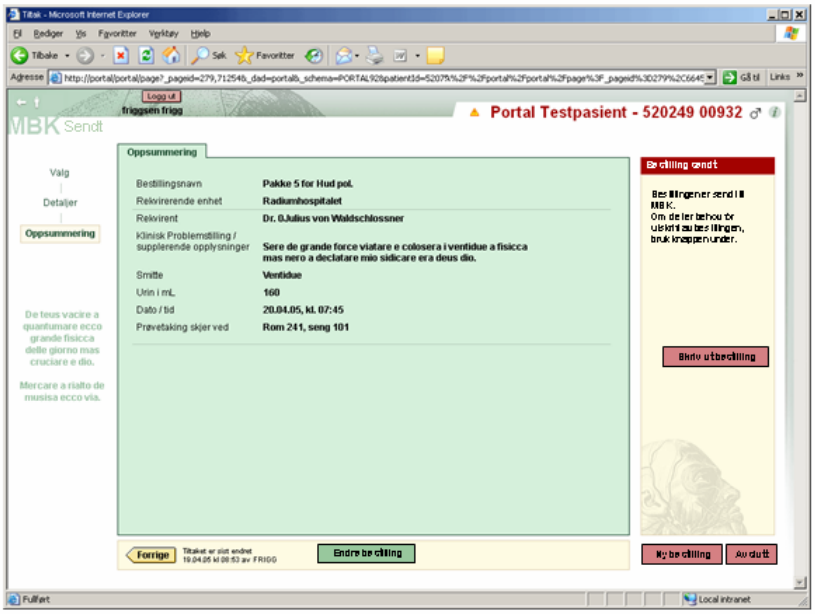


Figure 8.5 present a sketch of the third portal page in the checkbox form. It shows a summary of the information registered for the order, and presents the user with feedback on the registered information and the status of the order.

1. **Navigation Path** identical to the one described above.
2. **Oppsummering** (Summary) shows a summary of all details registered for the order.
3. **Status area** shows the status of the order, in addition to any potential error messages.
4. **Buttons** identical to the ones described above.

Incorrect information registration is indicated by the notion *Mangler* (Missing) written in red at the missing information's intended position in the portal page. Additionally, any wants are described in the left section of the page. The user can navigate back to the previous pages to fill in the requested information by aid of the *Forrige* (Back) button or by selecting *Valg* (Options) or *Detaljer* (Details) from the guide menu at the left side of the portal. When the checkbox form is filled out correctly, the user can save the order as a draft, change the requistion's status to *MBK Planlagt* (MBK Planlagt), or send the order. If the user chooses to save or to send the order, he/she can either perform a *Ny bestilling* (New order) or *Avslutt* (Exit). If the order is sent, the portal page illustrated by the sketch in figure 8.6, is shown. The order's status has been changed to *MBK Sendt* (MBK Sent). There are also two other buttons, offering the associated functionality *Endre bestillingen* (Change the order) or *Skriv ut* (Print out).

Figure 8.6: Confirmation of a sent order



8.1.4 The Users' Comments on the Portal's Checkbox Form

The portal pages that we have described in the preceding subsubsections was tested during the user tests that we observed the 16th and 17 of February 2006. We will present the users comments below. These comments will be further discussed in our analysis.

The Logical Configuration of the Portal Pages

The users had difficulties in finding the buttons, textfields, checkboxes, or other user interface components they were looking for. They looked for the components were they thought it was logical to place them. For instance, a number of users looked for the functionality to register immediate help near by the buttons for registering time for test performance, *Første*(First) and *Morgen*(Morning), without success. Furthermore, considerable number of user's didn't see that the status of the order was changed from *Kladd* (Draft) to *Sendt* (Sent), or the information concerning which specimen the test was performed on. This information was placed in the headline in the upper left corner of the portal pages. The location of this information was possibly unlogical to the users.

The Logical Relation Between the Portal Pages

There were also confusion in association with the logical relation between the portal pages that constitute the steps in the checkbox form path. When the users pressed the button *Bestill* (Order) in the *Valg* (Options) portal page, they were sent to the *Oppsummering* (Summary) portal page and received the message that they couldn't order because the order missed required information. The missing information had not been requested by the checkbox form earlier because when the user presses *Bestill* (Order), he/she is sent directly from *Valg* (Options) to *Oppsummering* (Summary), skipping the *Detaljer* (Details) portal page, where the information is requested. Therefore, the users were confused by this want. Next, when the user pressed the *Forrige* (Back) button, they were sent to the *Detaljer* (Details) portal page. This made the users even more confused because they was expecting to arrive at a page that they had entered previously. Presumably, the users expected to be sent to the portal page, *Valg* (Options).

Lastly, after completing the checkbox form and sending it, some of the users were insecure if they had performed the task correctly, and if the order had been sent. As mentioned above, they didn't see the headline with the order's status change.

Some of the users, expressed that they expected to be sent out of the checkbox form path and get a confirmation that, in a way that could be misinterpreted or overseen, stated that the order was sent successfully.

The checkbox form path had an illustration of the navigation path and logical relation between the portal pages at the left side of the portal page's main portlet. The comments made by the users during the test indicates that they didn't spot this illustrations.

Feedback

The users participating in the user test made use of the feedback provided by the portal in various degrees. Some of the users read the tooltips and system messages, while other just ignored the text, even in dialog boxes. However, several of the users announced for more and clearer feedback from the portal. Especially in association with completion of tasks were the users insecure if they had performed the task correctly. Some of the users said that they wanted a clearly stated and glaring confirmation of concerning either the order written in the checkbox form was successfully sent or not. Furthermore, there were announcements for tooltip text staying visible for a longer period of time, and for symbolization of system processing, for instance, in terms of a hourglass, which is a symbol used by the operative system *Microsoft*, known by most users.

Terminology

Some users who participated in the user tests was commented the terminology of Clinical Portal. Both a doctor, a dermatologist, and a nurse (the last two from the polyclinic) the characterized the term *tiltaksregistrering* as strange and/or unfamiliar. In addition, the doctor was unfamiliar with the term *MBK*. These comments may be indications on invidious and poorly customized terminology in the portal.

Efficiency in Use

Some of the users were concerned with the portal's efficiency in use. Efficiency in use may be regarded as a result of both the portal's performance and how fast or easily the users can perform their work tasks when these are supported by the portal. The users' comments regarded number of keystrokes and maneuvering mechanisms in the portal. A medical secretary said that she misses the possibility of using keystrokes in stead of mouse-movements in the picture. Both this secretary and a dermatologist wanted default values in textfields.

8.2 Retrieval of Results from the Clinical Chemistry Laboratory (MBK)

In the lower right corner of the screen shot in figure 7.6, the test orders associated with the patient are listed. This list can be filtrated in different ways to achieve the wanted combination of system performance and information load. The heavier information load, the poorer performance.

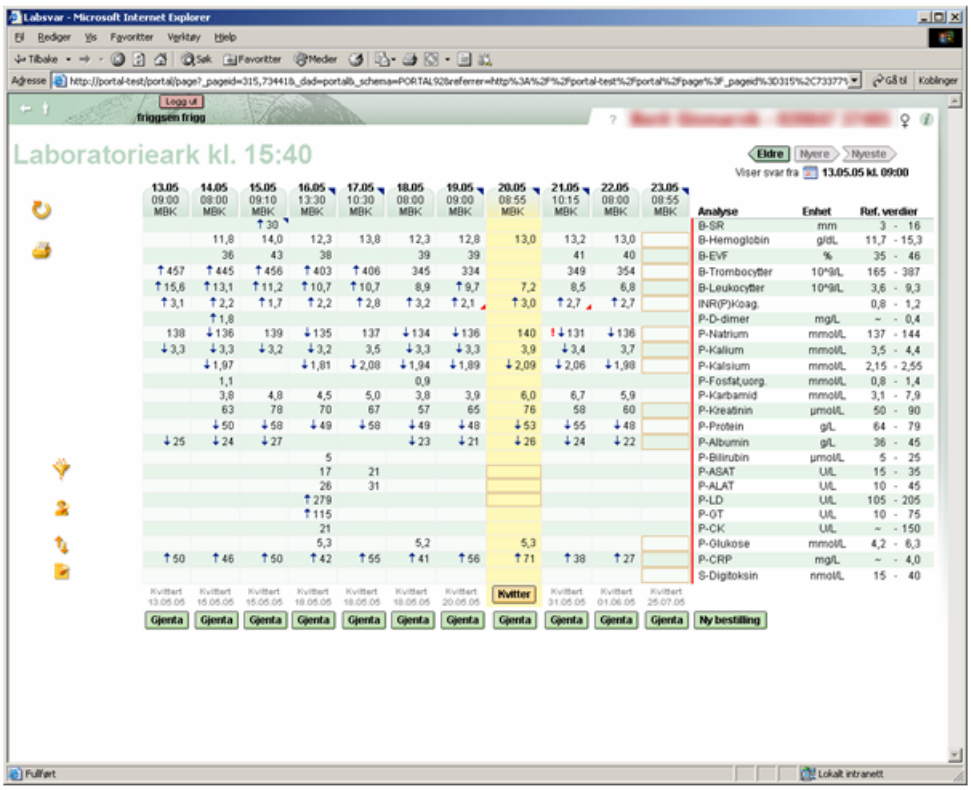
The user can access the accumulated answers from MBK, IMM, KOAG and the patient-close analyses (PCA) from the patient overview picture. Figure 8.7 is a sketch of the portal page that presents these analysis. The page shows the eleven last analyses associated with the patient in a sheet that we will refer to as the *laboratory sheet*. The columns represents orders for test analyses, and the rows show test analyses and results.

The icons at the left side of the table can be used to adjust the information in laboratory sheet. The user can update the table to retrieve newly arrived answers from server, or adjust the information load in the sheet by aid of information filtration and hiding. Filtration will restrict the sheet to containing only certain kinds of analyses. Patient-close analyses (PCA) and markings for high and low values can be hidden. This will result in a laboratory sheet with information restricted to analyses performed by MBK, IMM and KOAG, and only shows the actual values without markings. Furthermore, the user can print the answers being viewed by the user or the total set of answers.

