ICT architectures and Project Risk. A Longitudinal Study of Health Infrastructures

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Abstract
This paper investigates the relationship between ICT architectures and project risk, in the context of the development of large inter-organizational systems. Although previous research has identified ICT architecture as a project risk, the focus has been on technical issues. Expanding this perspective, we investigate how technical architectures have bearings on the organization of projects, which may, to a large extent, determine the outcome of large information infrastructure initiatives.

Our empirical evidence is ten cases from the health sector, collected over a period of 20 years. A multi-level analysis allowed us to identify two main approaches; the institutional interface architecture (INA) and the service provider architecture (SPA). Through the careful study of ten cases over a period of 20 years, we present evidence for the high project risk of the INA and the viability of the SPA strategy. We find that the SPA has significant impact not only on the complexity of the technological solutions, but – more importantly – also on the complexity of the projects developing the solutions. The organizational complexity, and hence the necessary co-ordination activities, were dramatically reduced, and the success rate of the projects and the benefits for the users similarly increased.

Keywords: risk management, ICT architecture, information infrastructures

1. Introduction
In the recent 20th anniversary issue of ISR, Tiwana et al. (2010) argue that there is a huge need for research into the coevolution of design, governance, and environmental dynamics of what they call “platform-centric ecosystems.” This paper aims at contributing to this research by addressing the relationship between technological architectures and project risk, in the context of large inter-organizational ICT solutions. In particular the paper focuses on how the
choice of ICT architecture influences significantly on the organization of the project, which again influences on project risk.

One excellent context for studying these issues is the health sector. Building health information infrastructures has proved to be notoriously difficult in most countries, with many large initiatives in trouble (Grenhalgh et al. 2010; Braa et al. 2007; Ellingsen and Monteiro 2008; Hanseth et al. 2006; Sauer and Willcocks 2007). An important explanation of this fact is the overall complexity of the tasks. This complexity derives as much from the organizational aspects of the efforts as the technological solutions.

Consider the following situation at the start in 2004 of the Norwegian ePrescription project, which is fairly typical for the sector:

- A national ICT initiative for improving medicine logistics in health care, and increasing patient safety, supported and financed by impatient politicians with high expectations
- Many involved public actors: Department of Health, Directorate of Health, the Labour and Welfare Administration (NAV), 5 Health Regions with 70 hospitals, local health care services in 450 municipalities, the Norwegian Medicines Agency, Norwegian Institute of Public Health
- A large number of involved private actors: Association of Medical Doctors, 3700 GPs, 663 pharmacies
- Several involved ICT vendors: Six Electronic Patient Record vendors, a national network service provider (Helsenett), NAF Data (provider of ICT solutions to the pharmacies), and several consulting companies.
- An installed base of hundreds of existing (mostly fragmented) systems and more than one hundred thousand users throughout the sector

All these actors (and others) will be stakeholders in a national ePrescription solution. The project has during its first 5 (6) years spent about 60 millions of Euros, and may take a decade. The IT project record of the health sector is not good, and parallel experiences from other countries indicate substantial challenges.

What kind of ICT architecture and what kind of project organization are appropriate for this challenge? Which options are there? In this longitudinal study we have identified two different approaches; the Electronic Data Interchange
(EDI) approach, with its architecture which we here call Institutional Interface Architecture (INA), and what we here call the service provider approach with its associated Service Provider Architecture (SPA). Through the careful study of ten cases over a period of 20 years, we present evidence for the high risk of the INA approach and the viability of the SPA based solutions. We find that the SPA had significant impact not only on the complexity of the technological solutions, but primarily – and most important – on the organizational complexity of the projects developing the solutions. The organizational complexity, and hence the coordination activities, were dramatically reduced, and the success rate of the projects and the benefits for the users similarly increased.

Our finding is a cause for concern, because the INA approach is dominant, and supported by the health authorities and much of the IT health professional community. Thus, we have two aims with this article. The first is to document an exciting account of twenty years of health information system initiatives in Norway, focusing on the interplay of technology architecture, health organisations and organizational complexity and risks. Second, we wish to draw attention to the importance of ICT architecture in improving the probability of success in future e-health projects as well as efforts aiming at building inter-organizational ICT solutions or information infrastructures in general.

We proceed in the next section by assessing related research. Then we present our research methodology and our empirical material, the development of information infrastructures for information exchange and collaboration across institutional borders in the health care sector in Norway. The concluding discussion is in the last section.

2. Related Research
In this section we review related research, focusing first on ICT architectures and then on project risk.

2.1 ICT architectures and Project Risk
Research on technological architectures has focused on how to decompose a system into modules so that system flexibility is maximized. This is assumed best achieved through loose coupling among components and strong internal cohesion (Aksnes 2006; Henfridsson et al. 2009; Parnas 1972). Loose coupling, as opposed to tight coupling, between components means that the inner working of a component is largely irrelevant and can be hidden to other components (Baldwin and Clark 1997; Sanchez and Mahoney 1996). This is what Parnas (ibid.) called
encapsulation. Loosely coupled components are therefore easier to modify and more available for new relationships in reconfiguration of a modular system.

Traditionally, research on technological architectures has focused on the architecture of one software system. More recently, as the number of system has been growing and their integration has increased, much attention has been directed towards architectures specifying the relations between individual solutions. This research has directed much of its focus towards Service Oriented Architectures (Vassiliadis et al. 2006), where the modular structure consists of services. The implementation of SOA may vary, from simple ASP solutions, to Web services, and further to more complex SOAs with Enterprise Software Bus middleware (Rosen et al. 2008). An example is Tiwana and Konsynski (2010), who found solid evidence for the widely held view that a modular architecture makes alignment of ICT solutions and business strategy easier to achieve.

2.2 Inter-organizational ICT architectures

The literature reviewed above focuses mainly on projects and solutions located within one single organization. The e-health solutions discussed in this paper are different in the sense that each single solution will be shared by virtually all health care institutions in Norway and a large number of independent software suppliers and other actors are involved in the development of the solutions. Such large scale solutions raise a host of new challenges when it comes to both ICT architecture and the management of development activates. These challenges are addressed within a growing body of research – to which the research presented here belongs – conceptualizing these large scale solutions Information Infrastructures (II) (see for instance (Ciborra et al. 2000; Edwards et al. 2007; Hanseth et al. 1996; Star and Ruhleder 1996; Tilson et al. 2010). Most of the II research has aimed at exploring the complexity of IIs and the impact of this complexity on the design, management and evolution of IIs. A few articles address design strategies or methodologies (Hanseth and Lyttinen 2010).

A somewhat similar field is e-business. In the e-business research it is often distinguished between two basic types of e-business architectures (Chaffey, 2008). The first is a solution with one dominant actor, who will define the architecture and often also implement it. Examples are vendors such as Amazon and Apple. The second type is a supply chain with several companies on equal terms, communicating from their own separate system, often with EDI
messages or web services (Chaffey, 2008). The risks of these architectures, however, are not systematically discussed, except for a general warning of the need for good contracts.

A more detailed assessment of e-business solutions was conducted by van der Aalst (1999), who found three relevant inter-organizational architectures:

- **Capacity sharing**, where one dominant partner defines the workflow and provides the technical solution.
- **The Loosely Coupled Architecture**, which uses a horizontal decomposition of the workflow.
- **The Case Transfer Architecture**, which uses a vertical decomposition of the workflow.

The focus of the analysis is on workflow, but it is interesting to note that in the case of loosely coupled architecture (with messages going back and forth between partners), existing technology can be used to exchange the messages and to manage local workflows. The price to pay for this, however, is high coordination costs, and a low degree of flexibility (Van der Aalst 1999, p. 30).

### 2.3 Project Risk Management

In response to the unresolved challenges of failed IT development project, the discipline of risk management was introduced as a key approach in IT project management (Boehm 1988; Boehm 1991). The IT project risk literature is extensive. At the top of the risk lists, researchers have identified top management commitment, user participation/commitment and incomplete/unstable requirements (Bannerman 2008; De Bakker et al. 2009; Keil et al. 1998).

