

POLYCENTRIC GOVERNANCE OF INTERORGANIZATIONAL SYSTEMS: MANAGERIAL AND ARCHITECTURAL ARRANGEMENTS

Research paper

Vassilakopoulou, Polyxeni, University of Agder, Kristiansand, Norway, polyxenv@uia.no

Pesaljevic, Aleksandra University of Oslo, Oslo, Norway, aleksape@ifi.uio.no

Margunn, Aanestad, University of Oslo, Oslo, Norway, margunn@ifi.uio.no

Abstract

In an increasingly digital world, introducing new interorganizational systems requires establishing associations and relying on contributions of multiple actors that control existing technical solutions. This article examines the question: “how can large-scale system implementations across multiple organizations be governed in situations of distributed control over components?”. To answer this question, we present the findings of a longitudinal case study on the introduction of e-prescription in Norway over a 14-year period. The findings point to complementary architectural and managerial arrangements that make possible a polycentric governance approach. This work contributes to research on Information Systems Governance by providing insights relevant to mandating large-scale system implementations across organizations by mobilizing and orienting multiple contributors that control various pre-existing solutions.

Keywords: polycentric systems, interorganizational systems, e-prescription, brownfield development.

1 Introduction

The topic of the track calls for studies on mandating large-scale system implementations across multiple organizations. Such interorganizational systems (Barrett and Konsynski 1982) are found in many different settings. For instance, they have been introduced since the 70s in the travel industry (Copeland and McKenney 1988) and in the banking industry (Zachariadis et al. 2013). Following the commoditization of network communications in the late 90s, interorganizational systems sprouted across commercial and public sector settings (Carugati et al. 2016; Constantinides and Barrett 2006; Currie and Guah 2007; Johnston and Gregor 2000). Interorganizational system endeavors are especially challenging when compared with intraorganizational ones due to their managerial complexity (they entail distributed managerial agency beyond each implementing organization's leadership). Moreover, the achievements of those systems are always perilous; their goals can only be met after being introduced into use across the network of organizations involved, hence, sustained network-wide adoption is a condition for benefits realization. As we move beyond the early digitization era, the introduction of interorganizational systems in our already "digitized world" is posing additional challenges. Today, new systems have to become part of technologically congested system landscapes. Such "brownfield" development requires taking into consideration existing systems and actors related to them (Bygstad and Hanseth 2016; Hopkins and Jenkins 2008). A key new challenge for deploying interorganizational systems today relates to finding ways for blending with what is already in place. One possible way for achieving this, is by adding functionalities to existing systems instead of introducing novelty in the form of new self-contained interorganizational solutions. This approach can facilitate adoption and minimise tensions with use organisations related to coping with externally imposed systems. In practical terms, new interorganizational systems can appear as mere extensions of what is already in use. Furthermore, such arrangements, can allow a level of distributed control over functionality even though the whole system is externally imposed. Although technically viable in most cases, this pre-existing system-friendly approach can be very demanding sociotechnically as it requires mobilizing various providers of systems that are already in place in different, heterogeneous organizations.

To explore the contemporary phenomenon of bringing interorganizational systems in already digitized environments, we studied the introduction of the government initiated e-prescription in Norway. This system supports prescribing, dispensing and reimbursing medications and other medical goods by circulating information between different organizations within healthcare (e.g. primary care units, hospitals, pharmacies) and beyond (e.g. reimbursing authorities). The adoption of e-prescription reduces the risks associated with traditional prescription-writing, and can bring different benefits to different healthcare providers, especially if implemented at scale (Cornford et al. 2014). At the same time, the inscription of rules to e-prescription can be a powerful mechanism for controlling prescribers and dispensers (Vassilakopoulou et al. 2012). In this respect, e-prescription has a dual role: it is a system introduced to improve healthcare delivery but also, to regulate, control and monitor a large array of professional tasks (Vassilakopoulou and Marmaras 2015). E-prescription reached the different use organizations in Norway through the systems that were already in use. Specifically, the government decided to leverage for the front-end the pre-existing systems that prescribers (mostly doctors) and dispensers (mostly pharmacists) were using. The decision to follow this approach triggered a lengthy and challenging process that entailed collective action from multiple actors that developed extensions for a multitude of existing systems (Hanseth and Bygstad 2017). This process led to the creation of an interorganizational system that allows some level of distributed control over functionality. The Norwegian e-prescription system facilitates services and information exchanges that cross multiple organizations but unlike typical integrated systems (Goodhue et al. 1992; Markus 2001; Singletary 2004; Tanriverdi et al. 2010) it can evolve without presupposing full visibility and centralised control. In other words, the different system parts can dynamically adapt through mutual interactions.

We delved into prior Information Systems Research and found limited relevant insights for putting in place such interorganizational systems that are externally initiated but allow some level of distributed control. Nevertheless, we found relevant insights in the work of Polanyi on governance and in the

commons literature where the concept of polycentricity has been proposed (Ostrom 2010; Polanyi 1951). Polycentric governance is suited for settings where multiple actors can exercise considerable independence within their own domains but there are also actors with cross-cutting jurisdictions shaping the arena of action.

This paper examines how e-prescription was deployed as a polycentric integrated system in Norway. Our study considers polycentric governance as especially relevant for the introduction of novel information technology capabilities in the current heavily digitalized environments where multiple semi-independent technologies are already in place. Specifically, it examines the following question: “How can large-scale system implementations across multiple organizations be governed in situations of distributed control over components?”. Answering this question, this paper points to complementary architectural and managerial arrangements and identifies polycentric governance of interorganizational systems as an approach that needs to capture more attention in Information Systems Research. This work contributes to research on Information Systems Governance by providing insights relevant to mandating large-scale system implementations across organizations by mobilizing and orienting multiple contributors instead of introducing novelty in the form of new self-contained solutions.

The remainder of the paper is structured as follows. First, we present related prior research and introduce the theoretical concepts that informed the case analysis. Then, we describe the method used to collect and analyse our empirical material, we provide an overview of the case investigated and we present our findings. Subsequently, we discuss the insights from our analysis, we point to the contribution of our research and we conclude by pointing to limitations of our study and further research directions.