The cells in the laboratory sheet have markings. Some of these are intended to alert the user about values that are alarming in relation to its reference area and/or related test results. Others reflect that there is a comment associated with the test result value, or that the comment has been changed. Furthermore, test results in parenthesis are temporary, and framed cells represent tests that have been ordered, but an answer has not yet been received.

The analyses are also marked according to whether the results have been signed or not. Unsigned results have an yellow background and the statement *Ukvittert* (Unsigned) is presented in red below the result's column. Users with the required rights can sign/acknowledge test results in the table. This is done by simply pressing the *Kvitter* (Sign) button associated with the test result to be signed. This changes the status of the test result from *Ukvittert* (Unsigned) to *Kvittert* (Signed), the *Kvittert* button and the yellow background disappears.

Figure 8.7: Accumulated answers from MBK, IMM, KOAG and PCA



The user can select one of the cells in the sheet to view the details of the analyses associated with the cell. The resulting picture contains all the available information about the chosen analysis with history, including details about the order, the test, the analysis, and the answer [Kri05b]. The analysis type and point in time that the test was done is shown at the top of the picture [Kri05b].

When the user selects the top of a column, the details of the order are shown. The headline of the picture that the user is lead to next, presents information about the material, time for the test, and the performing laboratory.

If the user selects the name of an analysis in the laboratory sheet, she is presented with a graphical illustration of test results associated with the analysis.

Test results can also be found in the user's Clinical Desktop. This is found under when choosing *Undersøkelser* (Examinations) in the menu at the left side of the

Clinical Desktop's main/center frame. In the *Undersøkelser* (Examinations) portal page, all the users' patients and their examinations are listed. The list can be filtered according to which ward the examination was performed by, which ward the patient belong to, and which ward is the requisitioner/orderer, as well as time for the examination, and responsible doctor.

8.2.1 Receiving Results from the Clinical Chemistry Laboratory

This section will describe the usage of test results by the two same occupational roles as above; medical secretary and physician. The description is based on our interviews and observations at Rikshospitalet, as well as the work of Bente Brevig [Bre06].

Receive Test Results: Medical Secretary

When the results are available, the medical secretaries have two options. They can either retrieve the results from the ward system EROS, the old system for retrieving test results, or use Clinical Portal. EROS shows just one result at a time, while Clinical Portal shows a laboratory sheet with all analyses performed on that patient. This functionality was described earlier in this chapter, in section 8.2. It is possible to see the results of just one test within the laboratory sheet as well, but there is no *Skriv ut* (Print) function. Some they felt the EROS system was easier to use, as they only needed the results one by one, and printed out, which only is possible in EROS. They also felt they used a lot of time navigating around the Clinical Portal, before they could find the laboratory sheet.

Receive Test Results: Physician

When the results have come from MBK, they will appear as *UKvittert* (Unsigned), until the responsible doctor has marked them as signed. This functionality is there to ensure that all results are being noticed. However, this leads to extra work for the physicians, as they have to mark the analyses one by one, patient by patient. The users of this functionality has expressed a way to do this more efficiently, in order to not use more time than with the paper system. Before clinical portal, they received a stack of paper with results on. They would then sit down, and really quickly decided on which results were normal, and which were not. All normal were thrown away without further ado, while the abnormal ones were signed end followed up. It is the ability of quickly filtrating out the normal results the physicians wants. But as we described in chapter 6, there are differences not only between occupational groups, but also between wards. The limits to what is

normal or not depends entirely on the patient, hence normal values for a patient that has had a kidney transplant, would probably be totally off the scale for a normal person.

The portal provides good opportunities to view many results at a time, and also a graphical representation of them. This feature facilitates seeing trends in the patient's development.

8.2.2 The Users' Comments on the Laboratory Sheet

During our interviews with the users, both a nurse and a doctor expressed wants associated with the laboratory sheet. The nurse (from the dermatologist ward) stated that Clinical Portal doesn't customize the presentation and the functionality associated with laboratory answers as well as the system she is used to, EROS, does. The laboratory sheet presents **all** the test results for the chosen patient at once as depicted in figure 8.7. The answers are shown in a table with order in the columns, analyses in the rows, and answers in the cells. This is helpful for a doctor because it provides him/her with the information need to see trends in the patients results that indicate the patients progress. However, nurses usually only need the individual answers from the tests.

The doctor, mentioned above, also expressed the need for functionality for transferring of laboratory answers/results from the laboratory sheet to the patient's journal in DocuLive. He needed this information to write about the patient's progress, reaction treatment, and reason for decisions. The lack of functional support to transfer these answers results in the doctor using a *work-around*. He uses the *copy-paste* functionality supported by the operative system, Microsoft. Described in detail, this means that he marks the wanted answer in the laboratory sheet, copies it, enter the patient's journal in DocuLive, and pastes the answer in to the journal. However, he finds this work-around very cumbersome and unsafe because there is a chance that he might paste the test result of one patient into the journal of another patient. Such mistake can have serious consequences.

8.2.3 The Laboratory's Test Analyses

This subsection describes briefly what happens at the laboratory after a test order has been received. The check box form is interpreted electronically by a scanner, which enters the information on the form into the IT system used at the laboratory (NetLab). Next the nurses visit the patients at their beds and take the requested test specimens according to the doctor's requisition. The test specimen is brought back to the laboratory, where it is analyzed. When the analyses are preformed, the

results are entered into the laboratory IT system (NetLab). If the requisitioning ward both use Clinical Portal, the results will immediately be made available and ready for signing by the requisitioner in the laboratory sheet. Clinical Portal namely retrieves the test results from the laboratory IT system (NetLab). If they don't use the portal, the test results must be collected and sent back to the requisitioning ward through the internal mailing system at the hospital. In the requisitioning ward, the test results are put in the requisitioner's mail box for signing. At the polyclinic, the internal mailing system is not used, and test specimen is taken when the patient visits the laboratory after his/her appointment with the physician. Depending on who long time the analysis takes, the test results are either reported to the physician and patient after a few minutes, or the laboratory reports it to the physician when the analysis is complete. On the basis of the test results, the physician decides on the further treatment of the patient.

8.3 Other User Comments and Observations

During the user test and interviews we also received explicit comments that do not apply directly to either the checkbox form implementation nor the laboratory sheet. These comments and observations will be presented in this section. The first subsection presents general comments from the users indicating a certain implicit resistance to change among the users. The second subsection presents the necessity of total coverage of the work of the medical workers.

8.3.1 Resistance to Change

The users was concerned for the duration of the transitional period and how well the portal will be able to support their work processes in comparison with their paper-based facilities. The users expressed an awareness of the decreased efficiency associated with periods of transition in when replacing one system with another. However, they stated that their positivity to the portal depended on how long it would take before the portal could increase the users' and hospital's efficiency. The users wasn't convinced that the portal was a good solution if it the duration of the transitional period turned out to be too long. What they meant by *too long*, is unfortunately not known by us.

Regarding the portal's ability to support the work processes better than paper-based journals and documentation, the users agreed that Rikshospitalet is too paper-dependent. The hospital can't hold on to an continually growing amount of paper. It results in paper literally falling down in the heads of the hospital's employees. However, the routines associated with paper seems to be so effective

and well-incorporated into the some of the users' working day that not all the users regarded *a paperless hospital* as the best solution. In the contrary, some of them argued that some of the paper-based work processes should be kept because they meant that computer-based systems could not support these processes as efficiently as paper.

8.3.2 Necessity of Totality

The effective and well-incorporated routines associated with paper-based order and retrieval of test results, and the resistance to change, give application systems, in general, small chances of implementing functionality that will make these processes more efficient. We talked to a doctor working part-time at the IT department of Rikshospitalet to be involved in the development of Clinical Portal. He stated the following:

> *It will* always *take longer time to complete an electronic check box form than a paper-based form.*

When dealing with an application system, the user may have to perform more actions to complete the process than when performing the same process with paper-based facilities. For order and retrieval of MBK test results are one of the processes that this statement pass for. The process actor, who previously completed a check box form in a few seconds, have to log on to a the system, navigate to the portal pages that implement the check box form, complete the check box form as required by the application system's implementation of it, and perform supplementary actions such as pressing confirmation buttons and the similar. Applications leave little room for negligence and inaccuracy caused by stress and time-scarcity that often occur at hospitals. When taking all of this into consideration, the total completion time (and complexity) of one single test order is considerably increased when the user is using any computer-based checkbox form than when he/she is using the paper-based check box form. This is why functionality supplementary to main applications/services in Clinical Portal is a condition for increased efficiency and profit from the implementation of the portal. *To increase the users' efficiency, the (portal) system must increase the efficiency of the total working situation of the user, as well as provide gains for the user's environment, Rikshospitalet*, stated the doctor mentioned above. Consequently, Clinical Portal must function as its users' *computer desktop*. This means that it has to support its users through their entire working day and in all possible working processes. No other information systems should be needed by the the medical workers at Rikshospitalet after the implementation and deployment of Clinical Portal is completed. The users can retrieve information and use applications provided by both Clinical Portal's underlying systems after logging onto the portal

once. Both clinical and non-clinical application and information systems can be launched from the portal. Accordingly, the user doesn't have to log off Clinical Portal to, for instance, write an e-mail or use an Internet browser. It will all be launched through the portal. Furthermore, the new functionality and services are developed on the portal's service layer will improve the portal's ability to provide efficient support for all possible working processes performed by its users during their working day.

Part IV

Analysis and Conclusion

Chapter 9

Analysis and Discussion

In this chapter we will analyze and discuss the findings from our case study at Rikshospitalet. We will start with a discussion of the heavy content load of the portal pages, in order to answer our first research question, outlined in the introduction. As described in chapter 4, excessive information typically has a negative influence on the user support of application systems, and we wish to establish how this is the case in Clinical Portal. Further, we will analyze the possibility of improving the user support by applying theory on tailoring of information systems, in order to answer our second research question. The dilemma concerning local variants versus one global standard of the portal's functionality and information presentation will be debated. We will discuss the factors that both promote and advise against a tailoring of the portal, as an attempt to answer our third research question.