A standard IT project management text book, such as Cadle and Yeates, offers a full chapter on risk management, emphasizing the need for a systematic identification, assessment and mitigation of project risks (Cadle and Yeates 2008). The identified types of risk are commercial, relationship, requirements, planning/resource, technical and subcontract risk, with the focus mainly on management interventions.

In a longitudinal study in the health care sector Sicotte and Paré (2010) identified several risks, such as political, technical, management and usability risks, and found that the risk factors were closely intertwined. They also found
that risk interdependence evolved dynamically over time, with a snowball effect that rendered a change of path progressively more difficult (Sicotte and Paré 2010).

2.4 Summing-up
Although the project management literature has been increasingly preoccupied with risk management, most research is related to management issues, as the examples above illustrate. Architectural issues are relatively superficially treated. In a similar way the literature on technological architectures concentrates mostly on how to achieve the required technological flexibility, and does not address risk.

One reasonable assumption from this review would be that sound architectural principles, in particular modularity, will decrease project risk. We do not contest this view, but as we will show in our cases, this is not as simple as it sounds. In practice, modularity may be implemented in very different ways, with different outcomes. We will discuss this in detail in the next section, where we assess two paradigms for inter-organizational solutions.

3. Two ICT architectures
In this section we present two different paradigms within inter-organizational health systems, and the associated ICT architectures.

3.1 The EDI paradigm and the Institutional Interface Architecture (INA)
What we define as the EDI paradigm in this paper, is a framework for electronic communication between organizations that emerged in the early 70-ies. It takes as it starting point the information flow between organizations. From the very beginning the paradigm has aimed at replacing paper based communication structures – the paradigm example being exchange of orders and invoices. This paradigm can then, in principle, easily be adapted to the health care sector to support the electronic exchange of information usually exchanged on paper forms like those being focused in the projects reported here.

Taking existing paper forms as the starting point, the focus of the paradigm has, obviously, been on defining electronic standards, in terms of EDI messages, equivalent of the (semi-standardized) paper forms. This implies that the paradigm is based on a technological architecture that mirrors exactly the organizational structure created by the information flow between the organizations involved as illustrated by fig. 1 below.
The standardization model of the EDI paradigm is much influenced by the telecom sector. Formal bodies, like those of the telecom sector around 1970, have been set up and their institutional framework (organization of sub-committees, voting rules, etc.) mimics those of the telecom sector at that time. Standards are defined in committees where various stakeholders are represented. When agreements about a standard are reached, all organizations are expected to comply, and implement the standards in their solutions. If the standards are defined properly, and the technical people are implementing them correctly, establishing the communication is assumed to be a straightforward task.

![Information flow](image1)

![ICT architecture](image2)

The main benefit of the INA, as was also argued by van der Aalst (1999), is that it leaves the technical solution to each actor in the network, as long as it complies with the standard message. Another benefit is that, since it is built on standardized messages going back and forth, it also allows for the scaling of solutions, as has been proven in the e-business field.

For many e-business solutions the EDI paradigm has been successful (Turban et al. 2006). But not for all – representatives from the oil industry are saying that EDI is inappropriate in the supply chain in their sector due to the high number of suppliers and a low number of transactions between oil companies and most of their suppliers. In
their view, EDI works well in supply chains with a lower number of suppliers and a high volume of transactions between each of them.

In the health sector the EDI paradigm has had a modest success. This claim will be substantiated later in this paper. Reaching agreement about standards’ specification among the stakeholders has been difficult. And coordinating the implementation of the standards so that the information can be exchanged correctly has been challenging (Hanseth et al. 2006).

3.2 The Service Provider Approach and SPA
The concept software as a service was coined in the 1990s as Application Service Provider (ASP) (but had long origins in IT service bureaus), when the Internet and web protocols enabled providers to offer services such as banking and logistics to customers, without requiring the customer to host and run the applications on their own hardware (Vassiliadis et al. 2006). Usually, the application service provider will own and maintain the software and servers, distribute the service over a network, and charge the users according to running use. The service provider will design an ICT architecture where the main components of the solution are centrally controlled, regardless of where they are distributed and used.

The main advantages of the service provider approach are:

- The technical integrity of the software is controlled by only one actor, the provider. This makes it easier to develop, distribute, integrate and maintain the product.
- The risks for clients are relatively low, because up-front investments are avoided, and the pay-as-you-go principle makes running costs predictable. The client also does not need to worry about new versions, internal IT competence and technology shifts.

The last decade the approach has been redefined and renamed service oriented architecture (SOA) (Vassiliadis et al. 2006). The implementation of SOA may vary, from simple ASP solutions to more complex SOAs with ESB middleware (Rosen et al. 2008). In our context, however, we have chosen to call it the service provider architecture (SPA). The important point is that the service provider architecture not only allows for a different ICT architecture,
compared to the INA paradigm, but also (as illustrated in figure 2) the communication between health actors is now handled by the SPA solution, requiring much less changes in the systems of the participating organizations.

The two architectures illustrate a well-known insight from organization research, namely that the technical architectures of products tend to mirror the organizational structure of the mother organizations (Henderson and Clark 1990). This implies that architectural innovation is more difficult in the INA approach, and more likely in the SPA model.

At a technical level it is unreasonable to argue that one of the solutions is better than the other; the INA solution has worked well in e-business contexts, while the SPA solution has been successful in other settings. However, in the context of large inter-organizational health infrastructures, we will now show, through the careful analysis of our cases, that the INA approach is a risky one, and that the SPA solution should be used.

4. Methodology
The empirical material reported in this study was collected more or less continuously for a period of over 20 years, in the Norwegian health sector. Our research has been guided by a strong interest to understand the development of large information infrastructures, at different levels, as they evolve over time. Studying these large socio-technical
structures over time is challenging, because of the complexity of the domain; the number of actors and initiatives is large, and the projects often last for several years. The significance of ICT architecture has been prominent, as they play a crucial role at different levels.

Our research approach has been a multilevel case study (Hitt et al. 2007; Miles and Huberman 1994). Specific projects have been studied in detail over time, and were documented extensively. At higher levels regional and national initiatives (with international links) have been followed, and we have been particularly interested to investigate the dynamics between different levels, where, needless to say, standards and architectures has been a focal issue.

4.1 Data Collection

The cases were chosen on a combination of systematic and pragmatic reasons, i.e. we have selected some key central national initiatives, and researched interesting local and regional projects that were available. The most important source has been interviews with informants in different roles; doctors and nurses, line managers, IT professionals, staff users and high-level bureaucrats. Literally hundreds of reports has been collected and analyzed. At several occasions, solutions have been demonstrated, and we have observed systems in use in many situations.

An overview of the cases is shown below.

- **Edimed**: One of the authors was involved in this activity in the period 1989-92. Data collected also in the period 1992-1996 and 2011.
- **ePrescription (1)**: Pilot project, in 1993-96. Data collected during 1990-96.
- **The Elin project**: Regional project, in 2004-09 Data collected during 2004-09.
- **ePrescription 2**: Large national project, in 2005-2010 Data collected in 2008-10.
- **Dr. Fürst's Medical Laboratory**: Commercial project, in 1987-2010 Data collected 84-96 and 2009-10.
• **Well/DIPS Interactor**: Commercial project, in 2006-2010 Data collected during 2006-10.

• **The Blue Fox Project**: National project, in 2005-2008 Data collected in 2009-10.


Many of the projects have been followed over a long period of time, and several informants have been interviewed several times. Results of the projects have also been discussed with informants many years after they were finished, in order to have informants’ reflections over the cases.

### 4.2 Data Analysis
Each case has been analyzed separately, focusing on the role of ICT architecture in the development project. Then the full portfolio of cases has been analyzed in two dimensions (Pettigrew 1985):

First a *temporal* analysis was done, focusing on the development over time. This analysis documented the trajectories of projects, but also of the various discourses in the sector. For example, the forward chaining of events served to explain intentions of stakeholders, while backwards chaining of events served to explain outcomes. Overall, the temporal analysis helped to understand the dynamics of the architecture approaches.

