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INTEGRATION AS ESCALATION OF COMPLEXITY

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Abstract

Cases reported in information systems (IS) research indicate an abundance of implementation projects that get delayed, run over budget, are not used as intended, or are stopped. Focusing on integrated information systems in the healthcare sector, we analyse the process of how complexities escalate stepwise during implementation. This escalation appears to take place despite sound planning, competent project leaders, committed management and involved users. Rather than the result of mistakes or misconceptions, the escalating complexity is the result of the type and extent of interdependencies between the different modules constituting the integrated systems. The paper also focuses on the actual outcome of the integration effort. In line with the debunking of overly dichotomous classifications of implementation projects into "success" and "failure", we contribute by characterizing degrees of integration in integrated information systems. A key point is that integrated Information Systems work, but unevenly in terms of functionality and level of necessary workarounds. Empirically, this paper draws on a longitudinal case study of the implementation of an integrated laboratory service at the University hospital of Northern Norway. Our case narrative reconstructs the processes of implementation; emphasising how "small" and often unforeseen issues transformed into larger issues i.e. an escalation of the project's complexity. We also point to how the integration in the laboratory portfolio was maintained with various degrees of workaround.

Keywords: Integration, Laboratory work, Escalation, Complexity, Healthcare, Workaround

1 INTRODUCTION

Cases reported in information systems (IS) research indicate an abundance of implementation projects that get delayed, run over budget, are not used as intended, or are stopped (Heeks, 2006; Hanseth and Ciborra, 2007). The problem seems to be even bigger and complex when focusing on integrated systems in healthcare as many studies on integration projects report on results lagging far behind expectations (Ministry of Health and Care Services, 2008; Auditor General, 2008; Cross, 2006). This makes it relevant to examine more closely the *process* of integrating different information systems, and particularly how complexities escalate stepwise during implementation. The paper argues that the escalation takes place despite sound planning, competent project leaders, committed management and involved users. Rather than the result of mistakes or misconceptions, the escalating complexity seems to be the result of the type and extent of interdependencies between the different modules constituting the integrated systems.

Still, we are critical about the tendency of debunking of overly dichotomous classifications of integration efforts into "success" and "failure". Usefulness of integration may depend on the actual context, who is involved, what is integrated and the frequency of use. Therefore we also contribute by characterizing *degrees* of integration in integrated information systems. Our point is that integrated IS work, but unevenly in terms of what is needed, implemented functionality and level of necessary workarounds.

Empirically, this paper draws on a longitudinal case study of the implementation of an integrated laboratory service at the University hospital of Northern Norway (UNN). The largely independently and to some degree manually based laboratories were to be more closely integrated with the "customers" of the services i.e. ordering physicians at the hospital together with general practitioners in the region. Embedded in the integration effort at UNN, there was also an ambition of standardising the pre-processing of the laboratory work across the different laboratories to enjoy efficiency gains through economy of scale. Our case narrative reconstructs the processes of implementation, emphasising how "small" and often unforeseen issues transformed into larger issues i.e. an escalation of the project's complexity. We also point to how the integration in the laboratory portfolio was maintained with various degrees of workaround.

2 CONCEPTUALISING INTEGRATED SYSTEMS

A Western health care infrastructure is distributed across several institutional boundaries that typically involve general practitioners, hospitals, nursing homes, and home care services. At the same time there is increased pressure on the different institutions for more collaboration and integration. For instance, in the UK's National Health Service it is argued that:

"Current healthcare policy initiatives in the UK make significant claims about the desirability of integrated services for better healthcare, i.e. more patient-centred healthcare delivery, improved resource utilization and better management of information" (Martin et al., 2007, p. 47)

No wonder then that the integration of healthcare software systems has remained one of the most prominent issues in healthcare software development (Mykkänen et al., 2003) to facilitate smooth information and workflow between the different institutions and practices. Boochever (2004, p. 16) for instance, underscores that: "system integration would provide the platform for improved workflow, patient throughput and patient safety, as well as decreased cost". Integration is also expected to automate medical processes, such as ordering of laboratory examinations and receipt of results (Tsiknakis et al., 2002, p. 11).

There have been many different strategies and approaches to integration. The integration mechanisms include technical solutions such as federated database systems, World Wide Web, Enterprise Resource Planning systems (Grimson et al., 2000), components and Internet portals. Common models, components and architectures are also suggested (Bernstein et al., 2005). There is also a lot of "promise" connected to a Service Oriented Architecture (SOA) as a way of dealing with fragmented

systems in the healthcare sector. SOA is beneficial in order to integrate heterogeneity and systems spread on various locations as it can 'bridge clinical and related administrative entities with improved flexibility regardless of platform and physical location' (Vasilescu and Mun, 2006:94).