9.1 Navigation in Excessive Information

Prior to the implementation of Clinical Portal, the personnel at Rikshospitalet were using a combination of various information systems to support their work. These systems could be paper-based, computer-based, or involving both. The computer-based systems had a rather restricted functionality, and provided a limited amount of information. Typically, the computer-based systems were developed by various supplier and independently purchased by individual departments. The systems delivered by different suppliers tended to be poorly integrated. Accordingly, the systems in the system portfolio had an autonomous characteristic, and each system's scope, in terms of users, functionality, and information provided, was restricted. Consequently, the personnel used different subsets of Rikshospitalet's system portfolio related to their various responsibilities and departmental belonging. Because the many of systems used were poorly integrated,

the users had to constantly switch between various applications in order to register, retrieve, or compare information provided by the various systems. This could be both cumbersome and inefficient. Even so, these systems may have been perceived as easy-to-understand and easy-to-use by the users because of the restricted scope of each system, mentioned above.

Distribution of functionality and information on a number of autonomous systems yields limited contribution to the value-chain of the enterprise, and, consequently, poorer value to the customer [Has00] [Moo01]. Even if hospitals are stand out from other enterprises as particularly complex organizations with very heterogenous users, usage contexts, and processes, hospitals are not by any means excepted from this argument. Hasselbring states the following.

> *To support the intraorganizational business processes within organizations effectively, the existing information systems must be integrated [Has00].*

Hospitals are not excepted form this argument. They have the objective to provide value to its the patients and their relatives, who are the customers of hospital's services. As stated in the strategy program, Te@mwork 2007, the information flow in Norwegian hospital's shall be enhanced to provide the enterprise's customers, the patients, with services that are perceived as continuous [Nor04]. Gunnar Ellingsen argue the following.

> *The existence of [...] specialist systems indicates that there is a need for a certain functionality that is missing in the EPR, especially at the larger hospitals, which are extremely specialized and complex [Ell02].*

This points to the need for a higher degree of integration between the various systems at a hospital is the key to achieve value creation. Clinical Portal is, as earlier described, an effort to do this. It integrates existing hospital systems using the SOA approach. The portal's ability to provide its user with the information and services he/she needs in a coherent way is a crucial quality of the portal. The physician cited in section 8.3.2 stated the following during our meeting.

> *When Clinical Portal covers all the medical work processes related to information retrieval and registration at the hospital, the portal will yield value to and increase the efficiency of both the individual user and the hospital.*

The portal offers the functionality and information access equal to the sum of all of its source systems, in addition to several new services integrated in its

service layer. This results in a considerable amount of services and information that all shall be presented by one single application system. The transition from several, autonomous user interfaces to an all-inclusive one single portal, may be challenging for the users. The users may perceive the portal pages as unaccustomed, complex and overloaded with content. Because of Clinical Portal's total amount of information and services, it may be more challenging for the users to follow and more time consuming to navigate in. Some of the participators in the user tests expressed that it took too many 'clicks' to attain their target information or service when navigating in the portal Some also stated that they experienced a feeling of going astray while navigating through the portal pages. The latter is a well-known problem in larger information spaces [Nie95].

The portal is intended to fulfill requirements of a huge and heterogenous user mass in terms of offered services and information. Simultaneously, it must restrict the total amount of portal pages to cope with the challenges associated with navigation, mentioned above. This is what Zazelenchuk et al., cited in section 4.3, refers to as *the paradox of information quantity*. The heterogeneity of the users, the scope of the portal, and the navigation issue, may result in the portal pages overwhelming its users with information and features. As described in chapter 8, the users had problems locating buttons and features in the portal pages. According to Heidi Collins and Zazelenchuk et al., cited in chapter 3, this may be caused by an overwhelming picture [Col03] [ZB03]. Collins states that the information load in a portal page mustn't be too heavy because this may cause the users getting lost in the page [Col03].

On the basis of this reasoning it seems that the distribution of information and features on the portal pages is challenges the portal's user support. If the content is distributed on too many pages, the users go astray while navigating through the pages. If the content is restricted to a limited number of pages, the amount of content in each page can become overwhelming. We will in the following sections point to characteristics of the user mass that affects the content of the portal pages. These factors will be highly regarded when identifying an approach for increasing the user support of the portal.

9.1.1 Diverse Needs

Clinical Portal's users are characterized by a high level of heterogeneity and they work in a very complex organization with various complex work processes and a high information consume. These characteristics are some of the main challenges associated with hospital information systems, and probably the main reasons for the high amount of information and functionality in the portal. Below we

will exemplify the heterogeneity of the users information and functionality needs, and show how this can lead to excessive information in the portal pages, and cumbersome navigation. Our examples are based on diversity in physicians' and nurses' needs in relation to laboratory results.

Differences in Information Needs

An example of a rather standardized information presentation in Clinical Portal is the *laboratory sheet* shown in figure 8.7. The user can personalize and manage the information load by turning filters for PNA-results and for notifications of exceptional results on and off. Beyond this the picture presents the laboratory analyses results the same way for all user groups. Our interviews with medical personnel at Rikshospitalet stated that nurses and doctors have quite different needs and interests in relation to the laboratory results. The doctors reads the sheet mainly to see trends in the analyses results and the patient's progress. The laboratory sheet allow for this need by presenting the results related to the patient in both a table and a graph. This visualizes the trends and progress of the patient very well. Nurses, on the other hand, are typically more interested in the individual test results. We were told by a nurse that, the individual results are, for instance, transferred to reports for research projects, or for kinds of routine work related to follow-up of the result. The portal user can select individual laboratory results or requisitions, and view the result or requisition details, respectively. However, the nurses must make additional actions to view the information they need in terms of selecting and clicking on a requisition column or result cell. This may be misinterpreted as insignificant extra work or actions. We must keep in mind the characteristics of hospital work; resource scarcity, time pressure, and complicated work processes, as well as the user test participants' comments on the number of clicks they had to perform to attain their target.

Differences in Functionality Needs

The functionality related to the order and retrieval of test results from MBK has is also rather standardized. By functionality, we refer to applications, buttons, and other portal components that offer some kind of functionality. We will base this discussion on the functionality related to generation of print-outs of laboratory results as we received many comments on this. The portal implements print-out functionality for the laboratory sheet only. This may be caused by the fact that the portal is intended to contribute to the hospital's paper-independence. However, the nurses and physicians we talked to expressed a want for print-outs. Print-outs of laboratory results are still needed to be put in patients' map for the stay. For this purpose, the laboratory sheet can be printed. However, as mentioned in section

9.1.1, the user can click on a laboratory answer or a requisition in the laboratory sheet, to view a picture of details of the laboratory results, or the requisition, respectively. These detailed pictures are not provided with print-out functionality as the laboratory sheet is. A nurse we talked to at the dermatology department told us that she wanted a print-out of the individual laboratory answers of the reasons described in section 9.1.1. The fact that the portal doesn't provide her with this functionality is enough for her personally to prefer EROS over Clinical Portal, she said. EROS provides her with plain and structured presentations and print-outs of the individual laboratory answers.

9.2 Factors Influencing the Feasibility of Customization

As mentioned earlier, Clinical Portal uses role-based access to restrict the set of information and services accessible to each individual user. These access rights are first and foremost related to security objectives. This is an imperative issue as the system handles confidential patient information. However, the technology and data possessed by the portal in association with role-based access opens a door to opportunities that probably can be taken one step further.

In chapter 3, we presented theory regarding approaches to design of application systems with large and heterogenous user masses and associated functional requirements. Based on the section 9.1.1, we argue that Clinical Portal's user mass have this characteristic. State-of-the-art literature and researchers within the field of software development suggests that adding more functionality not necessarily will establish universality [RM02]. Parallel or multi-representational forms, or variants, are required when facing incompatible information or data structures among users [sta94].

As described in section 8.2.2 *The Users' Comments on the Laboratory Sheet*, Rikshospitalet's solution of today implement functionality and show information in a more or less standardized fashion. The diversity in the pictures is mainly determined by the users' role-based access rights and settings registered for filtration mechanisms related to lists. The user's access rights see to that the content that the user don't have access to, is made unclickable or not shown, depending on if it is functionality or information, respectively. Users with all access rights preserved, are potentially shown all content, including the content he/she don't necessarily need, in a universal way. Typically, this is the case for physicians, who are an user group with many preserved access rights. However,

on the basis of our observations, the physicians tend to be impatient when they use the portal. Their work is very time-efficient and they have to regard a lot of information to make the right decisions, as well as be involved with the treatment of many patients during one working day. They need to retrieve the right information quickly, and may be hampered by high information loads caused by their extensive access rights.

The factors mentioned above suggests that customization of the portal interface based on the development of several parallel variants could be fruitful. The users could be classified, for instance, on the basis of their functional requirements, and variants could be developed for each identified class, or group, of users. However, as mentioned in the introduction of this chapter, there are many factors influencing the possibility of a customization. We will in the following present such factors, both in positive and negative direction. First, we will discuss factors that encourage the development of portal variants, such as the users' IT-experience, their attitudes towards IT-systems at the hospital, and qualities of the portal technology. Then we will look at factors that challenge the development of variants of the portal.

9.2.1 The Users' IT Experience

As stated in section 6.2.5, nearly all the users of Clinical Portal daily use some kind of computer-based information systems. In their daily work, they have been using mainly department-specific applications. These applications are, as mentioned earlier, developed for the special field of health care and the specific responsibilities of the individual user group situated at the department where the system is employed. The user groups that these systems have to please, have less differences in their characteristics than the total mass of Clinical Portal users. The confined diversity in user characteristics make it easier for the developers of the department-specific systems to manage the customization their applications systems. Consequently, many of Clinical Portal's users are used to well customized application systems. This can make them challenging for the portal to please.

All the users who participated in the user test have experience with online money banks and some of them uses e-commerce. E-commerce often employ a step-wise functionality implementation similar to the one in the checkbox form implementation in the portal. Accordingly, this kind of functionality is familiar to some of the users. However, even if the users have experience with both application systems and Internet applications, their IT experience is limited. They don't have an in-depth knowledge or experience with technology and computer. This, and the argumentation in the first section of this subsection, suggests that there is a

need for customization of the portal to make the portal easy to understand and easy to use. The argumentation in the last passage encourage the development of variants of the portal because such variants could be well customized for the specific characteristic of the individual user's user group in terms of departmental belonging and responsibilities. Probably, the transition from department-specific application systems to a portal with local variants would be softer than the transition to a global portal.