Then a *comprehensive* analysis was conducted, comparing the architectures and the outcome of the different cases. A central part of the analysis was the role of architecture in designing and implementing the solution. For example, the differences between ePrescription 2 and the Blue Fox project revealed significant differences regarding the role of architecture, in projects that had many similarities in goals and objectives. These differences served as input to identifying the effects of different architectures.

### 4.3 Validation
After conducting the data analysis we assessed our findings critically. In particular, we tried systematically to identify alternative explanations of our cases, which we briefly discuss at the end of the paper. We also discussed our findings with the eHealth community, at presentations and conferences. Some key members of the community disagreed with our main finding, which was critical to the dominating paradigm. Their feedback triggered more analysis, and influenced on and enriched our discussion of the two architectural approaches.
5. Cases: Developing Information Infrastructures for Health Care in Norway
In this section we present eight projects aiming at developing information infrastructures for information exchange and collaboration across institutional borders in the health care sector in Norway. An overview of the projects is shown in table 1.

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>ICT architecture</th>
<th>Overall results</th>
</tr>
</thead>
<tbody>
<tr>
<td>ePrescription 1</td>
<td>1993-96</td>
<td>INA</td>
<td>Terminated in 1996</td>
</tr>
<tr>
<td>The Elin project</td>
<td>2004-07</td>
<td>INA</td>
<td>Some success, slow diffusion</td>
</tr>
<tr>
<td>Elin-K</td>
<td>2005-09</td>
<td>INA</td>
<td>Terminated in 2009</td>
</tr>
<tr>
<td>ePrescription 2</td>
<td>2004-10</td>
<td>INA</td>
<td>On-going, but challenged</td>
</tr>
<tr>
<td>Dr. Fürst’s Medical Laboratory</td>
<td>1987-2010</td>
<td>SPA</td>
<td>Successful</td>
</tr>
<tr>
<td>Edimed</td>
<td>1989-1996</td>
<td>SPA</td>
<td>Successful</td>
</tr>
<tr>
<td>Northern Norwegian Health</td>
<td>1997-2003</td>
<td>SPA</td>
<td>Successful</td>
</tr>
<tr>
<td>Network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well/DIPS Interactor</td>
<td>2006-2010</td>
<td>SPA</td>
<td>Successful</td>
</tr>
<tr>
<td>The Blue Fox Project</td>
<td>2005-08</td>
<td>SPA</td>
<td>Successful</td>
</tr>
<tr>
<td>The Prescription Register</td>
<td>2003</td>
<td>SPA</td>
<td>Successful</td>
</tr>
</tbody>
</table>

Table 1. Projects

We describe how these projects have unfolded, and then zoom in on the role of the technological architectures chosen. Four of the projects aimed at developing solutions based on what we here call the Institutional interface Architecture (INA) which is a part of a broader EDI paradigm which is based on specific ideas about how information should be exchanged. We will first outline how the EDI paradigm was established as the standard paradigm for developing information infrastructures for information exchange and collaboration across institutional borders in the health care sector in Norway around 1990. This paradigm has remained hegemonic since that time.

5.1 Overture: The Establishment and hegemonic position of the EDI Paradigm and INA
The development of solutions for electronic information exchange between health care institutions in Norway started when a private lab, Dr. Fürst’s Medicine Laboratory (Fürst) in Oslo, developed a system for lab report transmission to general practitioners (GPs) in 1987. The system was very simple - the development time was only three weeks for one person. The interest of Fürst was simply to make a profit by attracting new customers. It was assumed that the system would help GPs save much time otherwise spent on manual registering lab reports, and that the GPs would
find this attractive. Each GP received on average approximately 20 reports a day, which took quite some time to register manually in their medical record system. The system proved to be a commercial success and brought Fürst many new GP customers. Its success made the potential benefits of this kind of solutions clear to many actors within health care. And many other labs, privately as well as publicly owned, developed and adopted similar solutions quickly not to lose out in the competition with Fürst. We will return to the Fürst project in section 5.3.1.

Telenor (the former Norwegian Telecom) had strong economic interests in promoting extensive use of telecom- and data communication based services. As telecommunication technology became more integrated with IT, Telenor searched for candidates for extensive use of new and advanced services. The health sector was selected as the potentially most promising one. After an initial experiment, Telenor launched the project “Telemedicine in Northern Norway” in 1987 which was running until 1993. Standardization had always been considered important within the telecommunication sector. Hence, Telenor took it for granted that the new health information infrastructure standards should be like any other telecommunication standard: “open” and developed according to the procedures of formal standardization bodies.

Based on their interests in general solutions and rooted in the telecommunication tradition of international standardization, Telenor searched for international activities aiming at developing "open" standards. The IEEE (Institute of Electrical and Electronics Engineers) P1157 committee, usually called Medix, did exactly this. This work was the result of an initiative to develop open, international standards taken at the MEDINFO conference in 1986. Medix, which was dominated by IT professionals working in large companies like Hewlett Packard and Telenor and some standardization specialists working for health care authorities, adopted the dominating approach at that time, namely that standards should be as open, general and universal as possible.

The appeal for open, universal standards adopted by Medix implied using existing OSI (Open Systems Interconnection) protocols, defined by ISO (International Standardization Organization) and supported by the governments in more or less all industrialized countries, as underlying basis. The Medix effort adopted a standardization approach - perfectly in line with texts books in information systems development - that the
development should be based on an information model being a “true” description of the relevant part of reality, i.e. the health care sector, independent of existing as well as future technology.

In 1990 the Commission of the European Community delegated to CEN (Comite Europeen de Normalisation) to take responsibility for working out European standards within the health care domain in order to facilitate the economic benefits of an European inner market. From this time CEN became the dominant standardization organization in Europe. Most Medix participants became active in CEN working groups which adopted, then, most of the Medix framework.

At this time the EDIFACT format and standardization framework had a strong position within exchange of structure business information and a European group for developing EDIFACT messages for health care, called EMEDI, was established. EMEDI members also became active within CEN and the EDIFACT standardization framework became a key element within CEN.

In Norway, the "Infrastructure Programme" run by a governmental agency (Statskonsult) during 1989 – 92 was a powerful driving force behind EDIFACT. Promoting OSI and EDIFACT standards for the whole public sector was a main objective. Responding to the calls for standards, the Ministry of Health established KITH (Norwegian Centre for Informatics in Health and Social Care) in 1991, which was delegated the responsibility for standardization. Its first director was the former head of Telenor’s telemedicine project. He aligned closely with Statskonsult and argued in favour of EDIFACT and OSI. KITH’s general strategy was that the health care sector in Norway should adopt international standards as far as possible and that Norway should be actively involved in the development of international standards. In 1991 the Norwegian standardization activities were organized into a programme established by the Ministry of Health and coordinated by KITH.

The most active actor developing solutions for information exchange in health care around 1990 was the Edimed initiative.¹ This was a joint initiative by two ICT companies: InfoMedica and Fearnley Data. Both believed that there would be a large need and market for solutions for electronic information exchange in health care. Both companies

¹ One of the authors was involved in this initiative from its birth in 1989 until late 1992.
also had a portfolio of ICT solutions for health care (including patient record systems for GPs and lab and patient administrative systems for hospitals). They wanted to enhance these systems so that the information they contained could be exchanged and develop a communication system taking care of this. Edimed saw standards as important in general. But they also considered being as compliant as possible with official standards a potential competitive advantage. Accordingly, they decided to work as closely as possible together with Statskonsult, KITH and Telenor at the same time as they actively contributed to the development of standards proposal and implement these as soon and as extensively as possible. One of Edimed's staff, then, worked full time of the development of standards proposals based on EDIFACT and was a key member of EMEDI and the relevant CEN working groups. The Edimed initiative was very successful. Around 1993 its solution was implemented by 9 of the 19 Norwegian counties (cover 75% of Norway's population) and 3 Swedish. Most labs and GPs used it for transfer of lab reports. Pilot and prototype solutions for some other information objects (prescriptions, lab orders, GPs' invoices) were developed. For all these reasons Edimed contributed significantly to the strong position of the EDI paradigm in the health care sector in Norway. But in spite of this and the fact that the Edimed solution was described by its development and marketing organization as one with a strong focus on standardized EDI messages, we consider it, somewhat paradoxically may be, being based primarily on the SPA architecture and, in particular, that Edimed's early success was based on this fact. It will be described in more detail in section 5.3.2.