The many integration mechanisms in play, does not only point to the many expectations to integration, it also reflect the enormous challenges and difficulties that integration entails. Despite many initiatives, only minor steps towards the improvement of electronic inter-organizational collaboration have been achieved (Auditor General 2008; Cross, 2006). Ham et al. (2011, p. 741) even claims that: 'integrated electronic medical record remains an aspiration rather than a reality', hence echoing Berg (1998, p. 294) who points out that fully integrated systems in healthcare is hard to find.

One reason for the challenges is that many software products have been built and acquired from heterogeneous sources over long periods, and the systems have differences in technologies and architectures (Mykkänen et al., 2003, p. 173). Another reason is that many integration projects focus too narrowly on technical issues. This is also reflected in the medical informatics literature, which is dominated by a technical perspective on integration.

In comparison, there are numerous contributions to the socio-technical nature of IS implementation in general, but distressingly few devoted specifically to integrated information systems (but see, for instance: Ellingsen and Monteiro, 2006; Boudreau and Robey, 2005). There is a similar scarcity of socio-technically informed studies of the escalation of complexity as part of integration processes (Hanseth et al., 2004). Hanseth and Ciborra (2007) contain illuminating cases of escalating complexities of information systems projects, largely due to spreading of side-effects (including those induced by integration). In a sense, integration projects *are* about creating interdependencies between different systems. Data exchange formats have to be agreed on and work processes shaped, etc. However, the danger is that several overlapping systems and practices may be too tightly coupled. In this regard, Perrow (1984) uses the notion of loose and tight coupling to describe the degree of dependencies between the various components. He warns that tightly coupled systems have very little slack with only limited ways to accomplish a task. A consequence is that there might by difficult to identify a specific cause for how and why an escalation occurs (Drummond, 1996).

Some studies have also pointed out how work routines are influenced by integration (Volkoff et al., 2007; Boudreau and Robey, 2005). However, only a few have focused on how work routines and (technical) integrations is closely intertwined in a sense that "working" solutions may depend on various degree of "taken-for-granted" workarounds. For instance, a relatively bad technical integration may work perfectly fine in combination with extensive workarounds as long as the frequency of use is relatively low. In comparison, if the frequency of use is high, it suggests that the amount of workaround should be correspondingly low to ensure a working solution. This inherent relationship between technical integration and workarounds take us beyond the position where integration is considered as either success or failure – it depends on the context and the frequency of use. This also echoes Berg and Goorman's (1999) point, when they argued that the further information has/needs to be able to circulate (i.e. the more diverse contexts it has/needs to be usable in), the more work is required/the more work it takes to disentangle the information from the context of its production.

3 METHOD

The case study was conducted at the University Hospital of North Norway (UNN) from January 2006 to November 2010. UNN is the largest hospital in North Norway with approximately 5000 employees. UNN has seven laboratories: Medical Biochemistry, Clinical Pharmacology, Immunology, the Blood Bank (a subdivision of the Immunology Laboratory), Microbiology, Pathology, and Medical Genetics. The laboratories receive requisitions from general practitioners (GPs), other hospitals, and the in-house clinical wards. The Medical Biochemistry, Clinical Pharmacology and the Immunology are the largest of the laboratories (measured by the number of analyses), conducting nearly 3 million analyses a year. In Norway, there is generally a medical biochemistry laboratory linked to each of the country's 85 hospitals. The Microbiology Laboratory at UNN is one of 20 microbiology laboratories in Norway and conducts about 400,000 analyses a year.

The study takes an interpretive research approach (Klein and Myers, 1999; Walsham, 1995). Data gathering by the first author consisted of participant observations (work settings and project meetings), interviews, document analysis, and informal discussions. 48 interviews were conducted, 37 of which were performed by the first author alone. Most interviews lasted approximately 30 – 60 minutes, but some lasted up to 1.5 hours. They were taped and subsequently transcribed. Handwritten field notes were written up as soon as possible after each observation session.

4 "GROUND ZERO" – A MANUAL AND FRAGMENTED PRACTICE

Both among GPs in the northern health region of Norway and among the management at UNN, there were increasing concerns about lack of efficiency and adequate quality in the communication between GPs and the laboratories. There were several reasons for this. Firstly, in the health region, most of the GPs ordered laboratory tests manually using various paper forms. For the GPs, the requisition routines implied a great deal of paper-based work as well as a lack of documentation of what had been ordered.