2 Related Literature and Theoretical Background

2.1 Prior research in interorganizational information systems and their governance

During the past decades there has been a growing volume of research on interorganizational information systems (Chatterjee and Ravichandran 2004; Reimers et al. 2014; Robey et al. 2008; Tsiga and Chong 2016). In most cases, research on such systems has been approached from the familiar perspective of clearly bounded information system projects (Reimers et al. 2014) within relatively short time scales and with either purely technical interests or with a clear interest on business impact and value creation. Furthermore, the governance of interorganizational information systems is relatively under-explored although it is attracting more research attention (Markus and Bui 2012; Prasad et al. 2012; Trang et al. 2013). Interorganizational information systems have been studied from a sociotechnical perspective in the information infrastructures stream of research which has investigated the evolution of unbounded, interconnected infrastructures that span localities (Monteiro et al. 2013; Pollock and Williams 2010; Star and Ruhleder 1996; Tilson et al. 2010). Information Infrastructures are used across many different organizational settings and endure over long periods (decades rather than years). Research in this stream has proposed different strategies. Hanseth and Lyytinen proposed growing large-scale infrastructural arrangements by bootstrapping small-scale novel capabilities designed for usefulness (Hanseth and Lyytinen 2010). Lately, researchers have proposed platformization as an approach for enabling interorganizational information exchanges while fostering innovation (Gawer and Cusumano 2002; Ghazawneh and Henfridsson 2013; Tiwana et al. 2010). Although prior research has shown that large-scale interorganizational systems can be based on an installed base of proprietary closed systems (Reimers et al. 2014) these insights have not been operationalized and governance of large-scale implementations in situations of distributed control remains a challenge. Architectural and managerial arrangements are pivotal for governance in interorganizational settings just as they are within organizations (Weill and Ross 2004). The governance of interorganizational information systems is relatively under-explored although it is attracting more research attention (Markus and Bui 2012; Prasad et al. 2012; Trang et al. 2013).

2.2 Polycentric governance

To analyze our case we draw from the concept of polycentricity. This concept was first introduced by Polanyi to distinguish between directed order coordinated by an ultimate authority through a command structure and a situation where individual decision makers can pursue their own interests within a general system of rules (Polanyi 1951). The concept of polycentricity has been adopted by Vincent and Elinor Ostrom, for the analysis of collective-action problems involved in the provision of public goods (Ostrom 2010). The key features of polycentricity are: (1) the existence of many centres for decision making, (2) the existence of an overarching system of rules where actors with cross-cutting jurisdictions play a significant role, and (3) the emergence of spontaneous order as the outcome of evolutionary dynamics (Aligica and Tarko 2012; McGinnis and Ostrom 2012). Polycentricity provides an analytical lens for the study of large-scale projects for interorganizational systems that are not fully defined and controlled by one central actor. It fits situations where multiple centres of decision making come into play. Each unit within a polycentric arrangement exercises considerable independence within a specific domain and can bring significant benefits to the overall system through learning and adaptation to disturbances over time (Finka and Kluvánková 2015). Polycentricity is different from federalism because it requires the existence of actors with cross-cutting jurisdictions specializing in particular matters (McGinnis and Ostrom 2012). This fits well with situations where a governmental agency pursues the introduction of interorganizational systems.

3 Method and Case Background

3.1 Method for data collection and analysis

We performed an in-depth longitudinal case study of the Norwegian e-Prescription tracing its evolution from initial conception back in 2003 until the end of 2016. This case study allowed us to investigate how large-scale system implementations across multiple organizations can be governed in situations of distributed control over components. Due to the complex nature of the phenomenon of interest, a case study was a natural choice of research method (Yin 2013). The Norwegian e-prescription case is an exemplar of developing interorganizational information system capabilities by multiple contributors in a distributed control setting. The multiplicity of contributors is due to the digital density of the existing landscape. In Norway, all hospitals, General Practitioner (GP) offices and nursing homes use Electronic Patient Record (EPR) systems (developed by different vendors) and exchange standard electronic messages (e.g. referrals, discharge letters) overall a national network infrastructure. Introducing e-prescription in this landscape, requires large-scale development across multiple organizations. Unlike other earlier interorganizational initiatives, novelty was not introduced in the form of a new self-contained solution but rather, as a series of extensions to existing system capabilities. This was done by soliciting contributions from multiple private system vendors and governmental technology providers. The case is paradigmatic (Flyvbjerg 2006) of an approach to system development that we expect to encounter with increasing frequency as new interorganizational information capabilities need to be introduced in digitalised environments.

The impetus for our study came from our involvement in a larger research project on the interplay between new information technologies and pre-existing sociotechnical arrangements. The collection of empirical material for this e-prescription case study, started in spring 2013 and ended in November 2016. One of the paper authors was initially involved as a professional project manager in the development of e-prescription for about a year, nevertheless, data collection continued for about three years after her professional involvement was discontinued. The case was already known to the authors through press coverage and published research. We were struck by the growing case complexity in terms of increased number of actors with various roles, increased coordination challenges, and also increased uncertainty on how relations evolve over time. Having good access to the case gave us the opportunity to explore its particularities.

Initially, data collection aimed to tracing the trajectory of the initiative and the key events since its start, to mapping the different components and to following the evolution of dynamics between actors. As we became more familiar with the case, we oriented our interest on Governance and specifically on the managerial and architectural aspects of the governance arrangements for e-Prescription. The first data collection period (till October 2014) allowed us to build an overall understanding, while, from October 2014 data collection was focused on Governance. Data were gathered from several different sources (semi-structured face-to-face interviews, documentation and observations in meetings and workshops). Overall 14 different informants were interviewed. Five of them, were interviewed multiple times. This was needed either for capturing new events or for asking questions on aspects that were not initially covered (related to managerial and architectural arrangements). Specifically, three informants were interviewed twice (a pharmacist, a project participant with testing expertise and a project participant with data expertise) while two informants were interviewed three times (one with a senior managerial role and a business analyst from the Norwegian Health Directorate). The documents collected and analysed include general strategic documents for Norwegian Healthcare System Planning, Policy, Regulations and Standards and specific documents on e-prescription (listed in the appendix). Overall, the research reported is based on empirical data collected using a combination of fieldwork and documents' analysis (Table 1). Additionally to empirical data we collected and went through peer-reviewed publications on interorganizational information systems. An initial search through ISI Web of Science led to 751 results but most of the papers were not very relevant for our research (for instance, a large volume of papers was on domain-specific issues within supply chain management and logistics). We refined the search by including "implementation process" and excluding papers published before 2000 which reduced the total number to 59 papers. We drew upon these papers to make sense of contemporary issues related to interorganizational information systems implementation. Exposure to this prior literature contributed to orienting our attention to governance.