The EDI paradigm and its INA architecture has been the dominant and hegemonic approach since its establishment around 1990 in spite of its modest success. This claim is supported by the following three important facts. First, the standardization programme established in 1991 is still running with a focus on the development of message standards (in addition to issues like security, classification and coding systems, and basic network protocols and standards to be used). A more detailed standard ICT architecture, fully consistent with our definition of the INA, has been worked out recently (Aksnes 2006, Warholm et al. 2010).

Second, standardizing and implementing messages have been a key strategic activity in all national strategies set by the Ministry of Health since the first one launched in 1996 (HOD 1996). This strategy document said at that time (August 1996) most information exchange was based on paper. Further, it set as one of the main aims that within the
end of 1998 all hospitals and GP offices should use standardized EDI solutions and within the end of 2000 the main rule should be that paper based communication was be replaced by electronic message transfer. Paper based communication should only be used for special purposes and packages. Almost exactly the same description of the situation as well as the aim for what should be achieved within two years has been repeated in the later strategy documents, published in 2000, 2004 and 2008. In the latest document for instance, it is said that “Today about 80% of the communication is paper based and only 20% electronic. Within three years shall 80% of the most important communication among collaborating partners in the health care services be electronic” (HOD 2008, p. 7).

Third, responding to the slow diffusion of solutions based on standardized messages, the Ministry of Health launched the “Message Boost” project January 1st 2008. The project was coordinated by the Health Directorate and was planned to run until the end of 2010. The explicit ambition was, yet again, that the “dominant part” of standard messages between hospitals, GPs and Welfare Authorities should be exchanged electronically by 2010. In a 65 pages follow-up report from the Directorate of Health (Feb. 26th, 2010) it was documented that (i) the number of messages under consideration and implementation was quite large, (ii) that the complexity of issues appeared to be rather overwhelming and (iii) that the aim of “dominant” electronic messages within 2010 will not be reached, by far.

5.2 INA Projects
We will present four INA cases. The first one, an initiative aiming at developing and implementing a solution for sharing prescription information among the relevant actors, we see as a typical example of the projects established in the 1990-ies. Then we turn to the Elin project, and one of its direct followers, Elin-K. The Elin project is seen as representing a change in strategy for developing ICT solutions for information exchange in health care. We agree that it represented such a change, but this change was modest in our view – both related to overall strategy, architecture and outcomes. Finally, we present the ePrescription project which started in 2004 and is still running. This is a large project with generous funding from the Norwegian Parliament, strong political backing from political as well as administrative levels, and with strong commitments and support from a large number of actors. We will for each project briefly describe its background and how it has established, the choice of architecture and how this came about, and, finally, project organization and outcome.
5.2.1 The ePrescription Project (1)
The idea of electronic transmission of prescriptions grew out of a feasibility study carried out by KITH as a part of Statskonsult’s Infrastructure programme in 1992. The feasibility study was followed by a pre-project aiming at working a message specification and an implementation guide. The pre-project was financed by NAF-Data, the provider of applications for the pharmacies. Only three actors with immediate interests were represented in the pre-project: the Association of GPs, the Association of Pharmacies and KITH. Later on more actors got involved, first to comment on the message specification, later also to discuss the design and implementation of a pilot installation.

The choice of the INA model was not strictly given from the outset. A representative of one of the vendors of electronic medical record systems (Profdoc) suggested early on that one should use bar codes instead of electronic messages. Another alternative to EDIFACT message exchange was suggested by the health insurance authorities. They proposed an architecture where prescriptions were stored in a data base instead of being transmitted directly to the pharmacies. The important difference between this solution and a pure EDIFACT one was that the pharmacies would retrieve the prescriptions only when the patient actually arrived at the pharmacies which would give the patient freedom to choose which pharmacy to visit. The project, however, never seriously considered deviating from an EDIFACT message based solution.

After producing a comprehensive requirements specification and a beta release, a pilot project involving one GP office and one pharmacy in the Bergen area started in 1994. The project was marred with problems. An advanced solution had been specified, requiring seamless integration with other systems, (such as welfare systems, EPRs and medical registers) which were not yet available. The EPR vendors did not prioritize the solution, because of other development pressures and poor financing. In the pilot solution there were so many errors that the doctors had to fax the prescription in addition to sending them electronically.

In 1996 the project ran out of steam (and money), and a project report summarized the remaining problems: the need for a central medical register, data security concerns, paying for running costs and user support. In our view these issues were symptoms of a larger problem: the INA approach was perceived as being relatively straight forward, but
was hiding a technological and organizational complexity that would plague the subsequent projects the next 15 years.

5.2.2 The Elin Project
The EDI paradigm was slightly modified by the ELIN series of projects. The main aim was to establish electronic cooperation between the GPs and other actors in the health care sectors, such as hospitals, pharmacies and welfare authorities. Several software vendors have developed the solutions, which were subsequently run in pilot projects.

In the first of these in 2004 (ELIN-main), comprehensive requirements specifications were designed as a basis for user friendly, standardized solutions for electronic health care related communications for GPs. The main aim was “better communication and collaboration, and not just development of technical solutions for message exchange”. This included the development of solutions for exchange of admission and discharge letters, lab orders and reports, illness and doctor’s declarations, prescriptions, and communication with patients. Similarly with the ePrescription project there was a strong focus on the main information objects, like lab orders and reports, admission and discharge letter and prescriptions. But in contrast to the previous standardization activities, these objects were much more seen and understood as integrated parts of the work practices they appeared within.

The ELIN-main project was split into three phases. In the first, the focus was on exchange of discharge letters between GPs and hospital departments and outpatient clinics. In the second phase the focus was on exchange of discharge letters between medical specialists’ offices and GPs, exchange of orders and reports between radiology labs to GPs, and information exchange with patients. The third phase focused on improving and piloting the technical solutions.

The ambitious project was based on the INA architecture, requiring all actors to comply with the EDIFACT and XML message standards and implement the necessary changes in their systems. A number of challenges surfaced. For example the existing EDIFACT standards did not fit well with the defined requirements, and for some messages standards were not yet available. Another challenge was that the exchange of the messages took too long time for various (and often mysterious) reasons. Accordingly, new standards and messages had to be specified based on a web services model but within the framework of an INA.
The project has played a major role in the development of user requirement for ICT solutions supporting communication between GPs and other health care institutions which are well aligned with user needs and requirements from health care authorities. The project also specified a standardized architecture for solutions for information exchange between GPs and hospitals in line with the INA as defined in this paper (Aksnes 2006), and was quite successful in establishing strong, enthusiastic collaborative networks of users and suppliers. However, the implementation and diffusion of solutions have definitively been very slow – much slower than expected.

5.2.2 The ELIN-k Project
The ELIN project also triggered a series of follow up activities. One of these was the ELIN-k project, initiated by the Norwegian Nursing Council in 2005, and focusing, as the first project in Norway, on electronic information exchange within the healthcare sector in the municipalities. The involvement of KITH was considered essential, and 13 messages were standardized. Seven vendors, covering relevant sectors within the healthcare, signed contracts with the project. Six municipalities wanted to run pilots - each municipality with typically one health care institution and about ten GPs.

The specifications for the first phase in the project, communication between nursing home and medical offices, were finished in 2006 and the vendors were supposed to deliver solutions in spring 2007. However, the messages were exchanged between the first pilot sites in spring 2009. At the beginning of 2011 a solution where some of the messages are implemented in 6 different systems (3 EPR systems for GPs and 3 systems used in care institutions for sick and elderly people) is claimed to be ready for large scale deployment.