Secondly, the hospital saw the lack of a common contact point as a problem. The seven laboratories at UNN had no common unit to handle the requisitions. Each laboratory took care of its own pre-analytic work, which involved unpacking, sorting and separating the incoming sample tubes and requisitions as well as registration of the requisitions in each laboratory's IT system. Consequently, identical patient information (patient identification, clinical information, etc.) had to be entered several times whenever a requisition addressed more than one laboratory. The strict division between the laboratory systems was also seen as part of the problem, since there was no common pre-analytic system or portal for the GPs to inquire about status and results. In addition, the fragmentation of the laboratories and their systems presumably affected the quality of the requests. Sometimes a part of the requisitions went missing, and was difficult to trace.

Thirdly, a major bottleneck was the substantial resources needed to perform preparation work on the requisitions received in the Medical Biochemistry Laboratory. An important part of this was to *distribute* 80-90% of the received sample tubes from the GP, meaning that the contents of the (primary) sample tubes were transferred into one or several new (secondary) tubes. There were several reasons for this: If the number of requested analyses was higher than the number of tubes received from the GPs, this involved several analysis machines in the laboratories. In addition, sometimes the tubes did not fit into the relevant analysis machine because they were not of the correct size or material. Combined with the distribution process was *re-labelling.* Re-labelling implied that the assistants printed out and glued a barcode label on every sample tube ready for analysis. This was necessary because the barcode provided the analysis machines links to instructions for how to analyse the samples. As the process of distributing and re-labelling involved 500 samples a day, this was an extremely cumbersome and repetitive process.

Consequently, there were very good reasons for establishing a new integrated solution between the GPs and the hospital laboratories. It was however obvious that the integration challenge would be considerable, as the four major laboratories used four different laboratory systems. The Medical Biochemistry Laboratory used DIPS Lab, which handled more than 80% of the laboratory production at UNN. DIPS Lab was closely integrated with the hospital's Electronic Patient Record (EPR), which also were developed by the vendor DIPS ASA. DIPS ASA controlled approximately 85% of the EPR market in Norway. The Microbiology Laboratory used SAFIR LIS Deltrix (SAFIR), implemented in 2007, which was developed by ProfDoc. The Pathology Laboratory at UNN had the system Sympathy, supplied by TietoEnator, which had been in daily use at UNN since 1997. Finally, the Blood Bank used the system LabCraft from the vendor LabCraft AS.

5 THE VISION – A UNIFORM FRONT-END

To face the challenges outlined, the hospital launched a concerted initiative to deal with the situation. Firstly, at the turn of the year 2005/2006, the GiLab project was established, involving laboratory personnel from UNN, the vendor Well Diagnostics AS, and four different GP practices in the Tromsø

area. The primary aim of the project was to develop a system (named Well Interactor) that could support a seamless electronic information flow between the primary care providers and the hospital's laboratory systems. Through integrating Well Interactor with the GPs' EPR, the GPs were supposed to be able to order laboratory services directly from their EPR.

Secondly, in September 2006 the hospital established the pre-unit, with a staff consisting of at the most 37 persons. The pre-unit was to assume the responsibility for all pre-analytic work from the laboratories. This included unpacking of the samples, registration of requisitions, quality assurance and preparation of the sample tubes before they were distributed to the various laboratories. All incoming requisitions and outgoing results would be routed through the unit – a "one-way-in and one-way-out solution", as the leader of the pre-unit expressed it. With these measures, the hospital management expected a staff reduction of 10.5 full-time equivalents for the laboratories.

Thirdly, the project group planned to establish a Pre-analytic Management System (PMS) to take care of all the incoming electronic requisitions. The idea was that after they were received in the PMS, laboratory test requests should be routed to DIPS Lab, SAFIR and Sympathy respectively. The use of the PMS would ensure that requisitions could easily be tracked down anywhere in the workflow, and would make it possible to find missing samples as well as to specify which laboratories were involved and the status of the analyses for any given requisition. From the outset, DIPS Lab was assigned the role of the PMS because DIPS Lab was just another module in the larger EPR portfolio at the hospital.

"We want everything to be routed through DIPS, including requests to the Pathology and Microbiology Laboratory. In this way, the staff will not need to search in many different systems for a laboratory analysis" (Laboratory technologist, pre-unit)

Fourthly, part of the strategy was to establish a single numbering system shared by all the different laboratory systems, enabling easy identification of requisitions across systems, among other advantages.