Source	Description
Interviews	21 semi-structured interviews with professionals involved in the development of e-prescription (with expertise in law, technical architecture, development, testing) and professionals with domain specific knowledge (a General Practitioner and a Pharmacist).
Observations during meetings and workshops	50 meetings including both meetings in the Norwegian Health Directorate and meetings between different e-prescription parties, 10 whole-day workshops with different actors (e.g. workshops with EPR system vendors, workshops with pharmacists).
Document analysis	Norwegian Healthcare Strategic Planning Documents; Policy, Regulation and Standards Documents; Project Documents (the specific documents on-e-prescription is are listed in the appendix)

Table 1. Data sources

We performed the analysis in an iterative way working with both empirical data and readings from literature. An initial timeline of events was created and a preliminary narrative on the evolution of the Norwegian e-prescription was developed. The different events identified were further investigated through document analysis and interview follow-ups. As we became more familiar with the case we focused our analysis on governance and on the related managerial and architectural aspects. Through this process some of the events were eliminated from the study as not relevant to governance. The aim of this within-case analysis was to achieve good familiarity with the relevant episodes (Eisenhardt 1989). This was followed by a cross-episode analysis to identify common themes related to managerial and architectural arrangements. As we analysed the case data we also studied different streams of literature on governance. Within this literature, we identified the concept of polycentricity as highly relevant to the particularities of distributed control in our case and we adopted it as a lens for data analysis. In Figure 1 we provide a schematic overview of the 3-step data analysis process followed.

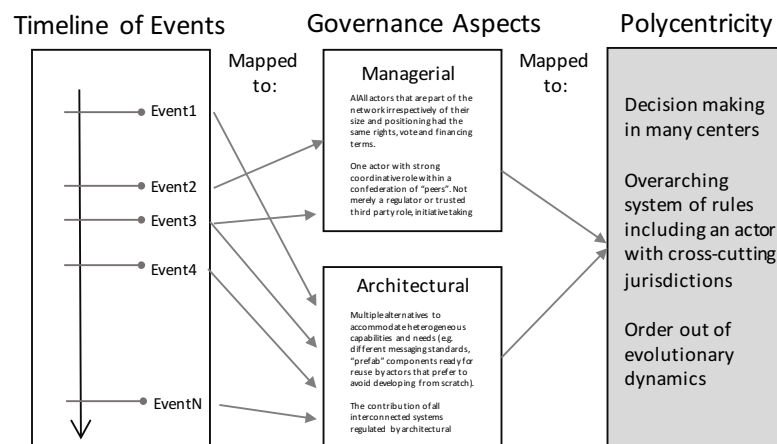


Figure 1. A 3-step data analysis process

3.2 Case background

The main users of the Norwegian e-prescription solution are shown in Table 2. The users are related to different organisational entities (hospitals, primary care units, pharmacies, medication regulators, reimbursement authorities). These organisational entities are key actors in the e-prescription initiative.

Role	Description
Prescriber	Healthcare professional that has the right to prescribe medications and reimbursable medical merchandise. Key prescribers are General Practitioners (GPs) and Hospital doctors.
Dispenser	Pharmacist or Bandagist that expedites prescriptions, dispenses and sends merchandise and passes settlement demand to the settlement body.
Settlement-body for reimbursable items	A body that checks dispensed prescriptions against regulations. Receives and processes applications for reimbursement. In Norway, HELFO (Norwegian Health Economics Administration).
Medications Controller	A body responsible for managing the list of approved medications (FEST) and processing applications for medications exemption-approval. In Norway, SLV (State Medicine Agency).
Patient	A person who contacts health professionals requesting health care. Prescriptions are individualized and patient-specific.

Table 2. Main Norwegian e-prescription users.

Beyond the actors that are related to the users presented in Table 2 there are several more. A key actor is the Norwegian Health Directorate that is a specialized agency under the auspices of the Norwegian Health Ministry which is bestowed with the authority to implement national health policies and to ensure secure and simple information flows in the health and care sector. Lately, the e-health related units of the Agency were detached from the overall organization and formed the “e-Health Directorate” which was established on 1.1.2016. The communication across organizations is supported by a dedicated, closed, secure network; the Norwegian Health Network (NHN). NHN was established in 2005 by harmonizing and consolidating previous existing regional networks, and by pursuing national standards for electronic communication in the health sector. A key reason for the consolidation of networks at a national level was the need to facilitate e-prescription. Additional key actors include the Electronic Patient Record systems (EPRs) vendors and other software companies involved in systems development in the healthcare sector.

The National Social Security Administration initiated e-prescription back in 2003. In 2005, e-Prescription was organized as a Program with multiple underlying projects led by the Norwegian Health Directorate. All the parties that took part in the e-prescription Program got 50% government financing of costs incurred for developing e-prescription functionality in their own systems (for EPR vendors there was a condition that the e-prescription would not cause increased license prices).

4 Analysis

4.1 The evolution of the e-prescription initiative

At the end of 2006, all the parties signed a Cooperation-Agreement (Samhandlingsprotokoll) committing to the development and introduction of e-Prescription in Norway. One of the initial steps was the launching of a call for tenders stimulating vendors to extend existing EPR systems with prescribing functionality. In this initial call, only one EPR vendor responded. This company was at that time developing a new EPR product. A contract was made and a pilot was planned for the end of 2006/beginning of 2007. This plan was overoptimistic and was later revised. Eventually, e-Prescription was piloted in May 2008. There was only one GP office included in the pilot so, it took some time to realize that the pilot was not satisfactory (mainly due to the overall immaturity of the new EPR product). The pilot stopped in September 2008 by the County Medical Officer. After the unsuccessful first attempt, the e-prescription Program was re-planned. It was determined that new version of e-prescription will be developed. All EPR vendors participated this time but the new pilot was based only in one vendor's solution as not all vendors were ready for piloting (this vendor was different from the one that developed the solution for the first pilot). The new pilot started in May 2010 and this time, it went smoothly.