9.2.2 Time-Limitations

As described in section 6.2.6, time is an extremely valuable resource at Rikshospitalet. It must be spent in an efficient way. This place great demands on both the hospital's employees and infrastructure. Particularly, the performance, user support, and availability of Clinical Portal will be critical for its users. The users needs efficient work process support, and they must be given the information they are looking for within reasonable time [BHR03]. Accordingly, retrieval, location and interpretation of the required information must be performed quickly, when and where ever they need it. Customized local variants may make it possible to see to that the information and functionality most critical and most frequently used by the variants user group is prioritized and particularly easy to attain. This may improve the portals offer the users efficient work process support.

9.2.3 Patient Focus

As mentioned earlier, a number of the users stated that they want to spend as little time as possible in front of a computer. They stated that their emphasis patient treatment and inter-human processes, not computer work. Therefore, they require easy-to-learn and easy-to-understand portal pages. The development of local variants that are well customized for the individual user groups could possibly increase the user support and efficiency in use for all of these groups individually. Also in association with the handling the patient focus of the users, the approach to variant development mentioned in section 9.2.2 could be employed.

9.2.4 The Portal Technology

Role based access and *personalization* is recognized as one of the most central qualities of portal technology. As mentioned in chapter 4, *Integration and Portal Technology*, the role and presentation features focus on access, and is based on the role of the knowledge worker, and the worker's responsibilities and preferences [Col03]. Role features determine the content offered to the user based on the access rights of the user's role, while personalization complement the role features

and concerns the user's personal organization and preferred presentation of the offered content [Col03]. Furthermore, both the content and the presentation can be personalized. Personalization of content concerns *which* content the user wants to be presented, and is, naturally, restricted by the user's access rights. Presentation personalization concerns *how* this content is presented [Col03]. As pointed out by Heidi Collins cited in chapter 4, a portal that provides its users' personal organization and preferred presentation of the content made available is more likely to continue to be accessed and used [Col03]. This indicates that the portal technology provide good possibilities for better customization of the portal.

9.2.5 Users Time-Limitations and Requirements Elicitation

As mentioned above, Clinical Portal's users are very busy and their focus is on the patients. They tend to be positive to the portal and a more paper-independent hospital, but, as Bente Brevig pointed out, the users rarely have time to participate on the sessions for development of the portal requirements [Bre06]. This was also acknowledged by representatives and members of the portal development team when we visited them. They told us that it wasn't always just easy to get the users to attend user test sessions because they of their time-limitations and focus on the patients and their responsibilities at the hospital. We experienced this when a few of the users who was signed up for the user test in February didn't show up.

Bente Brevig stated that when only a few users were participating in the development of the portal, the diversity in the user mass was not sufficiently visible [Bre06]. With a only a few users participating in the sessions, only the needs, preferences, and requirements of the specific user groups these users belong to, are represented and can be considered. This increases the risk of missing out on other user groups needs and requirement and, consequently, the risk of a portal design that is not satisfactorily customized for user groups that were not represented at the related sessions [Bre06].

As Bente Brevig described, Rikshospitalet had to initiate alternative methods for eliciting the users requirements to the portal [Bre06]. The meetings had to be better adjusted to the users' time schedule, and ad-hoc meetings and interviews with the users at their location were issued. This aspect might be source of even more problems in the case of a system with local variants, as it would multiply with the number of user groups.

9.2.6 Increased cost and complexity

As any other software development team, that of Clinical Portal has limited resources in terms of time, economy, and human resources. Both the project itself and its resource availability is influenced by both internal and external actors. Chapter described how the development of IT within the Norwegian health and social sector has been influenced by factors that are hard to control through the years. It is presumable that portal development is object for similar influence in terms of competition, strategy programs, and external actors. Among influential actors are the management of the customer organization, the project's owners, and competing projects. Stakeholders and their influence on the project may at times be, so to speak, impossible to predict or to control. Therefore, there can be surprises along the way. This makes it important to distribute the resources of the project carefully. Many theories on this topic are developed. The traditional methods (ie. CPM, PERT, Gantt, etc.) developed from 1910 to 1950s typically relay on intermediate due-dates. One of the innovators within the field of project management, Eliyahu M. Goldratt, has introduced the *critical chain project management*. This is built upon his *theory of constraints* [Gol97], and uses *buffer management* instead of intermediate due-dates to protect the final due-date [Gol97]. However, all project management practices seems to agree that projects has to distribute its resources carefully. Priorizations and sacrifices have to be made to cope with challenges and risks.

Developing several parallel variants of the portal functionality can be consume a lot of resources. We have already presented the users' lack of time to participated in the development process. Additionally, the time resources of the system developers is restricted. Furthermore, hiring more staff is expensive. The implementation of some number of local variants will require an equivalent amount of development resources. The complexity of the portal and its architecture may increase by the implementation of variants. The performance of the system in terms of response-time may get poorer due to more complex logic associated with various variants for various user groups. According to Zazelenchuk et al. the efficiency in use influences the users' satisfaction [ZB03]. Accordingly, there is a possibility that the implementation of variants may have an negative influence with the portal's user support.

9.3 Balancing the Local and the Global

In the previous sections we have analyzed our findings at Rikshospitalet, and identified several aspects that point towards the need for local variants. We have

also presented aspects and factors that limit the development project's ability to implement several variants. These pros and cons in relation to implementation of several local variants, indicate the challenge of landing on a suitable balance between the local and the global approaches. This issue relates itself strongly to the discussion of the adequate granularity when dividing the user mass into user groups. Whether an application system should have several local variants or one global standard depends on the need for, and the feasibility of, customization. If the user groups have quite similar characteristics and needs, the need for classification of the user mass and customization to the individual user groups is limited. The following passages discusses the balancing of variant implementation.

If too few user groups are defined, the implementation may be too standardized. In result, the benefit from implementation of different variants of the features can not be fully derived. This provides little improvement in relation to having one global standard. Accordingly, the resources spent on using a few classifications and implementing each of the variants related to each category, don't yield a satisfactory return. As Bowker and Star argued, an insufficient number of categories will result in a system so general that it is not useful [sta94]. On the other hand, with few categories, or user groups, and corresponding number of variants of the portal features, the portal logic would probably not increase much in complexity and, consequently, the performance would not be significantly hindered. Additionally, the implementation of only a few variants may lead to less error and maintenance cost than if a range of variants were implemented. It can also be easier for the developers to manage a few as opposed to a range of variants. The probability of mix-ups and confusion is correspondingly low. The requirements identification can take up less time from the developers and medical personnel when only a few variants are implemented, hence keep costs at a lower level.

If there are too many categories, or user groups, and associated variants, the portal logic can become very complex. As mentioned above, this may affect the performance of the system negatively. As indicated by users and representatives from the development project, performance is one of Clinical Portal's most critical quality attributes. A range of variants could also cause confusion of the various implementations and user groups, as mentioned above. This can result in errors, delayed release dates, and require costly coordination work. Consequently, the implementation of several well-customized variants may come at a correspondingly high price. Based on this discussion one may say that the choice of the number of variants is influenced by several factors, and the final decision should based on careful consideration of each individual situation at question.

9.4 Resistance to Change

The main objective of the implementation of the portal is making the hospital paper-independent. Roughly speaking, this goal is reached when the hospital's information system involves fully computer-based, opposed to the partly paper/computer-based, information sources and work process support. The processes at the hospital has to change and finally relay on computer-based information systems only. The portal's functionality reflect the intention to make the medical work processes paper-independent by, for instance, involving restricted implementation of print-out functionality. To reach the main objective of the portal implementation, the requirement specification can't be dictated by the users' needs and wants. The functionality of the portal must implement and encourage the organizational change and process development that lies ahead.

The results of our interviews and observations from the user test, imply that the users are sceptical of this change and of the introduction of a completely paper-independent information system at the hospital. Some of the users explicitly stated that they were critical to the concept *paperless hospital*. They were positive to computer-supported work, but not all of them believed that computer systems alone can provide them with the working support that they need. Especially physicians expressed that an information system consisting of both paper- and computer-based information sources were preferable to fully computer-based information systems. The resistance to a paperless hospital was present among the nurses as well. This is represented by the nurse who would rather use EROS because it gave her satisfactory print-outs of the laboratory results. The preference for (at least partly) paper-based information systems indicate that paper seem to be associated with a certain degree of confidence.

Based on this reasoning it seems that the users are very sceptical of a completely computer-based information system in general. This may signify that the challenge of Rikshospitalet and the portal development team is not only, or even primarily, to develop a portal that makes the users satisfied. Possibly, the main challenge is to accustom the medical personnel to fully computer-based hospital information systems. The fact that the medical personnel oppose such systems to this extent, may mean that the personnel will not find any (completely) computer-based information system preferable to the (partly) paper-based information system they are used to. The resistance to computer-based information systems fully replacing the existing paper-prone information systems may make it considerably harder for Rikshospitalet to develop a portal that the users associate with satisfactory user support.

If our reasoning in the last passages reflects reality, it may be more profitable to invest in efforts to accustom the medical personnel/future users to paperless information systems and the new work processes such a system involve, instead of consuming resources on developing multiple variants that are customized according to the users' present-day needs. As the needed fully computer-based information system, and the medical work processes it involves, are introduced and employed at the hospital, the users' needs will possibly change. According to chapter 9.2.6, the personnel, the work practices and the information sources (paper or computer-based) at the hospital constitute a network. When something is withdrawn from or added to the network, the network effects will cause changes in the objects that remain in the network. The considerable difference between the existing paper-prone information sources at the hospital, and the new computer-based source, as well as the work practices associated with each of these two, indicate that the replacement possibly has strong influence on the only object that is not replaced in the network, the medical personnel. If the replacement of the information sources and the work practices does not try to maintain the third part as stable as possible, the personnel can response to the replacement in unforseen ways. A co-operative user mass will possibly react to the introduced changes in less hostile or surprising ways. Therefore, the user support and user-friendliness of the introduced computer-based system, Clinical Portal, is still of great importance to make the network transformation as smooth as possible.