"A common laboratory number should be used, or the possibility to use the numbers across the different production systems in such a way that a sample with a given laboratory number in one system can be directly used in another system" (Laboratory strategy document, 2007)

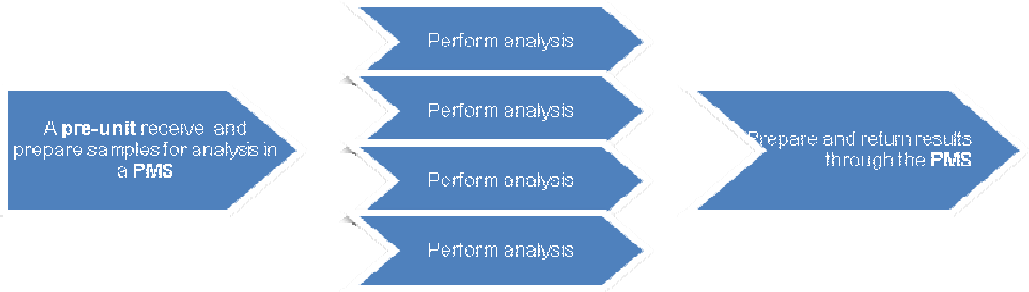

Figure 1. The envisioned information flow between the GPs and the laboratories

The vendor, Well Diagnostics, was a small software company specializing in systems integration. Part of the design strategy included not getting heavily involved in complex issues *inside* the organizations. According to the CEO, one reason for this was that they knew that hospitals were very complex organizations and thus certain clarifications with respect to the organization were preferred. Hence, integrating Well Interactor with a designated PMS would ensure that the vendor's developers could relate to a well-defined interface. However, at the same time, based on many years of involvement in the healthcare market, Well Diagnostics knew that it was very important to involve users. In line with this, the laboratory personnel and GPs participated intensively during the design phase of Well Interactor. On the GPs' side, great care was taken to design a useful requisition interface and to integrate the Well Interactor client with the GPs' existing Electronic Patient Records. On the hospital side, a great deal of effort was devoted to making sure that the electronic requisitions were successfully received in the laboratory portfolio. The first laboratory to be included was Medical Biochemistry, which had been able to receive requisitions electronically from four GP practices since

2006. In 2007, the Medical Biochemistry Laboratory received approximately 91 000 *requisitions*, of which 10 000 were electronic ones (11%). The Microbiology Laboratory was included in October 2008, while the Pathology Laboratory is still not included. The Blood Bank dealt mostly with in-house requisitions and results.

6 MOUNTING INTEGRATION CHALLENGES

6.1 Establishing sequential work tasks

To enable the new pre-analytic service unit (pre-unit) to undertake the new responsibility of receiving, processing and distributing sample tubes, the assistants had to undergo thorough training. It was relatively easy for the new pre-unit to undertake pre-analytic work tasks related to the Medical Biochemistry Laboratory. The reason for this was that analyses performed at this laboratory were fairly simple and clearly defined. The sample materials received by the laboratory were usually blood, serum and plasma, and were primarily performed by one of the laboratory's 30 analysis machines. This implied that the roles and responsibilities between the Medical Biochemistry Laboratory, the pre-unit and the GPs were easy to clarify. Hence, it was relatively easy for the new pre-unit to undertake the laboratory's pre-analytic work tasks.

In comparison, it appeared to be extremely difficult to define a boundary between the work processes in the Microbiology Laboratory and the new pre-unit. Despite a strong commitment to training, the pre-unit's staff did not manage to handle these requisitions, and their role amounted to unpacking and sorting the received materials. Further handling and assessment had to be performed by highly specialized technologists from this laboratory, who dynamically moved between particular desks at the laboratory and the pre-unit. In contrast to Medical Biochemistry, where the requisition clearly showed which analyses had been requested, a typical Microbiology Laboratory requisition described a problem. For instance, a GP might ask about hepatitis, and then there were arrays of different analyses that had to be done. In line with this, the Microbiology Laboratory had an extremely broad analysis repertoire. Depending on the stated problem, a range of specific analyses had to be performed. After unpacking and sorting of the sample tubes, the laboratory technologists from the Microbiology Laboratory narrowed down an investigation strategy. This was done by a combined assessment of the GP's request and the additional information accompanying the requisition. This was typically *clinical information*, *material* (articulation fluid, urine, plasma, etc.) and *location on the body*.

