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A Patchwork Planet: Integration and Cooperation in Hospitals

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Abstract. The 'seamless' integration of a collection of information systems has been recognised as vital in promoting and realising the collaborative aspects of work. This emphasis on the collaborative role of integration supplements other studies in CSCW focusing on more singular tools for collaboration. Empirically, we analyse the design and use of an electronic patient record system (EPR) in large hospitals in Norway. We discuss the conditions for and types of integration of EPR with the host of related information systems in hospitals. We formulate design principles for the integration of collaborative information systems based on a pragmatic study of the productive role of redundant, fragmented and ambiguous information.

Key words: ambiguity, collaborative work practices, electronic patient records (EPR), fragmentation, hospital information systems, integration, redundancy

1. Introduction

A by now thoroughly re-iterated lesson is how coordination, communication and sharing of information in organisations is inhibited by the proliferation of non-integrated, incompatible information systems (McNurlin and Sprague, 1997; Schmidt and Bannon, 1992). Clearly, collective work in organisations presupposes a minimum of compatibility of understanding and practices. Incompatibility among information systems arises from differences in scope, use and responsibility across sites and organisational units and spawning counter-measures, i.e., strategies of integration. Despite prolonged efforts, it is fair to hold that 'integration has been the Holy Grail of MIS since the early days of computers in organisations' (Kumar and van Hillegersberg, 2000, p. 23). A pregnant and relevant expression of how integration is expected to enhance collaboration is embedded in the recent interest into Enterprise Resource Planning (ERP) systems as they 'promise the seamless integration of all the information flowing through a company' (Davenport, 1998, p. 121). Despite early awareness of the collaborative aspects of integrated information systems (Schmidt and Bannon, 1992, pp. 21–22), a substantial fraction of studies within CSCW has focused on singular tools, artefacts, protocols and coordination mechanisms. Our focus on the collaborative aspects of integrating information systems feeds into the revitalisation of this early agenda (see also Hartswood et al., 2002; Symon, Lang and Ellis, 1996).

Strategies and approaches to integration vary (Hasselbring, 2000) and include technical solutions like federated database systems, World Wide Web and EDI (Grimson et al., 1998, p. 124) as well as Enterprise Resource Planning systems. In addition, object oriented technologies such as CORBA[1] and COM[2] have emerged as a promising way to enable integration, as they are independent of programming language and operating systems. Defining technical integration strategies does not, however, solve the problem related to the mutual *autonomy* between the components (Hasselbring, 2000; Sheth and Larson, 1990). In the following, this is a key aspect as we focus on one approach – historically influential and currently exemplified by Enterprise Resource Planning systems – based on a dominant, central database, which other information systems need to comply to. The modest success to date of curbing fragmentation, redundancy and heterogeneity of information systems warrants a critical examination of the implicit and explicit assumptions in the pursuit of 'seamless' integration.

Our analysis is aimed at addressing the following set of issues: how do users cope with non-integrated information systems; what are the 'costs' and benefits in practise of information systems that are fragmented and contain redundant information; to what extent should such core systems subsume and include other information systems; under what conditions is redundancy of information productive. The overall ambition of this paper is to provide guidelines for the design of integrated information systems aimed at supporting collaborative work practices. This amounts to specifying the conditions, extent and nature of integration taking into account the role of redundancy and fragmentation in practical, everyday, collective work settings. We pursue these issues through a particular instance of this problem, namely a study of electronic patient record systems (EPRs; or synonymously computer based patient/health records, CPRs). This paper is drawn from the ongoing, large-scale Medakis project promoted by the Ministry of Social affairs in Norway establishing EPRs (dubbed DocuLiveEPR) at the 5 largest hospitals in the country.[3] Exactly as with Enterprise Resource Planning systems, EPRs in large hospitals are expected to promote collaborative work configurations by integrating information and information based processes across departments, among different types of users and over time (Hartswood et al., 2002; Grimson, Grimson and Hasselbring, 2000). Currently, hospitals typically have an abundance of poorly integrated information systems including patient administrative systems, laboratory systems, specialist systems of numerous kinds, a range of sensory/ graphical input devices such as X-ray, ultrasound, EKG and computer-tomographic images together with paper based records and indices (Grimson et al., 1998, p. 124).[4]

Despite a series of heavily funded national and international initiatives, there is only very modest success in establishing working EPRs in large hospitals. Oddly enough, there does not seem to exist any systematic, comprehensive and critical evaluation of these efforts (although more narrow or restricted ones exist; see