The introduction of Clinical Portal is accordingly about making the users positive to the change and making them prefer the portal-based over the partly paper-based information system. The list filtration functionality is a quality of the portal-based information system that the partly paper-based information system do not possess. Consequently, further utilization and implementation of this functionality can have possibly increase the likability of the portal recognized among the users.

Chapter 10

Conclusion and Further Work

In the previous chapter, we analyzed and discussed the findings of our case study of Clinical Portal, developed at RR HE. In this chapter we will present our conclusions and our suggestions for further research and work.

10.1 Conclusion

Our analysis and discussion indicate that benefits may be derived from increased customization of Clinical Portal in general, and implementation of more variants, in particular. Such variants could increase the user support of the portal, for instance, by lowering the content load in each portal page. As described earlier, portal technology very much encourage this kind of customization. However, the implementation of several variants may also result in higher costs, as well as increased system complexity and lowered performance. Additionally, there tends to be a resistance among the medical personnel towards completely paperless information systems and the new medical work processes such a system involves. This possibly signifies that accustomation of the users to computer-based information system is just as, and maybe even more, important than customization and implementation of portal variants to meet the users' present-day needs.

It is usually harder to delegate resources to user support initiatives, as opposed to functionality initiatives, due to difficulty of measuring possible future gains caused by these initiatives. However, the implemented filtration functionality in Clinical Portal is an initiative to increase the user support. We regard this as a very valuable feature. Consequently, we believe continued expanding of this functionality is a profitable way to improve user support. This approach will decrease the information load at a lower cost than creating several implementations of certain functionality.

As new work processes are introduced and employed at the hospital, the users' needs will possibly change. The strategy outlined above could help both user support and cost to stay at a reasonable level, until the paperless work processes has gained foothold at the hospital. Functionality customization in terms of variants might become interesting to explore further in future releases when the users' needs in relation to the paperless medical work processes have evolved. In such future releases, the implementation variants should be considered due to its ability to support the diversity in HIS' user mass. The iterative development technique used by the project team [Bre06], would make this possible.

On a general basis, we still feel that the idea of customization is very interesting. Not just allowing for local variants to emerge, but to take it one step further, and actually design multiple variants of a system, is an approach that should be further elaborated. The increasing popularity of portal technology, which facilitates this approach, is a hint that customization is very much wanted by the users. The major challenge, as in the case of Clinical Portal, would be to balance the customization with the potential increased cost of resources.

10.2 Further Work

This work has been restricted in time to only 5 months, and during that time, several issues have emerged, to which we do not have had the possibility to find an answer. However, we find these subjects interesting, and will leave it to be explored in future work.

The first topic concern how to make users prefer a computerized system over a paper-based one. We have a theory that even the most user-friendly system is not enough, and that other factors influencing their attitude towards the system should be further explored.

A second issue regards how to calculate the ideal level of customization. We have in this work only been able to suggest a rough strategy, due to lacking inside information about the project, including the budget. However, given this information, is it possible to produce guidelines that could aid project managers in making the decision?

A third subject we would have liked to elaborate more on, relates to how, given a decision to make multiple parallel variants, one should decide the granularity of

the user groups. The solution must aim at achieving the ideal level of homogeneity, without spending to much of the resources of the project.

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Appendix

Appendix A

User Tests

This appendix presents our observations from the user tests performed at the IT department of Rikshospitalet 16th and 17th February 2006.
Table A describes the first user and table A.

Task	**User action**
Task 1	Comments the term *tiltaksregistrering* as unfamiliar and "a strange word". Completes the task.
Task 2	Completes the task.
Task 3	Comments that she seldom orders analysis. She can't find the chosen analyses in the list.
Task 4	Can't find *Ø-hjelp*. Tries to set it before *Change analyses*.
Task 5	Chooses correctly the antibiotics that all the bacteria are sensitive to.
Task 6	Completes the task.
Task 7	Chooses *Children clinic* and tics on the roentgen icon, which causes the icon to turn be turned off. This is illustrated by the icon turning from color to black-and-white.
Task 8	Completes the task.
User's comments on the test	She recognizes the functionality related to *Hent undersøkelser* as the functionality that is changed most. Is positive to the opportunity to get the clicical consultations that the doctor have had, also further back in time. *Ø-hjelp* is most difficult, and *Finne inneliggende i tidsrom* is not evident enough.

Table A.2: Test performence by user nr. 1

Subject	**User description**
Personlia	Woman, nurse at the policlinic at Rikshospitalet.
Clinical Portal	Some knowledge. Have been working with a test version only. Will be an instructor during the courses in DocuLive and Clinical Portal.
Other programs	RIS, SwissLab, May and MS Windows applications such as Word.
Internet	Internet money bank. Not daily.
Comments	She misses the opportunity to book roentgen appoitntments in SwissLab. This is possible for blood test. It is practical to be able to print out appointments to the patient before he or se leaves after an appointment, even if the next appointment is months ahead in time. It seems like the patient enjoys being given an appointment in this way.

Table A.1: Description of user nr. 1

Question	The user's answer
1	She is positive and expects her collegues to also be positive and mature for a new version.
2	She belives in efficiency improvement because they don't have to use multiple systems independently of eachother and identify the patient once for each system. In the Clinical Portal the user can choose the patient and have chosen patient as the basis for further work.
3	She is very positive to Clinical Portal's ability to make the hospital less paper-prone in an adequate way. This among other because there will be spent less time on folding and sending of letters. This kind of work can now be channeled to secretaries. Nurses can consentrate on nursing rather than paper/secretary work. Further more, it will be easier to document work and catch patient journals from "everywhere" and document comments and notes during for example telephone conversations.
4	She thinks the doctors will have to make the biggest work routine changes, and doesn't think she will have negative experiences in connection with change work routines when starting to use the new version of Clinical Portal.
Other	She is glad that Rikshospitalet drives the development project of this system because she thinks this will make it easier for the users to report and get changes and wishes realized.

Table A.3: Interview with user nr. 1

Subject	User description
Personlia	Man, doctor at Rikshospitalet.
Clinical Portal	Daily.
Other programs	Eros, DocuLive and MS Windows applications such as Word, Excel.
Internet	Daily; e-mail, online medical reference books, e-commerce.
Comments	Experienced Internet user.

Table A.4: Description of user nr. 2

Task	User action
Task 1	He tries to do a patient search on the first part of the patient's personal identification number. There is no functionality for this kind of search. Also, this user is unfamiliar with the term *tiltaksregistrering*. He isn't familiar with the term *MBK* either. Completes the task.
Task 2	He misses default values for planning of MBK, and questions the difference between the button texts *Neste* and *Første*. Completes.
Task 3	*Pasientskrivebord*, *Tiltak*-tab. The user has great confidence in that the system will tell him if something is wrong or values etc are missing.
Task 4	He wishes that it was possible to go directly from *MBK-bestilling* to other kinds of orders, but doesn't choose the *Back*-button directly. Misses checkpoint-boxes, brighter colours, group division of functionality. Selects analyses that can't be set to *Ø-hjelp* and orders without *Ø-hjelp*.
Task 5	Comments that it should be evident what kind of secretion that is used in the tests. Completes.
Task 6	Selects *Enhet*; Thoraxkirurgisk avdeling, then *Undersøkelser* and *Rekvirerende enhet* (and then ordering). He asks if own department is shown frist in the list.
Task 7	Sets *Pasientenhet* to *Barneklinikken*, selects *Dato, inneliggende* and sets the date. Tics on the roentgen-icon and the *Oppdater*-button. He doesn't understand how the list is filtrated and comments that patient are scattered around without regards of requisition unit.
Task 8	Doesn't understand that you have to click the page away.

Table A.5: Test performence by user nr. 2

User's comments on the test	He says that the order of the finished/delivered analyses should be grouped to avoid unnecessary scrolling. He advertises for the opportunity to do patient searches on the basis of parts of the personal identification number. Generally, he is conserned with manoevring and number of keystrokes, as well as logical grouping. He comments that it should be, possible, logical and easy to fetch answers from laboratory into the patient journal. There is no functionality that supports this in the system to day; the user has to write the answers manually or by copy-paste from the laboratory result page to DocuLive. Furthermore, he wants a *macro*. Information for transfer: column shows the requisitions; fetch the analysis' name, comments and date easily and fast. There is a security issue associated with such an information copy and paste. There is a chance that the doctor copies the information on the analysis from one patient in Clinical Portal and paste it into the journal of another patient in DocuLive. He misses an agile way to navigate between the Clinical Portal, DocuLive and the roentgen system on the basis of a patient. Today the systems work asynchronously of eachother and the user has to fetch and keep track of the patient in each of the systems independently. This, causes a redundancy in work and possibility for inconsistency. Furthermore, these three systems gives the user three kinds of independent sets of data to relate to; roentgen and labortatory results and the patient journal. Synchronization between these systems could lower the risk of faulty copy-paste-actions and make the manouvering between the three data sets more efficient.

Table A.6: Test performence by user nr. 2

Question	The user's answer
Generally	This user are generally more critical and doubtfull regarding Critical Portal and whether it will increase efficiency. He is also more demanding.
Increased efficiency	Recognizes the balance between how long the users have to work suboptimally and the quality of the new system.
Lowered paper-pronity	Questions how poor the hospital should be in paper and how paper-poor it is adequate to make the work performed here. Many paper-based routines have been evolved and are incorporated into the everyday work at the hospital. It is often more efficient to draw curves etc. on paper, and notes on paper are often easier to get an overview over.

Table A.7: Interview with user nr. 2

Subject	User description
Personlia	Female, surgeon, Rikshospitalet.
Clinical Portal	Uses CP as little as possible, not even for signing.
Other programs	Uses DocuLive (for roentgen), Pax and PIMS daily. Used *IMX Lege* when she worked on Gjøvik.
Internet	Internet, Riksnett often, as well as online medical reference books; online money bank and e-commerce.
Comments	Discontented with the fact that the user has to enter multiple systems to get a total overview of the system.