At the pharmacy side, e-prescription was based on a newly developed pharmacy solution. At that time all pharmacies in Norway were using the same solution which was developed by a software company owned by the pharmacists' association (as of 2017 there are three pharmacy systems). As the new pharmacy system had to be deployed in multiple pharmacies, the software company developed a middleware named migration-factory (Migreringsfabrikken) to speedily deploy the new system across Norway. Practically, the migration-factory was a demand from the Health Ministry as it was critical to ensure the possibility of dispensing electronic prescriptions from all pharmacies and not only from selected few.

During the second semester of 2010, the Health Directorate initiated the development of a prescribing module (Forskrivingsmodulen or FM) that could be used in the case of further delays in EPR vendor deliveries. FM was conceptualized as a generic, semi-independent component of existing EPRs; all information exchanges with e-prescription actors would be taken care of by this module but it would not be functional in a standalone basis (i.e. not possible to run without an EPR). For the development of FM, the Health Directorate issued a call for tenders which was won by a company based in Iceland. This company went bankrupt on November 2011. After a meeting between Health Directorate and consultants from the bankrupt company engaged in FM development, a new company was created to host the FM developers and a new contract was signed (after a new call for tenders) making the continuation of development possible. FM was initially used to secure deployment of e-Prescription nationwide, making it much easier for EPR vendors to add e-prescribing functionality when their in-house development efforts were not advanced (the estimated cost of linking an existing EPR to FM is 1/100 of the cost required for developing all the functionality that the FM module covers). FM was built having in mind some of the EPR vendors that were lagging behind in development and also smaller vendors that develop systems for health practitioners with low prescribing volumes (e.g. dentists, ophthalmologists) but, eventually it was used also for adding e-prescribing functionality to hospital systems and to the systems used in community care (Pleie- og omsorgstjenesten). The FM module was offered to all EPR vendors without charge for its use. For its implementation, vendors had to develop connections to their own systems and to handle user support. The introduction of FM, facilitated significantly the full deployment of e-prescription which started in 2011. By 2013, e-prescription was in use by doctors and pharmacists throughout the country. Figure 2 presents a timeline of key events.

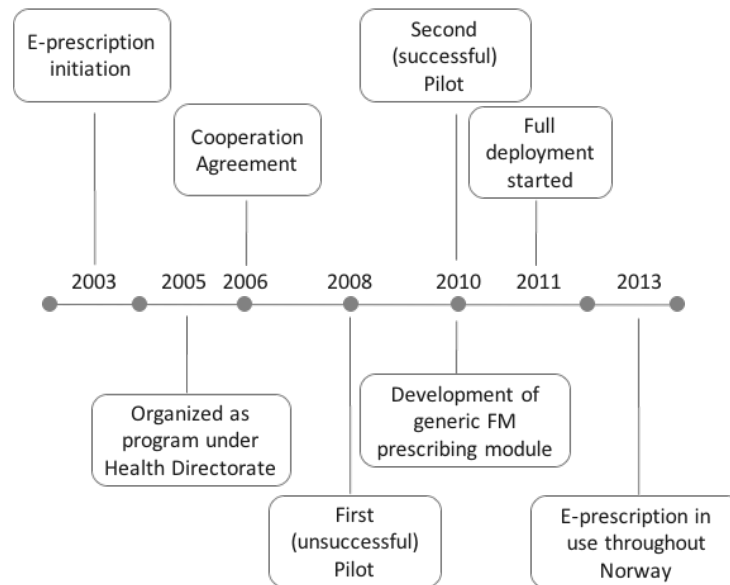


Figure 2. Timeline of e-prescription introduction in Norway

Beyond being built upon existing pharmacy and doctors' systems, e-prescription relied also to multiple other systems and registries of the Norwegian Health Sector. A key system is FEST, which provides information on approved medications and is maintained by the State Medicine Agency. The same agency maintains and provides access to the registry of all pharmacies that have a valid concession. Another key system is the settlement and control solution of HELFO (Norwegian Health Economics Administration). HELFO also supports the lookup into the GP registry containing connections between citizens and their GPs and also, into the registry of bandagists that have a settlement agreement for reimbursable medical goods. Bandagists are healthcare professionals specialised in medical goods such as wheelchairs, walking aids, dietary supplements etc. Another important registry connected with e-prescription is the health personnel registry which is managed by the Health Directorate and is required for authorizing prescribers. Two more key registries are the address registry which contains electronic addresses of all NHN users and is used as a basis for message exchange in e-prescription and the public key infrastructure (PKI) registry. All these connections are handled by a key component of e-prescription: the "prescription mediator" (reseptformidler), which was developed by a software company and is operated by Health Directorate (it was tested and accepted in 2009). The prescription-mediator has a central role in sharing and dispatching information among e-Prescription parties and safeguards the objective of free choice of dispensers (patients can go to any pharmacy and get medications with a valid electronic prescription). It has a role as a trusted party linked to the validation of prescription information that gets redistributed to other parties in the e-Prescription value-chain. Figure 3 provides an overview of the various system connections and the respective actors involved.