Massaro, 1993; Kushniruk et al., 1996; Safran et al., 1999; Sands et al., 1995; Lærum, Ellingsen and Faxvaag, 2001). EPRs have repeatedly been identified as ‘essential’ (Dick, Steen and Detmer, 1997) or ‘at the heart of the application of IT in health care’ (Grimson, Grimson and Hasselbring, 2000, p. 50). It has, however, proved remarkably difficult to achieve ‘seamless’ integration and to establish more than fairly isolated pockets of use (Berg, 1998; Levitt, 1994; Szolovits et al., 1995).

In section 2, we briefly outline the collaborative aspects of integration of information systems. We discuss how the strategies of integration for management information systems, for EPR in general and for DocuLiveEPR in particular share important similarities, namely privileging centralised solutions. Section 3 describes the setting of the case and reflections on the research design. In section 4 we present three case vignettes containing illustrations of collaborative work with and around DocuLiveEPR. Section 5 analyses the conditions for collaboration through ‘seamless’ integration. It is structured along two dimensions – integrated/non-integrated systems and identical/related but similar information – and aimed at identifying the ‘costs’ and benefits of the 2 × 2 generated matrix of situations. Section 6 contains concluding remarks including guidelines for design of ‘seamlessly’ integrated information systems in collaborative work settings.

2. Collaborative work and the integration of information systems

In an effort to highlight the similarities, we outline the collaborative aspects around integration of information systems at three levels: the general level of management information systems (MIS), the level of EPRs in general and a specific instance of an EPR represented by DocuLiveEPR.

2.1. MANAGEMENT INFORMATION SYSTEMS (MIS)

The source of the problem with non-integrated information systems and subsequent hampered organisational communication is hardly news. It follows immediately from

> ‘incompatible data definitions from application to application, department to department, site to site, and division to division’ (McNurlin and Sprague, 1997, p. 198).

This incompatibility, stemming from distinct situations of use, is identified as a key challenge for enhanced collaboration in organisations – and the problem where tighter integration is perceived as the solution (Davenport, 1998; Hartswood et al., 2001). In principle, one approach to integration is a non-centralised one with interchangeable components, modules and objects similar to middleware software like CORBA, COM or like the Internet suite of protocols (see above). In practise, however, an approach based on a central, comprehensive database as found in Enterprise Resource Planning systems is often compellingly attractive as ‘the promise of an off-the-shelf solution to the problem of business integration is enticing’ (Davenport, 1998, p. 121). SAP, the world’s leading vendor of such systems, advocates their product as a way to enhance collaboration across functional boundaries:

> ‘SAP R/3 overcomes the limitations of traditional hierarchical and function-oriented structures like no other software. [All the functions] are integrated into a workflow of business events and processes across departments and functional areas’ (*www.sap.com*).

Rephrased into the vocabulary of systems integration (Hasselbring, 2000), approaches with one dominating component, which the others have to comply to, are attractive to many.

2.2. ELECTRONIC PATIENT RECORD SYSTEMS (EPRS)

The discourse around collaboration and the integration of information in connection with ERPs mirrors exactly the more general and long-standing debate in management information systems and Enterprise Resource Planning systems outlined above (Hartswood et al., 2002; Hanseth and Lundberg, 2001). Perfectly aligned with the arguments for Enterprise Resource Planning systems, the project Synapses funded by the European Union points out that:

> ‘[U]sers performing diverse tasks (. . .) [in] different department within a hospital may have deployed different (. . .) systems that should be integrated in order to support the business processes adequately’ (Grimson, Grimson and Hasselbring, 2000, pp. 52–53)

Similarly, the W3 EMRS project (1995) sponsored by the United States National Library of Medicine aims at:

> ‘tam[ing] the Tower of Babel in current medical databases [by] defining a common medical record (. . .) [that enables] meaningful queries across patient information databases in multiple hospitals’

As for the more general case of management information systems, there are, in principle, different routes to the integration of information systems in hospitals. Yet, EPRs are – and have been for some time (Dick, Steen and Detmer, 1997) – perceived as essential in achieving this integration; EPRs *are* the nexus for integration. To illustrate this mode of thinking, Szolovits et al. (1995, p. 16) explain that it implies:

> ‘establishing a canonical electronic medical record structure with supporting data abstraction processes to provide consistent views of medical information independent of underlying database structures (. . .) [which allows] a common API for heterogeneous data sources’

This emphasis on the role of the conceptual model with associated interfaces has been heavily advocated also by the European standardisation organisation, CEN TC 251 (prENV13606 1–4, 1999). The problems with fragmented and non-integrated information systems in hospitals have largely spawned approaches building on abstracted and highly idealised models of clinical work as a result of premature standardisation following from the urge

> 'to make sure that unsuitable circumstances (e.g., proliferation of incomplete solutions) are not allowed to take root ... [so] standardisation must be started as soon as possible in order to set the development in the right track' (De Moore, 1993, p. 4).