Table A.8: Description of user nr. 3

Task	**User action**
Task 1	Confronts the search in the menu at the left in the GUI, is thrown to the *Pasientsøk* and finds this functionality cumbersome. Selects *Tiltak*. Task completed.
Task 2	Clicks *Ny MBK-bestilling*, selects a package and clicks on *Planlegg*, which brings her to the interface for *Oppsummering*. She is insecure if this was a correct move.
Task 3	Clicks on the *Ny bestilling*-button on the *Oppsummering*-interface. Completes the task, but finds it cumbersome and says that she never performes analysis orderings herself.
Task 4	Looks for the functionality for marking *Ø-hjelp* near by the *Første* and *Neste*-buttons. Can't find it.
Task 5	Chooses correctly the antibiotics that all the bacteria are sensitive to.
Task 6	Completes the task.
Task 7	Sets*Pasientenhet* to *Barneklinikken* and tics on the roentgen icon. Can't find out how to set the date. Task completion failed.
Task 8	Selects *Polikliniske konsultasjoner* and sets the date by navigating in the calendar by means of the mouse. Comments that she is doesn't know why she didn't find this functionality when performing the last task.

Table A.9: Test performence by user nr. 3

User's comments on the test	She doesn't order blood or other analysis from MBK because nurses normally do this kind of work. Furthermore, as a surgon she is more concerned with roentgen results. If she doesn't know what to do when she is using CP, she calls help desk. She is concerned with efficiency and the speed associated with the usage of the system. Therefore, she can get impatient if the pages are updated slowly. Thinks that there will be some frustration in connection with learning and understanding the new system in stead of just signing and treating patients.
Work routines and CP	Standard package is ordered by the nurses the day before the operation. She writes and reads patient journals and signs. Has her own post box/*My post box* that contains her jobs and tasks. Wants a similar function in CP. Mostly she uses *Kurven*. Reviews control tests. It is cumbersome to find the blood tests. Trusts the nurses and that they will write the test results out and see to that they are requisitioned. She admits that she wants to do office and paper work as fast as possible because her focus is on the patient.

Table A.10: Test performence by user nr. 3

Question	The user's answer
Generally	Impatient, focus on efficiency. Concerned with the confidence that paper gives.
Increased efficiency	She is critical to a new IT system because she fears frustrations associated with unknowned and hard-to-understand functionality and the inability to do tasks in an efficient way.
Lowered paper-pronity	Whether the shift to a new system will be serviceable depends on the transitional period. The system has to increase the efficiency considerably. Paper gives a certain confidence and is associated with many routines at the hospital. She finds it harder to trust IT-systems regarding whether they will do what you intend them to and what they say that they do. Has long-time experience with information systems consisting of paper and IT-systems working in parallell.

Table A.11: Interview with user nr. 3

Subject	User description
Personlia	Male, dermatologist, polyclinic.
Clinical Portal	-
Other programs	DocuLive, MS Office.
Internet	E-mail, online money bank, online medical reference books, e-commerce.

Table A.12: Description of user nr. 4

Task	User action
Task 1	The user is unfamiliar with the term *tiltaksregistrering*. Uses the *Pasientsøk* and searches on the basis of personal idenrification number, selects the user in the list, selects *Tiltak*. The task is completed, but the user is not sure if he has done as he was suppose to.
Task 2	Clicks the messages from the system without reading them multiple times. Comments that he doesn't have any experience with this task form earlier. Orders/Clicks on *Bestill* instead of *Lagre kladd*.
Task 3	OK.
Task 4	Thinks that *Tiltaksside* on *Pasientskrivebord* is confusing. Misses a better overview of the steps in the ordering process. Is confused by the two buttons *Bestill* and *Neste*. Finds the *Ø-hjelp*-checkpoint box, and assumes that he doesn't have to set the time for *ø-hjelp* analyses. Presses *Bestill* and the system advertises for date and time. The user regards this as meaningless.
Task 5	Chooses correctly the antibiotics that all the bacteria are sensitive to. He misses the annoncement of what kind of secretion that is used in the test, but likes the marking.
Task 6	This is not a familiar task. He sets *Pasientenhet* to *Thoraxkirurgisk avdeling* and updates the interface by means of the *Oppdater*-button.
Task 7	Sets*Pasientenhet* to *Barneklinikken* and tics on the roentgen icon, which causes it to be *turned off* and comments that the icon changes from coloured to black-and-white. Can't find out how to set the date. Doesn't read the system's message. Realizes that the icon that was clicked on is turned off and associated results are filtered out. He comments this as cumbersome. Does still not figure out how to set the date.
Task 8	Selects *Polikliniske konsultasjoner*, sets the date by navigating in the calendar by means of the mouse (using the «-buttons) and turns on all the filtering buttons.

Table A.13: Test performence by user nr. 4

Question	The user's answer
Generally	Positive.
Increased efficiency	He belives in increased efficiency in the longer term, but also thinks that the user-friendlieness of the interface needs further improvement.
Paper vacancy	He doubts how appropriate full paper vacancy is; what would happen if the system went down. He doesn't think there can be a total paper vacancy at a hospital, and is more confident in paper than IT systems.

Table A.15: Interview with user nr. 4

User's comments on the test	Many of the tasks he had to perform during the test would normally be performed by a nurse or secretary.
Work routines and CP	He is displeased with the automatic log out when the user is inactive. His work demands that he walks back and forth a lot, and when the system repeatedly throughs him out he doesn't want to bother using the portal. It is inconvenient that the user has to open CP before DocuLive, or open DocuLive via CP, to get the same patient in both systems. It isn't intuitive how to print results from blood tests. This is a very central functionality that should be easily available. The context sensitive log out causes automatic log on to the same interface as the user used the day before. Normally, you finish your today-task before you leave work. Therefore, a fresh start the next day is more useful. It should be possible to choose whether you want to do a context sensitive log on or not.

Table A.14: Test performence by user nr. 4

Subject	**User description**
Personlia	Male, dermatologist, polyclinic.
Clinical Portal	Daily, super user.
Other programs	DocuLive, MS Office, PIMS.
Internet	E-mail, online money bank, e-commerce.

Table A.16: Description of user nr. 5

Task	**User action**
Task 1	OK
Task 2	Tries to click on the package icon. Selects *Connarpasient* and *Planlegg*, and clicks on *Ny bestilling* in stead of *Forrige*.
Task 3	Don't *Send* -> opportunity for changing.
Task 4	Selects *Tiltaksområde*, searches by means of the search field below and marks the wanted analyses. She misses a curtain-menu for setting *ø-hjelp*. Writes *ø-hjelp ønskes* into the text box. Clicks on *Planlegg* and then *Endre analyser*. Now she sees the *Sett hastegrad til Ø-hjelp*-checkpoint.
Task 5	Chooses correctly the antibiotics that all the bacteria are sensitive to.
Task 6	She selects *Undersøkelser*, and sets *Pasientenhet* to *Thoraxkirurgisk avdeling* and updates the interface by means of the *Oppdater*-button. Reads the messages from the system.
Task 7	Selects *Fritt valg*, sets *Pasientenhet* to *Barneklinikken* clicks on the roentgen icon, finds *Velg dato, inneliggende* and turns off the blood test icon. Task completed correctly.
Task 8	Selects *Polikliniske konsultasjoner*, sets the date by navigating in the calendar by means of the mouse (using the <-buttons) and updates the interface. Test completed correctly.
User's comments on the test	Nothing in particular.
Work routines and CP	She comments a lack of consistency in the implementation of x-button for shutting windows. Would enjoy increased possibility for short-cuts implemented by keystrokes. Especially regarding printing of labels. Default values based on earlier used values would also be helpfull.

Table A.17: Test performence by user nr. 5

Question	The user's answer
Generally	Positive if there are improvements and the system works as it is supposed to.
Increased efficiency	She believes that the efficiency can be improved through increased support for keystrokes rather than just mouse navigation and that the system works properly. Further more, she sees the need for a safe back-up system for increased confident in the hospital's IT system.
Paper vacancy	She thinks paper vacancy can be implemented in the longer term.

Table A.18: Interview with user nr. 5

Subject	User description
Personlia	Male, Radiumhospitalet.
Clinical Portal	Nothing.
Other programs	SwissLab (not requisation), MS Office.
Internet	E-mail, online money bank, e-commerce.

Table A.19: Description of user nr. 6

Task	User action
Task 1	Selects the patient by clicking on it in *Pasientliste*, then he clicks on the *Tiltak*-button. Task completed.
Task 2	Selects *Ny MBK-bestilling*, marks the package and the *Planlegg-* button. Reads the tool-tip messages and the messages from the systems, and navigates well. Thinks the date and time setting is a little cumbersome because there are many and little intuitive buttons. Doesn't see the message saying that the MBK is planned successfully.
Task 3	Interprets *Tilbake* as meaning that he will get to the last interface or page, and is suprised when he arrives at the interface *Detaljer* when pressing *Tilbake* in the interface *Oppsummering*. He can't find the order from task 2. The task is not completed.
Task 4	Clicks on the *Ny MBK-bestilling*-button, selects analyses and presses the *Bestill*-button. He gets the system message that date and time isn't sett, clicks the *Forrige*-button and finds the *ø-hjelp-* checkpoint box. He comments that it is unlogical that not all analyses can be set to *ø-hjelp* because all the analyses are normally done at the same time.
Task 5	Sees the leadtext below the table after a while, misses colour code that symbolizes abundant and sparse growth. Further more, he finds it strange and unexpected that the material that is used in the test is given in the headline. Chooses correctly the antibiotics that all the bacteria are sensitive to.
Task 6	He misses a symbolization of system processing. Selects *Undersøkelser*, *Inneliggende*, *Thoraxkirurgisk avdeling* and detects that only roentgen results are shown in the list, but doesn't see which criteria are used to sort the results. Turns off the filtering on blood tests, which results in a presentation of blood test results as well as the roentgen results. Now he understands the filtration function.
Task 7	Selects *Undersøkelser* and *Inneliggende*, sets *Pasientenhet* to *Barneklinikken* and clicks on *Date* in the headline of the list, to sort on date.
Task 8	Turns off all filtration.