When the requisitions had passed the quality assurance, the laboratory technologists would move on to request specific microbiological analyses in SAFIR. If the GPs had requested a bacterial analysis on a sample from an eye, this would imply two specific analyses, involving an aerobic and an anaerobic culture process respectively. If the GP had requested virus-based analyses, the technologist had to call for a physician from the Microbiology Laboratory, requesting her to read the clinical information and possibly to add additional analyses before the technologist completed the registration process. These tasks were initially supposed to be conducted by the pre-unit staff on a rotation basis, but proved too complicated for them to handle. As a result, the "grand vision" of a uniform and competent pre-unit failed. As the pre-unit did not manage to establish standardized routines for microbiological samples, the whole basis for its existence according to the initial goal faded away, and the idea was abandoned after two years.

6.2 Failing to establish the PMS – the common portal

Although the pre-unit did not survive, a common portal in a minimal version was still a goal for the project management, as this would contribute to providing a much-needed function for tracking the received sample tubes and requisitions. Because DIPS Lab was already well integrated with the EPR as well as with LabCraft, the Blood Bank system, it made sense that it should serve as the PMS:

"One cannot demand that the staff handling the received requisitions should deal with four different systems. Therefore we thought that the received requisitions could be routed through DIPS Lab before they was sent to SAFIR. We have already done this quite successfully with the integration between

Labcraft and DIPS Lab, meaning that requisitions received by this laboratory are first registered in DIPS Lab before they are routed to Labcraft. The corresponding results are returned the same way through DIPS Lab" (Laboratory technician, Blood Bank)

However, integrating SAFIR with DIPS Lab was far from straightforward. The Microbiology Laboratory was only moderately interested in such a solution because, in any case, the essential part of the microbiological pre-analytic work was dependent on using SAFIR, such as for assessing the requisition and for ordering additional analyses. Hence, entering the requisitions in DIPS Lab effectively meant doing the work "twice, and creating a real bottleneck" as one of the microbiological laboratory technologists expressed it.

Another factor that ultimately crushed the PMS strategy was ironically enough the fact that DIPS Lab and DIPS EPR were too well integrated: they were different modules in a common software portfolio, and were using the same database. This implied that each external microbiological requisition as well as results produced for the GPs would not only be visible in DIPS Lab, but also in the DIPS EPR, where health personnel in the hospital clinics would be able to see them. According to the hospital's security officer and management at the Microbiology Laboratory, this would violate Norwegian law, which imposes restrictions on sharing health information across different organizations. The chief physician at the Microbiology Laboratory explained:

"All those who currently use DIPS Lab as their laboratory system cannot possibly avoid results of external requisitions being visible in the EPR. You may say that it is easier to beg forgiveness for breaking the law if you don't have any possibility to comply with it. For us it would be more problematic, as it would be an active choice to channel our results into DIPS Lab, and therefore we don't copy these results to DIPS Lab right now" (Chief Physician Microbiology Laboratory)

To deal with this situation, the security officer had suggested that the laboratory made an agreement with all of the referring GPs in which they asked each of the patients involved if they consented to copying of their test results to the hospital's EPR when the results were returned to the GPs. A positive response would then indicated by a check mark in the requisition. However, the laboratory did not pursue such a strategy, as it would put additional burdens on the GPs.

6.3 A pre-designed work flow

Due to the failure of the pre-unit, the project management had to look for other options to support its overall integration strategy. As the project management team saw it, receiving requisitions electronically through Well Interactor created the opportunity to prepare the sample tubes automatically for different laboratories, systems and analysis machines. Hence, to avoid the need to distribute and re-label the sample tubes received in the laboratory, the new method proposed was to make sure that the sample tubes were prepared for the analysis machines by the staff at the GP practice. At first glance, the idea did not seem revolutionary. It was a well-proven routine for requisitions from the wards within the hospital, which for Medical Biochemistry analysis constituted 50% of all the requisitions received at the laboratory. When physicians in the wards requested analyses, the technologists from Medical Biochemistry collected the blood specimen from the patient. In this process, the technologists had sample tubes that were already marked before they took the sample from the patient. The technologists also made sure to bring a sample tube designated for the relevant analysis machine. Accordingly, this required that the barcode glued onto the sample tube in the GP practice included a laboratory number that could be used throughout the whole workflow.

However, the plan did not become reality. In fact, the laboratory staff strongly opposed it. As the laboratory's IT technologists perceived it, this would establish a dependency between the systems in the GP practices and their laboratory infrastructure, which currently constituted over 30 analysis machines tightly integrated with DIPS Lab.