Such efforts represent unwarranted purifications that neglect the full complexity of clinical work. There exists to date little systematic, comprehensive and critical assessment of the experiences with practical EPRs. What exist are more restricted studies of particular projects and prototypes (Kohane et al., 1996; Massaro, 1993; Kushniruk et al., 1996; Safran et al., 1999; Grimson et al., 1998). Despite high aspirations, Berg (1998, p. 294) fairly accurately characterises the situation when he maintains that 'fully integrated [EPRs] ... are hard to find'.

2.3. DocuLiveEPR

A key concern in the Medakis project has been the role of DocuLiveEPR in relation to the rich variety of other information systems, in other words, the strategy of integration. The crucial problem – reiterating the theme from management information systems and EPR in general – is the proliferation of local, tailored and non-integrated information systems and their apparent hampering of collaboration.

In the requirements specification worked out in collaboration between the vendor and the hospitals, the presence of special purpose information systems is recognised. This produces fragmentation as:

> 'There is a tendency that the specialist functions create their own information system to store and systematise data. In Norwegian hospitals today, these systems are only to a limited degree integrated or available in a uniform interface' (Unified requirement specification, 1996)

This leads up to formulating a main goal of Medakis:

> 'to give access to, and produce the documentation that exist in the paper-based patient record. The EPR should replace many of the special purpose information systems that exist in the wards' (ibid.)

The basic premise for EPRs, as captured by the Medakis project specification and documentation, is of course to contribute to an overall improvement in productivity and quality (Unified requirement specification, 1996). The crucial element, however, is for the EPRs to function as the core information system and to

> '*collect all clinical patient information in a uniform computer system* (...) and offer a common interface to all other IT-systems' (ibid., emphasis added)

As the more general cases outlined above, integration could in principle be achieved without delegating a pivotal and ambitious role to DocuLiveEPR. In practice, however, DocuLiveEPR was delegated a central role as:

> 'Even an electronic patient record with a relatively narrow functionality will gain a unique position in a hospital as it deals with the most sacred information' (M1)

Thus, from the outset the strategy of integration was given and 'the EPR was supposed to be at the centre of information systems in the hospitals' (L1). Tellingly enough, another important source of information, namely the patient administrative systems (PAS) was assumed to be subsumed rather than integrated with the EPR:

> 'We expected that the EPR eventually would include the registration functions of the PAS (...) and that the registration forms of PAS instead became schemas in the EPR' (L1)

Given that PAS contains basic demographic information and support for budgeting, accounting, resource allocation, planning, waiting lists for procedures, appointments as well as patients' visits and stays, this delegates the central means of integration to DocuLiveEPR.

This is reinforced by the vendor's current strategy of subsuming specialist systems by replacing them by EPR controlled modules. As explained by a senior manager of the vendor:

> 'Instead of having many specialised systems you get an ERP that contains modules that can be added when needed. In this way, you get rid of many specialised systems from different vendors that otherwise had to be integrated (...) [hence] it is planned a PAS module in the next version of DocuLiveEPR' (S1).