Table A.20: Test performence by user nr. 6

User's comments on the test	Did note the difference in colours on the different desktops, and understood their symbolization correctly. That is, that there is one colour for each desktop. He doesn't like the ripped-of face in the background of the desktops. Further more, he misses a hourglass that symbolizes that the system is processing. He thinks that there is too much disturbances and changes in the interface when he moves the mouse or arrow across it. He also comments that the helptext in the tooltip should be shown longer, and preferably for as long as the arrow/mouse is touching the icon or symbol.
Work routines and CP	No experience with CP.

Table A.21: Test performence by user nr. 6

Question	The user's answer
Generally	Positive. He finds using multiple programs in parallell and paper-based pasient journals only quite impractical.
Increased efficiency	He fears frustrations in connection with using a new, unfamiliar program and lack of confidence in the system. He also considers the security of the pasients as an issue. However, he belives the system will increase the contentment of the employees because it will make the working enviorment more modern and the system can potetially support their working routines and tasks better.
Paper vacancy	He agrees that CP can lower the paper-pronity considerably, but he emphasizes that paper is usefull and he doesn't think the hospital can manage without any kind of paper-based information and information systems. He belives that the best solution is a mix between paper and electronical information systems. Paper support some processes better than electronical system ever can. Therefore, it is practical to let these processes be infested with paper.

Table A.22: Interview with user nr. 6

Subject	User description
Personlia	Woman, Rikshospitalet's IT department, advisor and nurse in primary practice.
Clinical Portal	Testing, haven't worked with the portal as a nurse in practice.
Other programs	MS Office.
Internet	Online reference books and money banks, e-mail, e-commerce.

Table A.23: Description of user nr. 7

Task	User action
Task 1	Task completed without problems.
Task 2	Searches for the package on the basis of *conorar*, selects the package and fills in the scheme for MBK draft. Marks *Prøvematerialet sendes*, and presses the *Lagre*-button.
Task 3	Selects *Endre analyser*, and is brought to the interface called *Valg* in the *MBK Kladd* path. She adds analyses and presses the *Bestill*-button, and saves the changes in the *Oppsummering*-interface. She's not sure if the order were sendt.
Task 4	She starts with questioning how she gets back to the *Tiltak*-interface. She doesn't think the answer is intuitive. She clicks on the test tube icon and searches for *hemoglobin* in the search field underneath the icons, selects it and saves the order. Rest of the analyses she marks in *kryssearket*. She selects *Alle alfabetisk* and then *Valgte analyser*, and presses the *Planlegg*. The system responds that the date isn't set, and she presses the *Forrige*-button. She is suprised that she arrives at an unknown interface. She looks for the *Ø-hjelp* marking by the *Første* and *Morgen* buttons. Finally, she locates the *Ø-hjelp*-marking. She is insecure if the system registrates that she wants immediate assicatence even if she pushed the *Første*-button earlier. She is confident that the order were sendt when she reads the system message.
Task 5	Arrives quickly at the correct answer. She comments that in the last task the colour yellow was syonymous with that the object was selected. Therefore, she thought the marking in this colour was an indication that this was the correct choice, but in this interface green marks the sensitive antibiotics, and thereby, the correct choice.
Task 6	Selects *Undersøkelser*, *Inneliggende* and sets *Pasientenhet* to *Thoraxkirurgisk avdeling*. She notices that the list includes results from radiology only, and updates the interface. She understands the filtration function and activates all the filter icons by clicking on them, because she want to see all results.
Task 7	She sets *Pasientenhet* to *Barneklinikken*, selects *Fritt valg* and turns of icon for blood tests. Selects *Velg dato, undersøkelsestidspunkt* and sets the date.
Task 8	Sets the *Pasientenhet* to *Poliklinisk*, sets the calendar right and turns on all the icons. Then she updates the interface.
User's comments on the test	She suggests that it might be better to name the *Fritt valg* part of the interface, *Avansert*. She thinks that it is too anonymous that the order was sendt. Furthermore, it should be easy to get back to the *Tiltak*-main page.
Work routines and CP	No experience with CP.

Table A.28: Test performence by user nr. 8

Task	User action
Task 1	Orienate herself in the *Pasientliste*, then goes to *Pasientsøk* where she seeks for the patient on the basis of his/her name. She finds the patient and clicks on the *Tiltak*-button. Task completed.
Task 2	Presses the *Back*-button and reads the system message. Selects *Ny MBK-bestilling*, marks the package and clicks on the *Planlegg*-button without noticing that some information is missing in the scheme. Clicks on the *Forrige*-button and is suprised and disturbed because she doesn't recognize the interface she lands on as the *last interface*.
Task 3	Adds analyses to the order, but doesn't know what se is suppose to do next.
Task 4	Clicks on the *Ny MBK-bestilling*-button, selects analyses and presses the *Bestill*-button, but doesn't know what to do when she is sendt to the *Oppsummering*-interface. She understands that she has to go back to a previous interface to set the missing values, but doesn't know how to do this. Presses the *Forrige*-button and arrives on the *Detaljer*-interface, where she selects the *Ø* associated with each of the analyses, and comments that she thinks she has marked these as needing *Ø-hjelp*, or immediate assistance. She thinks the two buttons *Ny bestilling* and *Bestill* are confusing because it is hard to see the difference between their functions. She chooses *Ny bestilling*.
Task 5	She doesn't notice the helptext below the table. Therefore, she doesn't understand what R, I and S stands for. Then she sees the helptext, and decides to trust it and the values in the table. Still, she doesn't arrive at an answer, and doesn't complete the task.
Task 6	Selects *Undersøkelser*, sets *Pasientliste* to *Thoraxkirurgisk avdeling*. Bent asks her to go to *Undersøkelser* again. There she selects *Inneliggende*, *Thoraxkirurgisk avdeling* and *Fritt valg*.
Task 7	She fails this task. However, she reads the tooltip helptext.
Task 8	She fails this task, too.

Table A.24: Test performence by user nr. 7

User's comments on the test	When asked what she thought were difficult, she responds that there is a massive inforamtion load in the interface and she tries to see the logic in the user interface without success. Furthermore, she is stressed by the test setting. However, she thinks she lacks the basic training in practical usage of the system.
Work routines and CP	No experience with CP.

Table A.25: Test performence by user nr. 7

Task	**User action**
Task 1	Chooses *Pasientsøk*, fills in the whole personal identification number, selects the patient and presses the *Tiltak*-button. The task is completed, but she is insecure if she has completed it correctly.
Task 2	She uses the mouse/arrow when she reads. Searches for the package on the basis of *conorarpas*, marks *Bestill MBK* and selects *Bruk valgte*. Then, she exclaimed "Haven't I ordered any package?" and "Order? No, I want to plan." She thinks the package is ordered because she searched for *conorarpas* and because she marked *Bestill MBK*. She chooses the package and presses *Neste*, and then *Planlegg*. After a while she figures out that she has to save. She reads the system message *Planlagt lagret*. She comments that she expected to arrive at a new page/interface when the order were planned successfully. When this doesn't happen, she is insecure if the task was completed successfully.
Task 3	Adds analyses to the order and presses *Bestill*. When Bent asks *Have you ordered?*, she answeres *I miss a confirmation or the apperence of a new page that confirms that the order was sendt successfully*. Henriette tells me that the user did actually send the order. This is shown in the upper left corner. The headline *MBK Kladd* is changed to *MBK Bestilt*.
Task 4	She marks the analyses as *Ø-hjelp* by clicking the *Ø*-icon for the relevant analyses. Then she askes why time and date needs to be set for analyses that are marked as needing *Ø-hjelp*. She advertises for a more evident confirmation of successfull ordering.
Task 5	Task completed.
Task 6	Selects *Undersøkelser*, *Poliklinisk*, *Inneliggende* and sets *Pasientenhet* to *Thoraxkirurgisk avdeling*. She turns on all the icons to get all the results.
Task 7	Turns off all the icons, and turns radiology on. Selects *Fritt valg* and sets *Pasientenhet* to *Barneklinikken*. Then she chooses *Velg dato, inneliggende*, navigates well in the calendar and finds the right date.
Task 8	Turns on the icons, selects *Poliklinisk*, sets the calendar right and updates the interface.

Question	The user's answer
Generally	Positive.
Increased efficiency	She thinks good basic training is critical. A mentor should be available for the users for during the first period after implementation of the system in the hospital. She thinks the courses that are given as an basic education in system usage are too paramount. Super users of the systems should be appreciated.
Paper vacancy	She thinks the protal can lower paper-pronity in the hospitals, but has to little practical experience with it too comment this issue any further.
Other comments	She was very confused when she pressed the *Forrige*-button in the *Oppsummering*-interface during doing a MBK-order, and was lead to a interface she didn't recoginze. This made her confused and she didn't understand the logic between the interfaces. She missed a logic path, as well as a a symbilization of the logic between the interfaces that constitute the path for ordering of MBK analyses. Furthermore, she suggested that it should be possible to proceed in the path through the ordering if all of the mandatory information is given. When the user tries to proceed the textfields where the mandatory inforamtion is supposed to be filled in, should be highlighted with a notice that informs the user that the fields must be filled in. This kind of functionality is inspired by among other ordering of flight tickets.

Table A.26: Interview with user nr. 7

Subject	User description
Personlia	Woman, Rikshospitalet's IT department, advisor
Clinical Portal	
Other programs	MS Office.
Internet	Online money banks, e-mail, e-commerce.

Table A.27: Description of user nr. 8

Subject	User description
Personlia	Kvinne, Rikshospitalet's IT department, advisor with IT education (informatics).
Clinical Portal	Works with NetLab, has only played with CP for entertainment.
Other programs	MS Office.
Internet	Online money banks, e-mail, e-commerce.

Table A.29: Description of user nr. 9

User's comments on the test	She expects automatic update of the interface, and advertises for a more evident confirmation on the orders. She would prefer to arrive at a new page/interface, and out of the ordering path, when the order is sendt successfully. Furthermore, she thinks it would be practical with a list of all the orders with a status showing if the order is sendt or planned. When she selected *Bruk valgte*, she expected to get a package and that this would be a *conorar-MBK-order*.
Work routines and CP	No experience with CP.