"An analysis machine has an effective lifetime of three years (…) and when you need to replace a machine you don't want an external system to maintain information about each individual machine park [at each hospital]" (Laboratory technologist, Medical Biochemistry)

Moreover, under certain circumstances the laboratory numbers currently generated in-house needed to be supplemented with checksums and special instructions to the analysis machines. This could not be performed as long as the barcodes were all set in the GP practices. Another issue that undermined the idea of having labelled sample tubes ready to use in the GP practice was that the re-labelling of the tubes in the laboratory served as a quality assurance procedure. The quality of each sample was checked, and gluing a new barcode on the sample tube represented verification in this regard. In addition, performing this procedure for all the sample tubes belonging to a requisition confirmed that the necessary number of tubes had been received.

Accordingly, for the Medical Biochemistry Laboratory technologists it was extremely important to uphold flexibility in their daily interaction with the internal infrastructure. Redistributing the barcode generation to the GP offices would create increased interdependency between the barcode code labels glued to the sample in the GP offices and the analysis machines in the laboratory. In this connection, the project team forgot to take into account that it was not realistic to compare the in-house strategy for preparing sample tubes with an external one because in an in-house context, the laboratory exercised control of the whole work chain and could make adaptations whenever needed.

6.4 The disintegration of a unified integration strategy

As both the idea of the pre-unit and PMS had failed to materialize, the goal of implementing a common laboratory number became even more important. A common laboratory number across the different laboratory systems could serve as a means to achieve a better overview of the requisitions. However, the Medical Biochemistry Laboratory and the Microbiology Laboratory had opposite opinions about what to do. The Microbiology Laboratory was interested in exporting series of its SAFIR laboratory numbers to the GP practice, and having the sample tubes ready marked in the GP practice. According to the staff, this would reduce the workload in the laboratory. In contrast, the staff in the Medical Biochemistry Laboratory argued that it was better that the infrastructure in the GP practice (Well Interactor) generated a unique laboratory number containing a prefix that identified the GP office. This would simplify tracking: to find out where a lost sample tube had come from, one could just look at the laboratory number on the tube. That implied that the "samples could be traced all the way to their origin" (Laboratory technician, Medical Biochemistry).

However, the Microbiology Laboratory insisted that the strategy of exporting SAFIR laboratory numbers should be used. Hence, to avoid having different laboratory number generators in play, it was decided that SAFIR should generate laboratory numbers for all the laboratories, including the Medical Biochemistry Laboratory. Accordingly, when electronic requisitions were received at the hospital, the Medical Biochemistry staff re-labelled the sample tubes with internal laboratory numbers as usual, while the staff at the Microbiology Laboratory kept their sample tubes with the original label.

Unfortunately, this strategy brought its own problems. The way the laboratory numbers were generated in SAFIR meant that within a few years the sequence would be repeated, potentially causing duplicated laboratory numbers. This problem escalated as the Medical Biochemistry Laboratory used the same generator as the Microbiology Laboratory. Ultimately, the Microbiology Laboratory complained that the Medical Biochemistry Laboratory used up their laboratory numbers – as one of the super users explained:

"The staffs at the Microbiology Laboratory complains that we [The Medical Biochemistry Laboratory] use up their numbers on our requisitions (…) and of course, we have a much larger production than they so it is absolutely clear that we spend their numbers to a much larger degree than they do themselves" (Super-user, Medical Biochemistry Laboratory)

According to the chief laboratory technologist at the Microbiology Laboratory, the laboratory number generator contained "a serious error that urgently needed to be dealt with". Further deployment of the system was put on hold while the laboratory in the autumn of 2009 requested the vendor ProfDoc to add a "date" field together with the laboratory number (to ensure uniqueness) before more GP practices were included. However, such a change was not straightforward, as the current laboratory

number was tightly embedded in the design of the system and was difficult to change. Throughout 2010, the laboratory tried to force the vendor to make the change, but the issue is still unresolved.

6.5 Blurring interfaces between the software components

When it came to actually integrating the different systems, the existing software interfaces were far from clear-cut. DIPS Lab lacked functionality for importing free-text information from Well Interactor. The requisitions were formatted according to the new national XML standard and DIPS ASA had not developed a XML interpreter yet. As a temporary solution, some super users at the Medical Biochemistry Laboratory designed an application that channelled the received requisitions through the existing optical scanning routine, which was could read structured data such as check boxes, but was not able to recognize free text. In practice, this meant that the clinical information and external laboratory numbers received had to be pasted in manually into DIPS Lab. An illuminated button in the user interface that was used to pair the sample tube and the requisition indicated the presence of a free-text comment. The user had to press this button to copy the comment to the clipboard in Windows. Then, the DIPS Lab window appeared on the screen and the user had to move the mouse marker to the proper field and paste the comment into it. According to one of the super users, the routine involved an "enormous amount of pushing the mouse to cut and paste these comments", but was regarded as acceptable in the pilot phase.