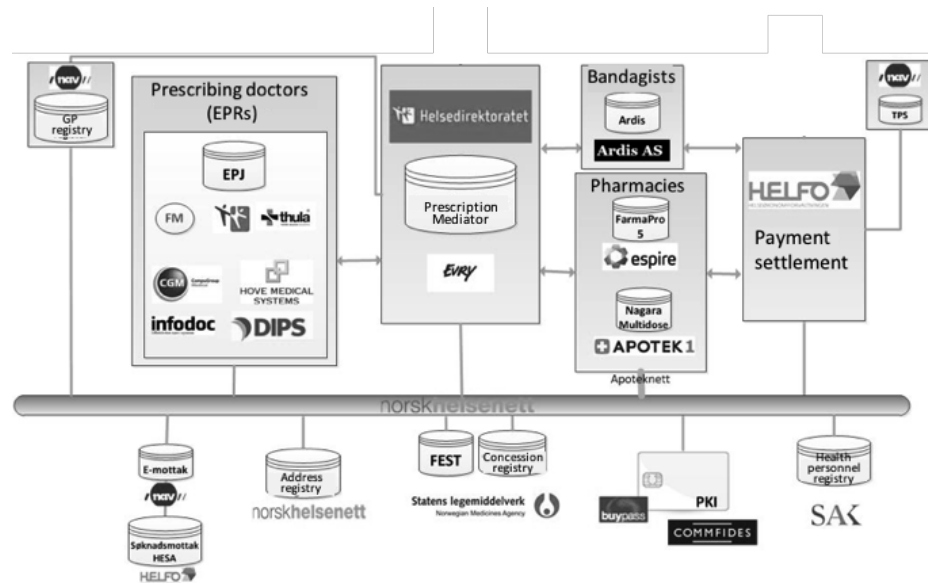


Figure 3. Overview of the Norwegian e-prescription solution including key actors

The deployment of e-prescription throughout Norway was followed by numerous improvements and extensions. A key extension was the introduction in 2014 of multidose dispensing (machine-packed medications in separate bags for each dosage time, labelled with Patient’s ID, drug information and timing of intake). Also, an extension was developed to support ordering of prescription medications through online pharmacies. Recently, additional initiatives were launched. A comprehensive and updated overview of patient’s medications at a given time is under development. Furthermore, the possibility to provide connections with the Norwegian Institute of Public Health is being assessed. The Public Health institute has requested access to information in order to get insights on how antibiotics are used. This information is valuable for the action plan to reduce usage of antibiotics.

In Table 3 we provide an overview of the evolution of e-prescription since 2003.

Phase	Period	Key Actors	Key events
Initiations	2003-2004	National Social Security Administration, Health Ministry, Health Directorate	Social Security Reform Decision to initiate e-Prescription
Planning & Initial Development	2005-2006	Health Ministry, Health Directorate, SLV, Pharmacists Association, Doctors Association, Bandagists, EPR vendors and other software development companies	Starting e-Prescription program Merging NHN on a national level Cooperation-agreement
Unsuccessful Deployment Attempt	2007-2008	Health Ministry, Health Directorate, SLV, Pharmacists Association, Doctors Association, Bandagists, EPR vendors and other software development companies	Tender First Pilot County stops pilot after significant problems emerge
Successful Deployment	2009-2012	Health Ministry, Health Directorate, SLV, Pharmacists Association, Doctors Association, Bandagist, EPR vendors and other software development companies, HELFO	Re-planning Prescription mediator launched Successful pilot and rollout Migration Factory for pharmacy systems Prescribing Module developed My Prescription service
Management, Operations & further Upgrades	2013 – 2016	Health Ministry, Health Directorate, Directorate of e-Health, Pharmacists Association, Doctors Association, Bandagists, EPR vendors and other software development companies, HELFO, PLO (Municipal Care institutions), Norwegian Institute of Public Health	Multidose Dispensing Online-pharmacy Initiatives for comprehensive overview of patient’s medications and for connecting with the Institute of Public Health

Table 3. Overview of Norwegian e-prescription evolution.

4.2 Managerial and architectural aspects of establishing a polycentric e-prescription system

In the following paragraphs we look at the actual managerial and architectural arrangements in the e-prescription case that supported the key features of polycentricity. Specifically, we look at the arrangements that accommodate many centers for decision making, the arrangements for an overarching system of rules including an actor bestowed with cross-cutting jurisdictions, and the arrangements for the emergence of order out of evolutionary dynamics.

4.2.1 Many centers for decision making

One of the key aims of the initiative was to build upon the diverse technological systems that were already in place. The initial approach assumed that the different parties would be able to develop their own components according to common high level specifications. This proved an unrealistic assumption, since the different actors had systems based on different technologies, and different internal levels of capabilities, resource availability and strategic priorities. To address this heterogeneity, the Health Directorate provided different options for building the e-prescribing extensions required for the various systems. One option was to develop everything from scratch (and get partially funded for this development), another option was to use “prefab” components (namely the prescribing module or FM) and incorporate them to existing solutions with minimal development work. Similarly, there were two methods supported for message transport: asynchronous (eXML over SMTP) and synchronous (Web services over HTTP). All the messages considered time-critical were planned as synchronous, while for the rest, the various actors could choose whether to go for synchronous or asynchronous messaging based on the characteristics of the peripheral systems connected. What happened in practice later on when the solution was taken to use was that asynchronous messages were rarely used since they were not as effective. As a consequence, asynchronous messages were phased out. By phasing out asynchronous messaging the overall architecture was simplified. However, this simplification was accomplished after the choices of the different actors were known and tried out.

4.2.2 An overarching system of rules including an actor bestowed with cross-cutting jurisdictions

The distributed decision taking by multiple actors proved to be challenging. The different private vendors had their own plans for the upgrading of their solutions and have been repeatedly lagging behind schedule in the development of their e-prescription components. Furthermore, the e-prescription program had to address the mishap of the bankruptcy of one of the key external software developers during a critical time period for the whole initiative. The Health Directorate had a key role in resolving all these different issues. Although the e-prescription program was conceptualized as collective action between multiple parties where no actor has full ownership, the coordinating role of the entity managing the program was pivotal for its completion. As different problems were faced, the coordinator had to step in, assess different alternatives and take action. In several cases, the coordinator had to take new roles related to development and support, in other cases issues were resolved through negotiations, updates of plans and new formal agreements.

4.2.3 Emergence of order out of evolutionary dynamics

Another key challenge was the need to continuously adapt to changes in the overall healthcare landscape. In today’s dynamic environment, needs keep evolving and new actors keep appearing. After launching the e-prescription solution additional needs had to be accommodated, for instance, dispensing of medications through e-pharmacies had to be facilitated, multidose packaging for chronic patients had to be supported and patient access to prescription history and logfiles had to be provided. The decisions for introducing novelty in the e-prescription solution were driven by the overall Norwegian Health policies and regulations. The loose coupling of different systems in the overall solution allowed multiple further adaptations and extensions. Practically, this loose coupling made possible to

handle many of the architectural choices as tentative and provisional. The renewal of the overall arrangement is happening in a gradual, evolutionary way (e.g. the document logic which was the starting point of the initiative, is being gradually phased out).