The ELIN projects changed the focus of attention away from messages only and more towards user requirements and overall functionality of the total solutions. But the projects were still based on the essence of the EDI Paradigm and the INA; the ICT architecture still mirrored the organizational and information exchange structures of the user organizations. And the development work required to build the information infrastructures was organized by the user organizations and the vendors of their applications.

Thus, the ELIN projects were slightly more successful that the early projects like the ePrescription project presented above, but the overall complexity, and the organizational complexity in particular, was still rather unmanageable. We
will now turn to the second ePrescription project. We consider this as the most ambitious, well-funded, and professionally managed project among those projects aiming at developing information infrastructures for information exchange and collaboration across institutional borders in the health care sector in Norway. Also this one was based on INA the EDI Paradigm as this was modified by the ELIN project.

5.2.3 ePrescription (2)

In 2004, the Ministry of Health initiated yet another pilot study on electronic prescriptions. The background was a report in 2001 from the Office of the Auditor General that raised concerns on the accountability of prescription refunds from the Welfare Administration Agency (RTV). The following actors were included in the pilot study; Norwegian Pharmacist’s Union, National Insurance Administration (NIA), Norwegian Medical Association (representing physicians) and Norwegian Medicines Agency (NMA). The Directorate of Health managed the project.

The ePrescription project was established with direct funding from the parliament of about 40 million Euros from the Norwegian Parliament during six years – from 2005 up to 2010. By the end of 2010 about 60 million Euros has been spent on the project. During 2006 several detailed requirements specifications and architectural document were written, specifying an ambitious, fully integrated solution. The Prescription Exchange was designed to handle 300 million transactions per year. This reflected that, in the designed solution, each prescription would generate approx. 10 transactions, from a national volume of around 27 mill prescription per year. As illustrated in figure 3, the architectural solution was based 31 different (standardized) messages being sent to the Prescription Exchange, which would perform various controls, before distributing them to other actors.

The top requirements specification of The Directorate of Health emphasized that the various actors were responsible for “their” modules, with a central database, the Prescription Exchange, as the key one. The project was organized in sub-projects reflecting each institution that was included in the service and five subprojects were established.

The six main EPR vendors were invited into one of the sub projects in 2006. The three suppliers of EPR systems for hospitals were too busy to participate. Another issue was that the suppliers of the hospital EPRs demanded more specific requirement specifications before they were willing to develop anything. Eventually, only the biggest vendor within the GP market agreed to develop a pilot version of electronic prescription.
In May 2008 the first pilot implementation was inaugurated by the Minister of Health. It was carried out in a village in the eastern part of the country, and included the GPs and the local pharmacy. It turned out to be a minor disaster, and after four months a crisis was declared. Said the municipal health manager to the local newspaper; “the system is so slow, and has so many errors and deficiencies, that we will stop the whole pilot”. The local authorities also raised concerns for patient safety. The main reason for the problems was not the ePrescription solution, but that the new version of the EPJ system was unstable. Somewhat unreasonably, the ePrescription project got the blame in an angry press.

Figure 3. The ePrescription solution: Main components

The main technical solution was tested and accepted during 2009, while waiting for the vendors to complete and test their new versions. A new pilot was planned in March 2010, and contracts for large scale operations were signed. The pilot testing started in Os municipality in June 2010, including two GP offices and one pharmacy. A second pilot
started in Larvik in September including two pharmacies and a handful of GP offices. All GP offices are using EPR system from the same vendor – the only one ready for use so far. When the new ERP system from the vendor with the largest market share (70%) will be ready is still up in the blue. The pilots are reported to be successful, but new challenges have emerged. For instance, it seems to be the case that more or less all GPs need to upgrade their ICT infrastructure - PCs, network bandwidth, and even printers – to be able to run the solution. This again raises the issue about who is to pay for this.

At the same time, other challenges surfaced. While the primary health care system (the GP level, administrated by municipalities) issues 70% of the prescription, the rest is issued by hospitals. These are organized in four health regions, as separate state companies. In the autumn 2009 it became clear that the IT managers in the health regions had made very little preparations for integrating hospital EPRs (which are different from the GPs) with ePrescription solution. Moreover, they raised comprehensive objections to the architecture of the solution. During some heated meetings in the winter 2009-10 some kind of compromise was reached: the health regions would follow their own framework for integrating various old and new systems, while making an effort to implement a short-term solution for ePrescription. Most important here was a modified and less sophisticated security solution. But, unfortunately, this modified security solution implied that significant changes had to be made also to the modules running in the other institutions. A work group was appointed in order to look more carefully into this. So far, the solution is not found.

The situation facing the ePrescription program in 2011, then, was a challenging one. First, the late schedule of the key vendors made the stated goals of adoption unreachable. While the EPR systems were expected to be ready in 2010 – they are not. The full scale solution for the pharmacies might be as late as 2012. And the hospitals signalled that they might be ready (to start) in 2013. This obviously does not mean that the ePrescription solution will be fully implemented nationally by 2013. Since the solution so far has never been really tested in real environments, one might expect – based on the experiences from previous large e-health projects - a number of complications, ranging from simple user complaints to fundamental functionality issues.
5.2.4 Summary of the INA Projects
In 2010, after large investments in EPR systems in the hospital and primary care sectors and almost 20 years after the standardization of health care messages started, the use of standardized messaging had diffused only modestly. The situation is described quite accurately by the report from the “Message Boost” effort from the Directorate of Health (Feb. 2010) which was quoted above. But we repeat it here: (i) the number of messages under consideration and implementation was quite large; (ii) that the complexity of issues appeared to be rather overwhelming and (iii) that the aim of “dominant” electronic messages within 2010 will not be reached, by far. The complexity is well illustrated, we believe, by the ePrescription(2) project. Even though the project is extremely generously funded and well managed (according to traditional project management recommendations), the technological complexity combined with the number of autonomous actors involved and the interdependencies between them caused by the technological architecture chosen just make the project unmanageable.

We will now contrast the INA based projects with a number of others that have adopted different architectures. We find the contrasts striking.

5.3 The SPA Projects
The six initiatives or efforts we are describing under the label “SPA projects” are, strictly speaking, not all traditional projects. Three of them are activates organized and conducted by various units within the health care sector. One of these (Fürst) is an ongoing activity run by a medical service provider, a lab, aiming at improving the quality of the medical services by means of enhanced ICT services, the second is a service established to support doctors’ decision making related to drug prescription, and the third is a service (data base) established by a public health institution enabling research on drug prescription practices in Norway. The other three initiatives are organized by ICT organizations. Two of these are software companies developing software products while the third is an ICT (communication/network) service provider. Just for the sake of simplicity, we call all these initiatives projects.

While being different in many ways, these initiatives also have some important features in common. One of these is the fact that the architecture the solutions are based on is different from the INA. None of the projects, however, are based on architectures that were well defined or well established within the ICT field.
5.3.1 Fürst

When Fürst's solution for lab report transfer (see section 5.1) was successfully adopted by the lab's customers, Fürst wanted to extend the scope of electronic services offered. The natural next step was electronic transmission of orders, and Fürst realized from the very beginning that this would be a different case. Receiving reports electronically is attractive for GPs because they get faster access to the results and they save time they otherwise have to spend on manually entering the report data into the patients' medical records. In the case of orders, there were no significant benefits for GPs. On the other hand, there were significant benefits to be gained at Fürst's if they could receive the orders electronically and automatically store them in their lab system instead of manually entering the data when paper orders were received. And in this case (opposed to the introduction of the lab report transfer solution) Fürst's primary motivation for implementing an order transmission solution was the reduction of manpower required internally in the lab that this would enable.

Fürst started the development of a pilot solution in 1992 together with one of the vendors of EPR systems for GPs. The solution was tested in a pilot implementation in a GP office in 1993. The experience of the pilot users did not create much enthusiasm; one reason was obviously that the overall usability of the solution was rather poor, but also that the GPs saw no immediate benefits. Fürst concluded that a successful solution would have to offer the GPs some added value.