3. Methodological considerations

3.1. SETTING OF THE STUDY

The Medakis project of the Norwegian health authorities has a long history (see (Ellingsen and Monteiro, 2001) for details), but has run since 1996 with Siemens as the privileged vendor. The DocuLiveEPR system, developed as part of the Medakis project is used to an interesting extent, especially at the regional hospital in Tromsø (RiTø) and the regional hospital in Trondheim (RiT). These two hospitals have used DocuLiveEPR for the shortest time (since February 1999), but nevertheless with the most widespread use among the five regional hospitals (Lærum, Ellingsen and Faxvaag, 2001).[5] Both RiT and RiTø have completed their installations of DocuLiveEPR. Aligned with the development strategy, the users are currently primarily physicians and secretaries. Computer availability is reasonable for these two groups. The 5 regional hospitals together have about 6000 defined users of DocuLive EPR. On a normal working day, there are approximately 1400 concurrent users. A rough estimate suggests that there are about 2,5 million electronic documents, mostly physicians' notes but also sick notes and prescriptions. It is possible to import certain information from the patient administrative system (PAS) into DocuLiveEPR, but not the other way around.[6] With the upcoming (v5.0) version, the laboratory systems will be integrated and accessible through DocuLiveEPR. DocuLiveEPR also includes a workflow module that is strongly encouraged by management. A principal function here is the (digital) signing of notes by the physicians.

3.2. DATA COLLECTION AND THE PROCESS OF INTERPRETATION

This study belongs to an interpretative approach to the development and use of information systems (Klein and Myers, 1999; Walsham, 1993). Although broadly oriented within this tradition, this study is shaped by our analytic affinity with science and technology studies (STS) in general and actor-network theory (ANT) in particular (Latour, 1999; Bowker and Star, 1999). Traditionally and predominantly employed as a vehicle in historical reconstructions, ANT is increasingly used as we do here to also make sense of unfolding, real-time practise in much the same way as ethnographic studies (see Berg, 1999; Knorr-Cetina, 1999; Timmermans and Berg, 1997).

We rely on four types of data: participative observations, interviews, documents and informal discussions. The participative observations by the first author took place during two periods (February 2000 and January–February 2001) at the University hospital of Tromsø (RiTø) resulting in 61 hours of observations. During the observations, 105 pages of handwritten notes were taken and subsequently transcribed. Photographic documentation highlighted work situations of particular interest. Additional reflections, comments and questions were added to the notes, resulting in 45 pages of documentation. The observations were especially aimed at work situations involving physicians as they are recognised as a particularly important user group for the success of the Medakis project, but nevertheless often included secretaries, nurses as well as patients. Questions were posed to clarify and elaborate observations to obtain the kind of background understanding that is emphasised by Klein and Myers (1999). The extent and format of these obviously varied with what was possible without intruding too much with the ongoing work, often postponing them to less hectic periods.

We have conducted 27 in-depth semi- and unstructured interviews with users (coded as U1–U16), Medakis project members (M1–M6), EPR lobbyist prior to the Medakis project (L1–L2), policy and decision makers (D1–D2) and senior management of the vendor (S1). Through students the second author has supervised, we have also had access to 12 transcribed interviews with the vendors. These have been used for background information only.

We have had access to a number of electronic and paper based documents. We have gained access to two, comprehensive archives belonging to two of the key actors among the policy and decision makers. Firstly, the Norwegian Research Council, a principal sponsor of EPRs in the years immediately preceding the Medakis project, and, secondly, KITH (centre for IT in health care), a publicly owned agency aimed at establishing IT related standards in Norwegian health care. In addition, we have had detailed access to contracts, memos, specifications and documentation within the Medakis project.

In striving to adhere to Klein and Myers' (1999) principles of multiple interpretations and suspicion, we have relied heavily on validation through iterated discussions with 25 involved actors challenging our interpretations: 3 policy and decision makers; 8 users; 1 EPR lobbyist prior to Medakis and 13 Medakis project members. In addition, earlier versions of this paper have been circulated and discussed with these involved and engaged actors who provided extensive feedback, which in one instance resulted in 12 pages of written comments.

Klein and Myers' (1999) principle of interaction between researchers and the field raises highly relevant concerns about how we were conceived and how our roles influence our interpretation. Neither of us were perceived as detached observers as the first author used to be part of the local Medakis project organisation in Tromsø and the second author is heading a research project assessing EPRs in Norway through an emphasis on the Medakis project. This has involved a delicate, and at times problematic, balance between engaging constructively in debates with the Medakis project members at various levels while simultaneously keeping a critical distance.

4. The case vignettes

Medical practice varies enormously across different domains, departments, hospitals and countries (Atkinson, 1995; Strauss et al., 1985; Berg, 1998; Grimson, Grimson and Hasselbring, 2000). We have no ambition of paying justice to this variation in any systematic or comprehensive manner. Rather, we merely aim at motivating for an appreciation of this variation through a sampling of 3 wards at RiTø. This variation in practice also translates into a corresponding variation in the use and type of information sources. Characteristic features of the work situation in the wards are

1. Outpatient clinic, Dept. of Medicine: a hectic environment marked by a constant improvisation to cope with unplanned events (and patients). As a result, much of the clinical record keeping takes place in parallel, not finishing one patient before attention needs to be shifted to the next.
2. Department for Eyediseases: a largely self-contained department conducting highly specialised work. This takes place with relatively little interruption and interaction with other wards at the hospitals, promoting an emphasis on research oriented activities.