Overall, the Norwegian e-prescription initiative went through a lengthy exploration process before delivering results (conceptualized in 2003 but full deployment started in 2011). The lengthy exploration process can be linked to the polycentric character of the initiative. Although it took several years to put in place a workable arrangement, the resulting system is now ingrained across the sector and shows significant dynamism evolving and expanding in terms of functionality. Already in 2014, more than 37,5 million prescriptions were processed through e-prescription (75,3% of the country total). As of 2017, e-prescription covers more than 80% of prescriptions. It is in use by all pharmacies (868 as of 2017), general practitioners (about 4650 as of 2017) and emergency units (182 as of 2017). Table 4, summarises the key findings.

Key Features of Polycentricity	Architectural Arrangements	Managerial Arrangements
many centers for decision making	Multiple alternatives to accommodate heterogeneous capabilities and needs (e.g. different messaging standards, “prefab” components ready for reuse by actors that prefer to avoid developing from scratch).	All actors that are part of the network irrespectively of their size and positioning had the same rights, vote and financing terms.
an overarching system of rules including an actor bestowed with cross-cutting jurisdictions	The contribution of all interconnected systems regulated by architectural principles.	One actor with strong coordinative role within a confederation of “peers”. Not merely a regulator or trusted third party role, initiative taking is key. Stepping-in by undertaking additional roles.
emergence of order out of evolutionary dynamics	Loose coupling of different systems allowing multiple adaptations and extensions.	Directions based on national healthcare policy and regulations.

Table 4. Key features of polycentricity and relevant architectural - managerial arrangements

5 Discussion and Conclusion

Our study of the Norwegian e-prescription solution shows that a polycentric governance approach was followed. This Norwegian e-prescription solution is leveraging numerous pre-existing systems of the Norwegian healthcare landscape: the EPRs in use by doctors, the pharmacy systems, the systems used by bandagists, the systems that support medications’ control and reimbursement and a series of registries (the GP registry which contains connections between citizens and their GPs, the registry of bandagists that have a settlement agreement, the health personnel registry, the NHN electronic addresses registry and the public key infrastructure (PKI) registry). The new interorganizational system has a polycentric character allowing distributed control and is expandable allowing the accommodation of evolving information needs of multiple parties without presupposing full visibility about other sides. The overall arrangement for e-prescription is interesting as it is based on a malleable core that links multiple systems. Some of these linked systems are slow changing while others are being rapidly transformed following market trends. All these systems are loosely connected ensuring the flexibility and evolvability of the overall solution (Tanriverdi et al. 2010; Yoo et al. 2010). Polycentricity is a concept we sourced from the literature. It was not used by the participants in the e-prescription initiative and it had not guided decision taking by the actors involved. The identification of key polycentricity features in the case studied holds implications for the governance of interorganizational systems in already digitized environments. The case shows the possibility of adopting a polycentric approach and opens up for further conceptualising polycentric governance in the interorganizational Information Systems context.

Our findings contribute to Information Systems Research by identifying polycentric governance as an approach suited for interorganizational systems that need to come out of brownfield development (i.e. situations where there is a multitude of systems, data repositories and actors already in place).

Polycentric governance is an alternative to the centralization/decentralization dichotomy that has been omnipresent in the IS governance literature. Furthermore, our study contributes to the literature on systems integration that has received significant attention in Information Systems research (Hasselbring 2000; Saraf et al. 2013; Truman 2000). Integration has been discussed for intraorganizational systems such as Enterprise Resource Planning Systems (ERPs), banking systems and hospital systems and also, for interorganizational systems in the context of logistics, join up government services and cross-agency public services in general (e.g. Grimson et al. 2000; Malhotra and Temponi 2010; Sharif et al. 2005). We believe that integrated systems that come out of polycentric arrangements need to capture more attention in Information Systems Research. Each unit within a polycentric arrangement exercises considerable independence within a specific domain and can bring significant benefits to the overall system through learning and adaptation to disturbances over time (Finka and Kluvánková 2015). This can result to transformational benefits that go beyond the informational, strategic and transactional support (Gregor et al. 2006).

On the methodological side, the importance of studying interorganizational systems longitudinally over significant periods of time, cannot be overestimated. The case studied includes a lengthy initial phase where multiple different arrangements were tried-out before reaching a workable configuration. The emergence of order out of evolutionary dynamics is one of the key features of polycentricity and points to the importance of time. The formation of such arrangements requires time to mature. Beyond polycentric arrangements, in general, the temporal aspect plays a significant role for all interorganizational systems because multiple actors need to adjust and re-orient. For instance, Carugati and colleagues showed how an interorganizational technology was first created, then rejected, then changed and finally adapted in a way that suited the interests, learning needs and appropriation skills of all actors (Carugati et al. 2016). Therefore, the study of interorganizational systems requires longitudinal studies that cover lengthy periods (Mignerat and Rivard 2009).

For practitioners, the empirical case can be used as an exemplar of polycentric information systems governance. The architectural and managerial arrangements that supported polycentricity can be easily operationalised in new projects. The arrangements adopted in the Norwegian e-prescription case are suggestive of a general strategy that caters for continuity as much as for novelty (Grisot and Vassilakopoulou 2017). Such an approach can minimise tensions between use-organisations and external entities (e.g. from the government side) imposing novel systems and is worthy of practitioners' and policy makers' attention.

Few theoretical lenses have been applied in the study of interorganizational systems governance (Trang et al. 2013); the polycentricity lens provides an avenue for theoretically informed conceptual development in the domain. Furthermore, two areas for further exploration are particularly interesting. First, different coordination mechanisms for polycentric governance need to be explored (for instance, we need to understand better the role and impact of standards, incentives, service level agreements etc.). Prior studies have explored the evolution of relationships among people, organisations and technologies for interorganizational systems development and have pointed to issues related to the creation of synergies, the alignment of interests and goals, the motivation of participation and cooperation sustainment (Bietz et al. 2010; Spencer et al. 2011). Second, the interrelationship between contemporary architectural patterns (for instance, working with logical layers for orchestration) and managerial arrangements needs to be further explored. There is a great need to go beyond established conceptualisations for information systems governance through research that takes into account the characteristics of contemporary technologies and contemporary system landscapes.