After some time Fürst came up with the idea of offering the GPs the possibility of ordering new tests of a specimen after the results of those ordered first were available. Usually a GP orders several tests of the same specimen. Often, which combination of tests that is most relevant cannot be decided until the results of some of the analysis are seen. Accordingly, it would make sense to order some tests, look at the results and then decide on which additional analysis that is relevant. When both orders and results were transmitted electronically, this possibility could become reality. And Fürst started developing such a service based on the simple but enabling ICT architecture illustrated in figure 3. In this solution the lab service includes a client module on the GPs PC, leaving the EPR system almost unaffected. The communication between the client module and the lab system was designed and controlled by Fürst. The client module has some communication with the EPR system; it retrieves some patient information, and returns
some basic lab test information. This is done through rather primitive mechanisms. What is significant in this SPA solution is that it (i) ensured tight and easy communication between GP and lab and (ii) that it does not require any changes in the EPR system.

Fürst used the standard messages for orders and reports. But these covered only a small part of the information exchange between the client module running in the GPs’ computers and the server module running inside the lab. The rest of the information was exchanged using proprietary formats and protocols. Just as important as the messages exchanged between the GPs’ computers and the lab is the very simple interface between Fürst’s client software and the EPR systems.

![Figure 3. The ASPA: Fürst’s technical solution](image)

After some pilot testing of the solution, Fürst concluded that the interactive solution required broadband networks and decided to wait until this was more broadly available – and cheaper. So real life testing started again around year 2000. Then the planning of the establishment of the Norwegian Health Care Network, which should offer broadband connections to all health care institutions, started, and Fürst decided to postpone deployment of the solution until this network was in operation. So in 2003 Fürst and the pilot users of the interactive ordering service became the first
users of this national broadband service. The interactive ordering solution has increasingly got a reputation for being a useful tool and the growth in number of users has accelerated. The number of users has currently (Nov 2010) increased to about 3,500, i.e. more than 50% of Fürst’s customers. At any time during ordinary work hours 1,100-1,200 users are logged in. And Fürst’s customer base has been growing about 25% the last year. 10% came from the acquisition of another small private lab. Of the rest, Fürst believes that most of them have become Fürst customers because of the attractiveness of the interactive ordering service.

The important difference between this solution and the INA solutions is, as far as this article is concerned, the fact that the architecture made it possible for a very simple project organization, inside one formal organization or company, to develop the whole solution. Further, the development organization could do so without almost any coordination or cooperation with other organizations or companies. Another important difference is that this combination of ICT architecture and development organization made it simple to extend the range of services offered to the users (i.e. GPs) through an experimental and evolutionary innovation and development process which again led to a situation where users were offered a broad range of services they highly appreciate beyond just sending orders and receiving reports, i.e. the interactive ordering service.

5.3.2 Edimed
As said in section 5.1, the most active actor developing solutions for information exchange in health care around 1990 was the Edimed initiative. Its official strategy was to focus as much as possible on official standards. They did so by actively contributing to the development of such standards, implementing draft standards as early as possible, and by aligning with other actors also prompting the same standards. (See also section 5.1 for more general information about this initiative.) But, economic survival made it necessary to deliver solutions to customers ASAP. And because there were no officially approved standards yet available, a pragmatic approach was required. So the strategy with the extremely strong focus on official standards was rhetoric as much as reality. And this strategy enabled Edimed to sell and deliver a large number of solutions within a time frame of about three years. Around 1993 its solution was implemented by 9 of the 19 Norwegian counties (cover 75% of Norway’s population) and 3 Swedish ones.
An important element contributing to Edimed’s success was the fact that they were able to sell and deliver a solution to the Haukeland hospital in Bergen and the Hordaland county. The Edimed organization was able to deliver this solution after short time mainly because one of the companies behind Edimed (Fearnley Data) owned the NOMIS lab system used at the hospital and the Infodoc EPR system used by a majority of the GPs in Hordaland and the overall area served by Haukeland’s lab. This demonstrated success made it rather easy to sell the solution to the other counties whose hospital labs were running the NOMIS lab system. This again made it easy to sell the solution to yet more counties/hospitals. The counties/hospitals had a strong interest in being able to deliver lab reports to all their customers. So when the solution was proved to work well for all Infodoc users, it was difficult for other EPR vendors not to adapt their systems to the Edimed system. And this was a rather trivial task for them because Edimed adapted their client module to interfaces they already had implemented, for instance the one used for integration with Fürst’s solution.

Officially the Edimed solution was presented as one supporting exchange of standardized EDIFACT messages. But in reality the architecture of the solution was closer to that of Fürst, as illustrated in fig. 3, than the INA architecture. The solution was based on one client module that was integrated with the lab systems and running on the hospitals ‘computers and a client module integrated with the GPs EPR systems. And the Edimed organization was, usually, doing almost all the work required to integrate with the various applications. The Edimed organizations included about 10 people, all working full time, which were taking care of software development, integration with applications, sales and marketing, implementation in customer organizations, user support, etc.

In late 1992 the Edimed product was bought by a large ICT organization and integrated into this company’s broad EDI strategy. A few years later they sold this out to yet another. During these transactions the focus on the health care sector seems to disappear.

5.3.2 North Norwegian Health Care Network
The North Norwegian Health Care Network (NNHN) was established as a project in 1997. The aim was to establish an ICT network for exchange of information such as orders and reports, and admission and discharge letters among
health care institutions in the Northern Norwegian health region. The Directorate of Health (and ministry) approved the idea and decided to fund the project. They also decided that the other four health regions should do the same.

The services were established in close collaboration with GPs and the hospitals. In addition to message exchange, a number of web based services were also established. Internet technology and the Internet itself were used as much as possible. Similar to Fürst NNHN also did the work required to integrate the communication technology with the applications, i.e. lab, radiology systems, etc. in hospitals and patient record systems in GP offices. NNHN also decided that an important criterion for successful establishment and operation of the network was to keep the complexity of the client module running the GPs' PC at an absolutely minimum level. Instead as much as possible of the software functions were implemented in the server module running at the hospitals. This would increase the stability of the software in the GPs’ computers, i.e. decrease the probability of errors and the need for updating the software by adding new functions – for instance when a message format is changed. In 2003 NNHN, together with other regional networks, was taken over by the newly established National Health Care Network Company.

The project was staffed with people having worked at the IT department at the University of Tromsø. They were all familiar with Internet technology and the Internet way of building networks and services, i.e. developing simple working solutions first, and then defining the standards when the solutions are working and proved useful. More generally they had a very pragmatic approach to standards and standardization – the focus was on establishing services that were widely adopted as fast as possible. (The other four regional projects started instead extensive activities aiming at specifying needs etc.) The project was reorganized into an independent company, owned by the three counties of the northern health region in 1999.

Overall the NNHN effort was very successful. All hospitals and GP offices in the region were connected to the network and almost all documents covered by the services were exchanged electronically. This was in strong contrast to the slow uptake of similar services in the other regions. This was achieved by a fairly small organization.

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2 It implies that most electronic information exchange in Norway was taking place in this region and that the numbers for the rest of Norway are significantly below the national average presented
At the time NNHN was merged into the new national organization, its staff included in total 12 people. Of these 7 were doing all the software development and integration work plus operating the services. Its total budget for its last year was 4.5 MNOK (0.55 M Euros). NNHN was well informed about the interactive services developed by Fürst, and were convinced that the implementation of such services was a very important next step.

5.3.3 Well/DIPS Interactor: Interactive Orders and Referrals
In 2001 the University Hospital of North Norway (UNN) studied the use of resources and error rates related to their own laboratory activities. This study revealed that the paper-based orders from primary care often contained errors, lacked clinical information or had a mismatch between the paper-based order and the sample tube. In addition, manual and repetitive work in receiving the samples was considered a waste of resources. UNN believed electronic ordering would help improve the situation regarding both problems. They had worked together with the local IT vendor Well Diagnostics for some time (as a part of the NNHN activities) and discussed how a service for electronic ordering could be designed. Both were well aware of Fürst’s solutions. Well Diagnostics was interested in developing a similar solution, but with the difference that it should be a generic interactive ordering product for the health care market that could be used by many labs and also support other kinds ordering like referrals and radiology orders.