Table A.31: Test performence by user nr. 9

Appendix B

National Functions Offered by Rikshospitalet-Radiumhospitalet HE

Table B.1 presents the national functions provided by RR HE.

Treatment of large hemangioms and vaskular malformations	Transsexualism	Advanced retransplantation surgery	Cochlea implant (artificial ear) with children
Reumasurgery with children	Organ transplantation	Perfusion chemotherapy	Autologous and allogenous stem cell transplantation
New-born screening of hypothyreosis and Føllings desease	Treatment of congenital hypoplastic left heart syndrome	Surgical arrhythmia treatment	Craniofacial surgery
Epilepsy surgery	Consideration of epilepsy surgery	Embolition of cerebral AV malformations	Consideration of patients with epilepsy and heavily handicapped patients
Rehabilitation of epilepsy patients	Elective haemophiliac surgery	Pelvic eccentration	Treatment of choriocarcinom

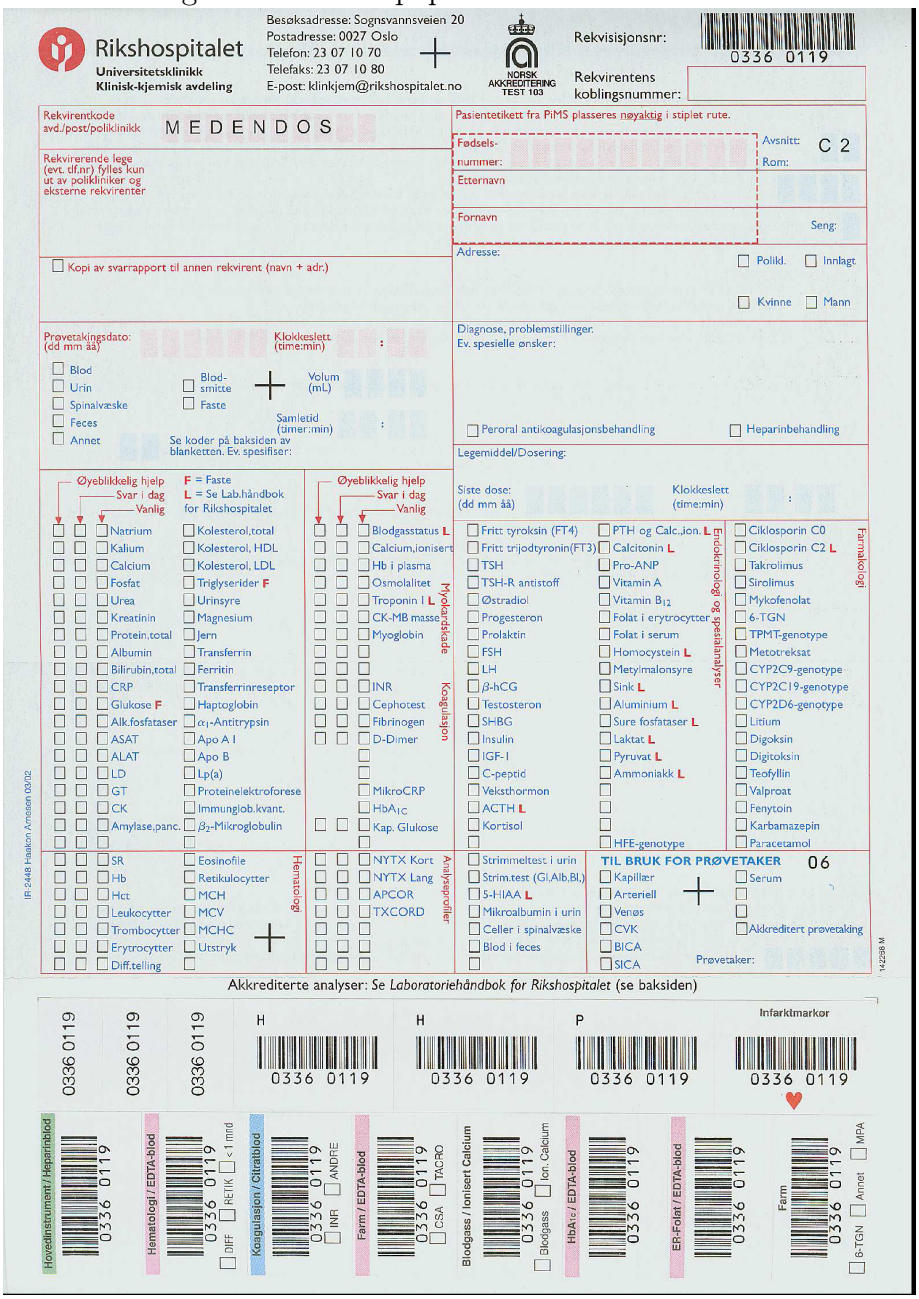
Table B.1: National functions offered by Rikshospitalet University Hospital [HF06]

Appendix C

The Paper Checkbox Form

Figure C.1 shows the paper-based checkbox form.

Figure C.1: The paper-based checkbox form



Appendix D

The National Health Plans

This appendix gives an extended introduction to the two national health strategy plans, *Say @!* and *Te@mwork 2007*, presented in chapter 9.2.6.

D.1 Say @!

This section presents the *Say @!* initiative plan and is based on the publication of this plan made by the Norwegian Ministry of Health and Social Affairs [Nor01]. The plan states the governmental initiatives for electronical interaction in the time period 2001 to 2003. Its purpose is to incite for electronical interaction that strengthen and increase the effectivity of the cooperation between various disciplines and administrative levels in the health and social affairs sector, enhances the contact with patients, those in need of nursing, and clients, and strengthen the quality of the services. In *Say @!* *electronical interaction* is defined as cooperation and information retrieval by means of information technology and suitable infrastructure for communication. The plan presents four priority areas. These are listed and described below.

National Health Network is the basis for electronic interaction between health personnel, and between health personnel and patients. It is based on a physical infrastructure with satisfactory capacity and coverage, and a set of basis services to arrange for interaction. It also concerns the insurance of data quality, information security, and personal protection.

Electronical Interaction in the Health and Social Affairs Sector involve central messages like physician referrals, epicrisis, and national insurance bills. The prioritized areas are the following.

- Standardization of important messages and electronical patient journals, and follow-up activities in relation to standardized solutions.

- Incentives for broad application of electronical interaction within the public health service, and between the public health service and the National Insurance Office.
- Evaluation and testing of solutions for electronic interaction for the nursing and care services and the social services.
- Information exchange and interaction between central registers, better information basis in the health service.

Tele Medicine is concerned with medical diagnostics and treatment in relation to the employment of digital information technology for patient information transmission. It has the following two prioritization.

- Stimulate for broadband expansion between the hospitals, and between the hospitals and the primary care, so that tele medicine even with demanding capacity needs can be employed in larger scale.
- Clarification of responsibility relationships, rules, guidelines, and taxes in relation to tele medical consultations.

General Public Service ensures a unified and quality assured supply of public health and social affairs information, and arrange for better Internet services for interaction between the general public and the health and social affairs personnel. The following two categories of initiatives are prioritized.

- Strengthened usage of the Internet as a canal for information and service contribution within the health and social affairs sector.
- Arrangement for electronical services for certain user groups (physically disabled, elderly, social affairs clients).

D.2 Teamwork 2007

This section presents the *Teamwork 2007* and is based on the Norwegian Ministry of Health and Social Affairs' presentation of it [Nor04]. Teamwork 2007 is the national strategy for IT development in the health and social affairs sector from 2004 to 2007. It is a continuance of the *Say @!* plan, and its vision is that patients and users encountering of the services shall be experienced as a unified and continual progress. Electronical cooperation and interaction in the sector is the strategy to realize this vision. The following two paragraphs present the two focuses of the strategy and the priority areas associated with these focuses.

D.2.1 Enhancement of information flow in the sector

To enhance the information flow, multiple focuses are stated. A complete and well-defined information basis must be established, and the national health network must be developed and managed by a nationally mutual organization. Furthermore, information security and data protection must be attended to by the implementation of an sector norm and a strategy and roll-out program for *Public Key Infrastructure*. The electronical patient record (EPR) must represent the whole patient progress, support cooperation through messaging and information sharing, the information in the EPR must be reused and be arranged for planning, management, research and quality enhancement, and the EPR must be able to give decision-support for health personnel through quality assurance of procedures, integration of guidelines based on expert knowledge and access to existing regulations. The dissemination of electronical messaging shall be consolidated through messaging standards and electronical session booking. Finally, expert knowledge must be easily accessible. For the last focus, the ministry suggests the establishment of a national Internet site.

D.2.2 Electronical interaction with new actors

Electronical interaction with users, patients, and relatives will facilitate a more unified and continual patient progress. The following strategies to realize this are relevant for the clinical portal: a Internet site with health and social affairs information, electronical cooperation between the patient and health personnel, self treatment in the patients homes. Furthermore, electronical prescriptions through the implementation of a standardized message for e-prescriptions to pharmacies. Finally, electronical cooperation between municipal health and social affairs service and the specialist health service shall be enhanced through the implementation of municipal plans.

Teamwork 2007 stress that the following actions must be taken before the gains from adequate usage of IT in the sector can be enjoyed.

- The paper must be eliminated where the electronical solutions are implemented.
- Electronical cooperation must be extended to all collaborators in the sector and to multiple areas of the cooperation.
- IT development must attend to/ensure unity and continuity by emphasizing common standards, good information flow between the various solutions and national circulation of important use/application.

- IT development must be connected with the organizational development, changes in work processes, and new forms of cooperation and distribution of work.

As mentioned above, the gains of the strategy can't be gathered without and organizational development. There are also technological choices related to the implementation of the strategy. When the electronical patient record is presented the various systems that contribute with content to it must be integrated and/or its information must be collocated. Accordingly, a integration strategy must be chosen. Also the information sharing strategy must be chosen. Depending on the purpose of the information sharing combination of different strategies may be performed. Furthermore, there are juridical constraints that must be attended to. These are mainly related to protection of personal data and the obligation to maintain secrecy.