The research reported in this paper is based on a single case study within a specific institutional setting. The role of institutional influences for polycentricity needs to be explored by follow-up studies. It seems possible that polycentric arrangements fit well the Scandinavian environment but may be incongruent with national settings where healthcare is more market-driven or more centrally managed. Since e-prescription has been introduced in many different national settings (Aanestad et al. 2017), there is a significant opportunity to explore how the institutional characteristics of different countries have shaped e-prescription in different contexts. Such research would yield insights about the institutional settings that are more or less conducive to polycentric governance arrangements.

References

- Aanestad, M., Grisot, M., Hanseth, O., and Vassilakopoulou, P. (2017), 'Information Infrastructures for eHealth', in M. Aanestad, et al. (eds.), *Information Infrastructures within European Health Care: Working with the Installed Base*; London: Springer.
- Aligica, P. and Tarko, V. (2012), Polycentricity: from Polanyi to Ostrom, and beyond, *Governance*, 25 (2), 237-262.
- Barrett, S. and Konsynski, B. (1982), Inter-organization information sharing systems, *Mis Quarterly*, 93-105.
- Bietz, M., Baumer, E., and Lee, C. (2010), Synergizing in cyberinfrastructure development, *Computer Supported Cooperative Work (CSCW)*, 19 (3-4), 245-281.
- Bygstad, B. and Hanseth, O. (2016), *Governing e-Health Infrastructures: Dealing with Tensions*. Carugati, A., Fernández, W., Mola, L., and Rossignoli, C. (2016), My choice, your problem? Mandating IT use in large organisational networks, *Information Systems Journal*.
- Chatterjee, D. and Ravichandran, T. (2004), Inter-organizational information systems research: a critical review and an integrative framework, *System Sciences*, 2004. Proceedings of the 37th Annual Hawaii International Conference on (IEEE), 10 pp.
- Constantinides, P. and Barrett, M. (2006), Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete, *Information and Organization*, 16 (1), 27-55.
- Copeland, D.G. and McKenney, J.L. (1988), Airline reservations systems: lessons from history, *MIS quarterly*, 353-370.
- Cornford, T., Hibberd, R., and Barber, N. (2014), *The evaluation of the electronic prescription service in primary care: final report on the findings from the evaluation in early implementer sites*. University College London. London, UK.
- Currie, W. and Guah, M. (2007), Conflicting institutional logics: a national programme for IT in the organisational field of healthcare, *Journal of Information Technology*, 22 (3), 235-247.
- Eisenhardt, K.M. (1989), Building Theories from Case-Study Research, *Academy of Management Review*, 14 (4), 532-550.
- Finka, M. and Kluvánková, T. (2015), Managing complexity of urban systems: A polycentric approach, *Land Use Policy*, 42, 602-608.
- Flyvbjerg, B. (2006), Five misunderstandings about case-study research, *Qualitative inquiry*, 12 (2), 219-245.
- Gawer, A. and Cusumano, M. (2002), *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation*: Harvard Business School Press Boston
- Ghazawneh, A. and Henfridsson, O. (2013), Balancing platform control and external contribution in third-party development: the boundary resources model, *Information Systems Journal*, 23 (2), 173-192.
- Goodhue, D.L., Wybo, M.D., and Kirsch, L.J. (1992), The impact of data integration on the costs and benefits of information systems, *MIS Quarterly*, 293-311.
- Gregor, S., Martin, M., Fernandez, W., Stern, S., and Vitale, M. (2006), The transformational dimension in the realization of business value from information technology, *The Journal of Strategic Information Systems*, 15 (3), 249-270.
- Grimson, J., Grimson, W., and Hasselbring, W. (2000), The SI challenge in health care, *Communications of the ACM*, 43 (6), 48-55.
- Grisot, M. and Vassilakopoulou, P. (2017), Re-Infrastructuring for eHealth: Dealing with Turns in Infrastructure Development, *Computer supported cooperative work (CSCW)*, 26 (1-2), 7-31.
- Hanseth, O. and Lyytinen, K. (2010), Design theory for dynamic complexity in information infrastructures: the case of building internet, *Journal of Information Technology*, 25 (1), 1-19.
- Hanseth, O. and Bygstad, B. (2017), 'The ePrescription initiative and Information Infrastructure in Norway', in M. Aanestad, et al. (eds.), *Information Infrastructures within European Health Care: Working with the Installed Base*; London: Springer.
- Hasselbring, W. (2000), Information system integration, *Communications of the ACM*, 43 (6), 32-38.