In 2006 they established a joint project. The system for electronic ordering of laboratory services was built in an iterative way and in close collaboration with the users at UNN and in general practice. Four months into the project, Well Diagnostics presented a simple, but working solution which satisfied the minimum requirements to enable submission of an electronic order and which was more or less a digitized version of the existing paper-based requisition. This system was based on existing interfaces developed by Fürst, and required little or no effort from the EPR vendor. But based on the real-life use and testing of this solution the product was continuously changed and adapted to the needs of the users. The result of this incremental process was the product named Well Interactor. In collaboration with Akershus University Hospital and UNN, Well Diagnostics extended the software to also support interactive referrals. DIPS Interactor was in 2010 used by nine hospitals and approximately 60 GP, while a pilot for interactive referrals included six GPs.
The types of analyses a lab can perform are quite dynamic and may change continuously. This implies that the part of the system where the GPs make their orders need to be modified every time a lab makes changes in their repertoire of analyses. In addition each individual lab offers a unique repertoire of analysis. Accordingly, the systems supporting electronic ordering need to know the repertoire of analysis offered by each single lab, and they need to be updated every time a lab changes its repertoire. Well and UNN therefore agreed that electronic ordering had to be based on a model where the labs specify their repertoire electronically in a software module on the health network. The updated repertoire is downloaded from this module to the client who is used when orders are specified. This client is tightly integrated with and appears as part of the GPs EPR. The module for referrals is based on the same ideas and the same technology for integration as for interactive lab ordering. When the GP starts to make a referral she uses the referral module of the EPR system as usual, and then the Well Interactor screen shows up as part of the regular referral window. After a laboratory order or referral is filled in it is sent using regular communication services in the national health net. The hospital has all orders sent to one unit inside the hospital and then distributes them to the labs performing the analyses. In this way the ordering GPs do not have to pay attention to internal organization of laboratory work in the hospital.

The exchange of orders and referrals is based on standardized messages as far as possible. However, much of the information exchanged between GPs and hospitals had to be specified by Well Diagnostics as no standards exist, for instance for the specifications of content of the analysis repertoire, requests for the latest versions, etc. And, as for the Fürst and NNHN solutions, the interface between the Interactor modules and the GP and hospital systems is crucial. This is done by simple file exchange, but also here the formats had to be negotiated between the different vendors. The existing standards for sending of orders and referrals are used, but have showed to be insufficient and the vendors had to find workarounds. For example, the users wanted to be able to send analyses to different laboratories (microbiology and clinical chemistry) in one order, while the national standard specifies one order for each. The vendors then had to allow for an order marked as “other” which is not in accordance with the national standard.
5.3.4 The Blue Fox Project
The Blue Fox project was run from 2005 to 2008 by the Norwegian Medicines Agency (NoMA), who is the national, regulatory authority for new and existing medicines and the supply chain. The agency is responsible for supervising the production, trials and marketing of medicines, and is a central actor in the ecology of the Norwegian health sector.

The background was a government report raising concerns that the case of subsidized medicine routine (“blue prescriptions”) was out of control. The costs of blue prescriptions were high (1 bn Euro per year) and rising. The report documented that the regulation was too complicated, resulting in different practices from doctors and concerns on accountability of refunds. In 2005 the Ministry of Health asked NoMA to suggest a new set of regulations, and a plan for implementation. NoMA consented to this, but also argued that a successful change of doctors’ (and pharmacies) prescription practices demanded not only new regulations but also support of a new IT solution.

The Blue Fox project decided on one single common module for all users. This module would then be integrated with the related systems. In the case of general practitioners and hospitals this meant their ERP systems and in the case of pharmacists the systems used in the pharmacies. In total this included seven different systems. The basic functionality had been prototyped by a consultant in 2006, and discussed with various EPR vendors during the project. The solution was implemented by all the EPR vendors, both in the GP and the specialist segments. In most cases the solution was pretty simple; the whole Refund Register is downloaded to the system (web service 1). It is maintained by a (web service 2) call for regular updates.

For pharmacies, the refund code (the ICPC or ICD code) is registered by the pharmacy at the point of sale. The PharmaPro system was extended to receive the code. This transaction also serves at documentation for the refund from NAV to the pharmacy. In addition, in order to survey the use of medicines in the population, the Norwegian Prescription Database (administered by The Norwegian Institute of Public Health) receives a copy of the transaction. A web based service was established in order to allow all patients access to the same information.
The project group consisted of six employees of NoMA: An economist as the project manager, and one lawyer, one GP and three pharmacists. There were no IT people in the project, but a consultant was hired to develop a prototype of the solution.

The project group conducted an extensive awareness campaign during 2007, aimed at all involved stakeholders. In addition to the aim of implementing the regulation, the campaign also sought to influence the culture of medical personnel, to ensure commitment to the reform. The Blue Fox project executed a number of country-wide activities, in order to inform and promote the regulation. The materials argued that the Blue Fox would ensure uniform and accountable prescription, and also enable the doctors to explain to the patients why (or why not) a blue prescription was granted.

The Blue Fox solution was implemented in March 2008, and was in full use in the whole country during 2008. After six months, almost 90% of the blue prescriptions were issued according to the new regulation. This included all the doctors of Norway, and all pharmacies. For the project costs of a modest 5 mill NOK per year, this was a rather outstanding result.

5.3.6 The Prescription register

The last project we will mention here is the establishment of the nationwide Norwegian Prescription Database (NorPD), a data base to which the pharmacies send all prescriptions (for more details on this project, see (Furu 2008)). It is used for research in pharmacoepidemiology in Norway and monitoring of doctors’ prescription practices and patients’ practices regarding taking prescribed drugs. The solution was developed and implemented in 2003 by a small project team within the Norwegian Institute for Public Health. The complete solution includes the data base, a web based interface for making queries to the data base, and a module for extracting data from the pharmacies’ systems and storing them in the data base. The whole solution was developed by the project team and delivered on time and under budget on 10 MNOK (1.25 M Euros). It is interesting to note that this register and the Blue Fox solution together cover a significant of the functionality of the ePrescription solution and the total costs of their development and implementation added up to about 4% of what is spent on the ePrescription solution so far.
5.3.7 Summing up the SPA Paradigm

The SPA approach has been implemented in a few but significant projects. These projects are different in many ways. But they also have some important similarities. When it comes to architecture none of them are based on one being explicitly defined or conceptualized – neither within the projects nor in the research literature. However, we find that it makes sense to see all of them as examples of the SPA as defined in this paper. All projects aimed at developing a communications solution which linked applications together and not extending applications so that they could communicate. In that way the communication solutions may be considered resembling the ESB concept. We also find it relevant and correct to say that the solutions were based on the SPA because the focus in all activities was to improve or give easier access to services provided by service providers, like labs, or the establishment of new services like the Prescription Register.

All SPA projects have successfully developed well working solutions at low cost and which have proved useful and delivered benefits to their users and user organization and the overall health care sector. The solutions have also proved flexible to adapt to changing user needs and to support new ideas for better ways of working and organizing as such ideas emerge. We will in section 6 discuss the key differences between the two approaches.

5.4 International experiences

We will also mention a couple of international experiences. A well known, and widely discussed, initiative regarding ICT in health care is the National Health Services programme “Connected for Health” in UK established in 2003 (for some of the discussion about this programme, see the special issue of Journal of Information Technology (Sauer and Willcox 2007)). One of the main elements of this programme is the establishment of a nationwide Summary Care Record system, i.e. a system containing a summary of the patients’ patient record. This includes primarily information about medication and allergies, i.e. a solution which is on the conceptual level quite close the Norwegian ePrescription solution. The project started in 2004 and was frozen in May 2010 after about 250 MGBP (300 M Euros) were spent (Greenhalgh et al. 2008, Greenhalgh et al. 2010)! In contrast to this is a similar solution developed in Scotland. The development of the solution started in 2004 and it was rolled out nationally in 2005/6. The development costs were about 3 MGBP. In total about 25 MGBP have been spent over 9 years on the planning,
development and operations of the solution. The English system is based on the IIA and the EDI paradigm while the Scottish is based on the SPA (Hyslop 2010, Bushendorfer 2010, Herbert 2010).