A key problem related to the lack of an overview originated from the Blood Bank. The laboratory regularly received samples from maternity clinic check-ups, which were analysed at both the Blood Bank and the Microbiology Laboratory. Coordinated follow-up was thus required. To achieve this, the laboratory staff started to enter these requisitions into DIPS Lab when they were received in the laboratories, assigning them a DIPS laboratory number and then performing the requisitions for the other two laboratories from DIPS Lab:

"There are so many variants of these samples, and we have tried to achieve an overview of all the possible ways they come to us. Then we found out if we enter the requisitions in DIPS Lab and then make requisitions from DIPS Lab to LabCraft [Blood Bank] and to SAFIR [Microbiology] we will be able to keep track of what happens" (Laboratory technician, Blood Bank)

One major problem in the requisition process for microbiological analysis was that the number of possible analysis codes was huge and amounted to around 500 analysis codes for bacteriology alone. This had been solved quite efficiently for external requisitions in Well Interactor by defining a tree structure where, for instance, 20 different analysis codes on a lower level were collapsed into only one code on a higher level. Uniqueness of analysis was then achieved because the GP added the type of material. In contrast, this was not possible for internal requisitions conducted through DIPS EPR in the hospital clinics. Here, the ordering physician did not know exactly what kind of analysis code to use; in practice, it was nearly impossible or at least very difficult to have an overview of the codes. As a result, some of the experienced laboratory technicians in the laboratory designed 15 dummy analysis codes representing a group of DIPS analysis codes, which were added to DIPS Lab. When using the dummy codes; the ordering physician was then strongly encouraged to add clinical information and the type of material to the requisition. Based on the combination of the dummy code and the clinical information, the laboratory technicians at the Microbiology Laboratory were able to add the correct analysis codes for the internal requisitions received in the laboratory.

While it was possible to send external results from the Pathology Laboratory to the GPs, the internal results were another matter. Previously, some effort had been committed to sending results internally, i.e. to DIPS Lab, but there had been some technical problems. Results consisting of more than 4000 characters could cause some part of the text to get lost, which could happen both within and at the end of the result. After a while, some new integration tools were tried, which also failed. Because of the different systems involved, it was difficult to identify exactly where the problem was. Eventually, the Pathology Laboratory chose to continue sending pathology results on paper, whereupon the secretaries in each hospital clinic scanned the paper-based results into DIPS Lab, thus making them available for the physicians.

7 CONCLUDING DISCUSSION

7.1 The process of escalation: Unfolding complexity

Considered in isolation, one at a time, each of the reasons for delays, additional costs and redefined goals in this project described in our case narrative (the common pre-unit, the PMS and the common laboratory number generator) seem in hindsight to be solvable, arguably almost trivial, problems. How, then, is it that they create the level of problems for the implementation?

A key point with our case has been to describe how apparently rational and well-founded ideas failed to materialize and instead become part of an escalating process that was partly out of control. Initially, the project was well planned and based on well-founded project management principles. These included involving the users and other stakeholders in the process. However, during the process several unforeseen circumstances emerged, inducing the project management to deal with them and find alternative strategies shaped by a reduced number of options. As in other escalating large-scale projects (see, for instance, Drummond, 1996) we do not think we can tease out a single cause to explain why the envisioned workflow did not materialize, but note that there may be several interlinked causes interacting with each other, which may explain why the escalation happened.

This is essentially an argument about complexity resulting from the unforeseen *number, type and scope of interdependencies* between modules, systems and work routines (Hanseth and Ciborra, 2007; Boudreau and Robey, 2005; Volkoff et al., 2007). These interdependencies, e.g. how the common use of SAFIR's laboratory number generator might cause the system to run out of available numbers due to extending its use to the analysis-intensive Medical Biochemistry Laboratory, are easy to recognize in retrospect, but materialized only during the implementation of the project. It is only with the benefit of hindsight that the problems become "obvious"; during implementation, the implications of the interdependencies exceeded what could be reasonably expected from careful planning and project management.