- Hopkins, R. and Jenkins, K. (2008), *Eating the IT elephant: moving from greenfield development to brownfield*: Addison-Wesley Professional
- Johnston, R.B. and Gregor, S. (2000), A theory of industry-level activity for understanding the adoption of interorganizational systems, *European Journal of Information Systems*, 9 (4), 243-251.
- Malhotra, R. and Temponi, C. (2010), Critical decisions for ERP integration: Small business issues, *International Journal of Information Management*, 30 (1), 28-37.
- Markus, M.L. (2001), Reflections on the systems integration enterprise, *Business Process Management Journal*, 7 (3).
- Markus, M.L. and Bui, Q.N. (2012), Going concerns: The governance of interorganizational coordination hubs, *Journal of Management Information Systems*, 28 (4), 163-198.
- McGinnis, M. and Ostrom, E. (2012), Reflections on Vincent Ostrom, public administration, and polycentricity, *Public Administration Review*, 72 (1), 15-25.
- Mignerat, M. and Rivard, S. (2009), Positioning the institutional perspective in information systems research, *Journal of Information Technology*, 24 (4), 369-391.
- Monteiro, E., Pollock, N., Hanseth, O., and Williams, R. (2013), From artefacts to infrastructures, *Computer Supported Cooperative Work (CSCW)*, 22 (4-6), 575-607.
- Ostrom, E. (2010), A long polycentric journey, *Annual review of political science*, 13, 1-23.
- Polanyi, M. (1951), *The logic of liberty*: Routledge & Kegan Paul
- Pollock, N. and Williams, R. (2010), E-infrastructure: How do we know and understand them? Strategic ethnography and the biography of artefacts, *Computer Supported Cooperative Work (CSCW)*, 19 (6), 521-556.
- Prasad, A., Green, P., and Heales, J. (2012), On IT governance structures and their effectiveness in collaborative organizational structures, *International Journal of Accounting Information Systems*, 13 (3), 199-220.
- Reimers, K., Johnston, R.B., and Klein, S. (2014), An empirical evaluation of existing IS change theories for the case of IOIS evolution, *European Journal of Information Systems*, 23 (4), 373-399.
- Robey, D., Im, G., and Wareham, J.D. (2008), Theoretical foundations of empirical research on interorganizational systems: assessing past contributions and guiding future directions, *Journal of the Association for Information Systems*, 9 (9), 497.
- Saraf, N., Langdon, C.S., and El Sawy, O. (2013), IS integration and knowledge sharing in multi-unit firms: the winner's curse, *European Journal of Information Systems*, 22 (6), 592-603.
- Sharif, A.M., Irani, Z., and Love, P.E. (2005), Integrating ERP using EAI: a model for post hoc evaluation, *European Journal of Information Systems*, 14 (2), 162-174.
- Singletary, L.A. (2004), Applications integration: is it always desirable?, *System Sciences*, 2004. Proceedings of the 37th Annual Hawaii International Conference on (IEEE), 265-273.
- Spencer, D., Zimmerman, A.S., and Abramson, D. (2011), Special theme: project management in e-science: challenges and opportunities, *Computer Supported Cooperative Work (CSCW)*, 20 (3), 155-163.
- Star, S.L. and Ruhleder, K. (1996), Steps toward an ecology of infrastructure: Design and access for large information spaces, *Information systems research*, 7 (1), 111-134.
- Tanriverdi, H., Rai, A., and Venkatraman, N. (2010), Research commentary—reframing the dominant quests of information systems strategy research for complex adaptive business systems, *Information Systems Research*, 21 (4), 822-834.
- Tilson, D., Lyytinen, K., and Sorensen, C. (2010), Digital Infrastructures: The Missing IS Research Agenda, *Information Systems Research*, 21 (4), 748-759.
- Tiwana, A., Konsynski, B., and Bush, A.-. (2010), Research commentary-Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics, *Information Systems Research*, 21 (4), 675-687.
- Trang, S.T.-N., Opitz, N., and Kolbe, L. (2013), IT governance in a network context: Literature review and agenda for research.

- Truman, G.E. (2000), Integration in electronic exchange environments, *Journal of Management Information Systems*, 17 (1), 209-244.
- Tsiga, Z.D. and Chong, A.Y.-L. (2016), An extensive review of interorganizational systems research 2006-2015, PACIS 2016.
- Vassilakopoulou, P. and Marmaras, N. (2015), Investigating technology-induced transitions in healthcare: Work practice adaptations within their overall context, *Health Policy and Technology*, 4 (3), 277–285.
- Vassilakopoulou, P., Tsagkas, V., and Marmaras, N. (2012), From “Rules to Interpret” to “Rules to Follow”: ePrescription in Greece, *Electronic Journal of e-Government*, 10 (2), 147-155.
- Weill, P. and Ross, J.W. (2004), *IT governance: How top performers manage IT decision rights for superior results*: Harvard Business Press
- Yin, R.K. (2013), *Case study research: Design and methods*: Sage publications
- Yoo, Y., Henfridsson, O., and Lyytinen, K. (2010), Research commentary—the new organizing logic of digital innovation: an agenda for information systems research, *Information systems research*, 21 (4), 724-735.
- Zachariadis, M., Scott, S., and Barrett, M. (2013), Methodological Implications of Critical Realism for Mixed-Methods Research, *MIS quarterly*, 37 (3).

Appendix: Project documents on Norwegian e-prescription

- Direktoratet for e-Helse. (2014). Kodeverk i e-resept. Versjon 1.6. 19.mai 2014. Retrieved from https://ehelse.no/Documents/E-resept/Dokumentarkiv-Meldingsdefinisjoner/kodeverk_i_e-resept_v1.6.pdf
- Direktoratet for e-Helse. (2015a). e-Resept Detaljert Funksjonell Spesifikasjon. Versjon 2.08. 03.november 2015. Retrieved from https://ehelse.no/Documents/E-resept/Dokumentarkiv-Meldingsdefinisjoner/Detaljert_funksjonell_spesifikasjon_DFS_v2.08.pdf
- Direktoratet for e-Helse. (2015b). Multidose i e-resept – Legemiddel i bruk (M25). 10.november 2015. Unpublished documentation.
- Direktoratet for e-Helse. (2016a). e-Resept Arkitektur Versjon. 2.8. 2.juni 2016. Retrieved from https://ehelse.no/Documents/E-resept/Dokumentarkiv-Meldingsdefinisjoner/e-resept_arkitektur_versjon_2.8.pdf
- Direktoratet for e-Helse. (2016b). National Summary Care Record, Meeting with the Polish Ministry of Health. 30.juni 2016. Retrieved from https://ehelse.no/Documents/E-helsekunnskap/National_summary_care_record_Bent_A_Larsen_.pdf
- Direktoratet for e-Helse. (2016c). Introduksjon til Forskrivingsmodulen for nyansatte. 9.mai 2016. Unpublished documentation.
- Direktoratet for e-Helse. (2016d). Detaljert design Nettpotek v1.20 – Ekstern versjon 4.juli 2016. Unpublished documentation.
- Helsedirektoratet. (2011). E-resept forvaltning. Mai 2011. Unpublished documentation.
- Helsedirektoratet. (2012). Fakta om e-resept. Mai 2012, Retrieved from <http://legeforeningen.no/PageFiles/92369/Skriv%20fra%20Helsedirektoratet.pdf>
- Norsk Helsenet (2015) Registerplattformen – teknisk dypdykk. Oslo 24. Mars 2015. Unpublished documentation