Finally, we will also mention the development of the Danish national summary care record system. An official project started by The National Board of Health in 2000 (Aanestad and Jenssen forthcoming). About 20 people worked full time on the project at The National Board of Health in addition to those involved working for hospitals and IT vendors. At the same time a small project started in collaboration between two smaller municipalities in western Denmark aiming at developing a solution enabling sharing of patient data. The first version of the system worked well and was appreciated by users. As knowledge about this spread other municipalities adopted it as well. In 2004, due to lack of progress, the activities in the project organized by The National Board of Health dried out. The project was officially closed down by 2008, after the other solution had diffused and become the de-facto national solution. Again, the successful solution was based on the SPA while the failed one on the INA (ibid.).

These cases, then, matches perfectly the picture emerging from the Norwegian experience.

6. Discussion
Discussion the INA and SPA approach, we will focus on three key issues; the ICT architecture, the project organization and the associated risk. We summarize our argument in table 2.

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<th>INA approach</th>
<th>SPA approach</th>
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<tr>
<td>ICT architecture</td>
<td>Many applications, sending messages to each other</td>
<td>Single application, distributed to clients</td>
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<td>Project organization</td>
<td>Co-ordinated teams in many organizations</td>
<td>Single team, within one organization</td>
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<td>Overall risk</td>
<td>High</td>
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Table 2. Comparing the two approaches

6.1 The INA Approach
As our case studies showed, all the INA projects were problematic. They all suffered from various problems associated to complexity; the large number of involved actors, the heterogeneity of technical solutions, and the many dependencies that created postponements and friction when schedules were not kept. The key to these problems are illustrated in figure 4. The chosen ICT architecture was (as usual in EDI solutions) based on the data flow between
the involved organizations. This led to a relatively complex ICT architecture, with a large number of messages flowing between a large number of systems, which means that many local applications must be modified in order to produce and receive messages. In practice, each vendor has to develop their own client modules of the solution. For example, in the ePrescription project described earlier, the 6 vendors of EPR systems present in the Norwegian marked (3 GP and 3 hospital systems) each had to make their own version of a quite complex piece of software with exactly the same functionality.

Further, the INA solution implies a project organization with participants from all involved actors, usually organized as a number of sub-projects, with a central co-ordinating actor. As observed by van der Aalst (2009) this increases the challenge of co-ordination. The co-ordinating actor cannot usually instruct the other participants (since they represent independent organizations), but will have to manoeuvre with compromises and politics. This combination of technical and organizational complexity increases significantly the risk of postponements and even failure, as shown in the cases.

![Figure 4. The INA approach](image)

### 6.2 The SPA Approach

The SPA projects, although different in type and scope, were all successful. Our analysis shows that the overall reason was the chosen ICT architecture. This architecture did not reflect the information flow between the numerous
organizations, but it was based on a solution from one application service provider. As illustrated in figure 5 this simplifies greatly the solution.

In the SPA based solutions the important interfaces within the overall solution are the interfaces between the communication solution and the applications - not the interfaces between the different modules of the communication system that are running within different organizations. In the SPA architecture there is a tight coupling between the different components of the communication system and weak coupling between the communication system and the applications, while the INA based solutions are based on tight coupling between the applications and the communication system (i.e. the module running within the same institution) and loose coupling between the modules within the communication system.

The most crucial aspect of the SPA based solutions, in the context of this paper, is the fact the architecture of the communication solution allows the complete solution to be developed by one single project team within one single formal organization. Only minor development work needs to be done by other organizations like application vendors. In more general terms, the important aspect of the SPA architecture is the fact that the complexity of the development organization becomes dramatically reduced compared to those of the INA based solutions.
Summing-up the increased risks of the INA approach compared to the SPA approach:

- A more complex technical solution, with a higher technical risk
- A more complex project, with very challenging co-ordination
- Higher costs, because the vendors will all have to develop their own client solutions
- Higher implementation risk, because the INA solution requires that all actors start at the same time. Such “big bang” strategy is more risky than an incremental approach (Bygstad et al. 2010) as the SPA allows for.

6.3 The role of architectures
The role of architecture is considered most significant related to the maintenance of ICT systems over time, i.e. proper modularization is more important when it comes to maintain and make required modifications in an existing solution that during the initial development of the solutions. In this paper the focus has been on the role of architecture related to the initial development of ICT solutions. We believe that the requirements regarding proper modularization are more extensive when it comes to maintenance and modifications based on changing requirements also for the kind of ICT solutions we have focused on in this paper. The empirical evidence presented here has demonstrated that the INA architecture generates a technological and organizational (in particular) complexity that makes it very hard to successfully develop the solutions. None of the INA based solutions have reached a stage where maintenance and modifications based on new requirements has become an issue. What we have seen, however, is that new requirements emerge during the development stage and that accommodate to these new requirements have been challenging indeed. We find it reasonable to believe that the maintenance of INA based solutions, in the cases when they are successfully developed and deployed, will be quite a challenge. The SPA based solutions presented here have all been successfully developed and deployed. Although our focus has been on development, we see that some of them (Fürst, Interactor, NNHN) have been changed significantly over time. Accordingly, the SPA also seems to make maintenance and modifications easier.

6.4 Alternative explanations?
We have presented our evidence, and argued in rather strong terms that the INA approach should be avoided in large eHealth projects. Since this view currently goes against conventional wisdom of the field, we concede the need
to discuss alternative explanations. For example, if the INA approach has worked well in e-business, why doesn't it work in eHealth?

We believe that the health sector presents some challenges on another scale of complexity than the e-business. In e-business there is a limited set of message types, such as orders and invoices, which are relatively easy to standardize. E-business solutions are generally characterized by a high volume of relatively simple commercial transactions between relatively few types of actors (typically vendors and buyers). The eHealth field is in contrast much more complex, with many different actors and a vastly larger number of application areas and message types.

Are there alternative explanations of the outcome of the cases? For example, were the INA projects generally larger and more complex than the SPA projects, and thus unreasonable to compare? This is an important issue, because it is true that the INA projects generally were larger. Our view, however, is that the INA projects were larger because of the chosen architecture, rather than because the problem to be solved was larger. The key point is that the choice of ICT architecture greatly influences on the size and complexity of the project.

7. Conclusion

In this paper we have addressed the relationship between technological architectures and organizational risk. In particular the paper focus on a technological architecture’s impact on the complexity of the project organization required to develop the solution, and how this complexity again influences the success rate of the projects.

The efforts aiming at developing information infrastructures for improved collaboration among health care institutions in Norway have from its very early days been dominated by one technological architecture – which we here have called INA. But a few, but significant number of, projects, have adopted an alternative architecture which we here have called SPA. The contrast between these two groups of projects is striking – in terms of success rate, development costs, flexibility to adapt to changing user requirements, and not the least benefits delivered to users and user organizations.

We found that the SPA has significant impact not only on the complexity of the technological solutions, but – more importantly – also on the complexity of the projects developing the solutions. The organizational complexity, and
hence the co-ordination activities, were dramatically reduced, and the success rate of the projects and the benefits for the users similarly increased.

The implication of the research presented here is that the choice of architectures of information infrastructures needs to be more carefully considered by those involved in projects aiming at building such infrastructures, and that a more service oriented architecture should be preferred in favour of institutional interface architecture when building infrastructures like those presented in this paper. And in particular, one needs to consider carefully the implications of proposed architectures on the complexity of the organizations required developing, operating and maintaining the infrastructure.

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