In addition, integrated systems may represent dependencies per se and are thus a source of complexity. Here you may consider how reiterating efforts of integrating results from the pathology system Sympathy into the EPR failed each time and where it was not possible to identify the problem exactly. Furthermore, Boudreau and Robey (2005, p. 5) make the general argument that when "technological artifacts become more tightly integrated into larger systems or networks, a narrower range of enactment may be expected from users". We also found it fruitful to recall Perrow's (1984) notion of loose and tight coupling to describe the degree of dependencies between the various components in a larger system portfolio. He warns that tightly coupled systems have very little slack, with only limited ways to accomplish a task. A striking illustration of this is how the project management group envisioned a predesigned workflow with ready-marked sample tubes between the GPs and specific analysis machines in the Medical Biochemistry Laboratory. This initiative failed due to the increased dependencies that such a design would cause. Similarly, the pre-unit, the PMS and the common laboratory number represented tightly connected initiatives, where the failure of one of them would limit possible options for the others. Compared to the envisioned seamless workflow, the actual results were discouraging: the new design failed to materialize. This also had quite serious consequences for the vendor Well Diagnostics, which initially wanted to clarify its responsibility vis-à-vis the hospital through a well-defined interface. Ultimately, the vendor had to integrate Well Interactor directly with both DIPS Lab and SAFIR, and will later do this for the Pathology Laboratory as well.

7.2 Integrated information systems revisited

Bracketing the process of escalating complexities of implementing integrated systems, what is the resulting image of integration that emerges? Clearly, we want to move beyond the many snapshot-based assessment studies conducted in the IS research field, which essentially focus quite narrowly on the gap between the system's functionality and its usefulness in a given practice. For example, Pollock and Williams (2008) emphasize the need to invest time in the organization to uncover the long-term effects of an implementation. While the "grand" vision failed to materialize in this case, a parallel and

more modest process emerged in the laboratories, which has resulted in some interesting results. Here, the actual result of the integration effort is neither a complete failure nor a complete success. The outcome is rather more nuanced, and, in our opinion, better reflects the dynamics of IS implementation projects where substantial time and context are taken into account.

We supplement this longitudinal perspective (i.e. adding a time dimension) by paying attention to the different contexts involved (i.e. a special dimension), viz. the various laboratories. In table 1, we summarize the long-term effects of the integration efforts, where it was achieved and a rough outline of its nature.

	Med. Biochemistry	Blood Bank	Microbiology	Pathology
Reading test results (external and internal)				
Producing requisitions (external and internal)				
Obtaining an overview and status of the text				

Table 2. The different degrees of integration in the laboratory portfolio are indicated by different shadings - the darker the shading, the larger the degree of workarounds needed to sustain the integration

Based on the table, we may easily interpret the horizontal axis (the different laboratories) as each laboratory's *volume of transactions* (i.e. requisitions and results) where the Medical Biochemistry Laboratory was engaged in the highest interaction and the Pathology laboratory the lowest. A similar interpretation of the vertical axis indicates the *importance of the service* for the ordering physician from high to low.

The Medical Biochemistry Laboratory (with least shading) is fairly well integrated, while the other laboratories are integrated to a greater or lesser extent. To explain the (middle) shaded area: in the Blood Bank, having an overview of external maternity check-up samples was extremely important, which was achieved by establishing a manual routine. This involved first entering data into DIPS lab, then requesting analysis at the Blood Bank and the Microbiology Laboratory respectively. Similarly, internal requisitions for the Microbiology Laboratory needed to be sustained with dummy analysis codes. Finally, results for pathology were integrated using a manual routine where the secretaries scanned the pathology results into the EPR, thus making the results available to the physicians.

Given the outline of integration as presented in table 2, it is quite interesting that the laboratory IS portfolio appears much less fragmented than the project results may suggest. Hence taking into account the variables *volume of transaction* and *importance of service* provides a more homogeneous picture of the current state of affairs. According to this concept, the combination (few transactions/many workarounds and many transactions/fewer workarounds) is quite acceptable for sustaining the integration in general terms.

This suggests that a strategy that makes some economic sense in integration projects is to commit the main effort where it may have the best effect: in the top-left corner, gradually extending downwards and to the right. We suggest that the content of the table may serve as a conceptual framework for large-scale integration projects, as the "grey" or "black" gaps indicate where to prioritize future integration initiatives. One may then choose to focus on the gaps for the most important services and the highest volume of transactions. The framework also allows tailoring to the specific need at hand. For instance, one might add new organizational units (horizontally) or services (vertically), or possibly zoom in on the existing services to achieve greater granularity.

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