Figure 1. The workplace in the Outpatient clinic, Dept. of Medicine.

3. Department of Rheumatology: dominated by chronic patients that require extensive, collective and inter-disciplinary discussions among the health professionals rather than instantaneous, individualistic decision-making.

4.1. THE OUTPATIENT CLINIC: IMPROVISATION AND FRAGMENTATION

The Outpatient clinic is an integral part of the rest of the Dept. of Medicine. Hence, they have responsibilities for patients already at the hospital as well as those arriving. Only the secretaries and nurses are assigned to the Outpatient clinic on a permanent basis. Admittance is predominantly based on referrals (i.e., letters) from local general practitioners. Other patients turn up for scheduled checks following a period of hospitalisation. The offices in the Outpatient clinic are small and crowded, implying that they are often shared among different user groups. To illustrate the work of physicians and their use of information sources, consider the following vignette involving the chief physician.

> His office contains two desks, containing 12–15 stacks of paper-based, patient records and a computer (see Figure 1). On the shelf above the desks, there is an additional stack of patient records with a yellow post-it label stating 'to be signed'.
>
> Immediately upon entering the office, he starts looking for a specific patient record, calling out 'Where is it? I was just working on that record'. He leaves the office to inquire at the secretaries', but quickly gives up and instead starts to dictate reports from one of his own consultations. He examines the EKG-printouts turning them back and forth while continuing to dictate. He studies

the physicians' text notes in the patient record, and alternates by looking in the notes and dictating. He turns to the computer and logs onto the PAS system to check laboratory results through an established interconnection between the PAS system and some of the laboratory systems.

He selects an A4 paper form and enters values from a myocardial scintigraphy procedure. He fills in why and how the investigation was done, the result, and its impact on his final assessment of the handling of the patient. When he is done, he places the form in a paper archive on the shelf immediately above him. The chief physician and one of his colleges use this archive both as an element in their product quality system and as material for their research. This paper archive has been used for eleven years and contains almost 1900 patients.

Logging onto DocuLiveEPR, he activates his personal working list (part of the workflow system) and locates the appropriate patient record. Frustrated by not finding an electronic record for a blood test, he turns to the paper record, hoping that a note has been included. Still without any luck, he turns to the PAS system to continue his search. Upon finding it, he inserts paper in the empty printer and prints it together with 2 previous results from the same patient. He places the three copies in a sequence on the desk in order to assess possible progress of the results. Next, he picks up a small picture and studies it. It is a nuclear medical examination. By now his desk is covered with several text notes, the renogram and 3 A4 sheets of blood results. Appearing in different windows on the screen, the patient's information is showing in both DocuLiveEPR and in the laboratory system. He proceeds by typing his final evaluation into the policlinic note in DocuLiveEPR, about 6–7 lines of text and signs it electronically. To finish, the paper based patient record is extended with a letter, a post-it note, the hard-copy laboratory result from PAS and an A4-paper-sheet draft. They are all attached to the front cover of the patient record with a paper clip.

Someone from the accounting department is on the phone requesting help to change diagnostic codes. The ICD[7] and NCSP[8] codes are stored in the patient record but also in the PAS. But these codes take on quite distinct meanings in these two contexts of use. In the patient record, the ICD codes relate to the care and treatment of the patient and are the basis for subsequent discharge letters. In PAS, however, the ICD codes are used in a carefully designed way as the basis for governmental reimbursement according to the US adapted DRG[9] coding scheme. If the ICD coding fails to translate into the predefined DRG scheme, the hospital will not be reimbursed.

The accounting department routinely checks the validity of the codes and reports back to the wards about errors or other reasons to make modifications such as the last phone call. RiTø estimated a loss of 15MNOK in 1999 due to 'incorrect' ICD/DRG coding. As the consultant from the accounting department explained to us afterwards, they requested this particular chief physician

Figure 2. The laser room with the assistant physician placed in the patient's position.

to make the changes in the ICD/DRG codes in PAS because they knew he was willing and 'quick in the head'.

4.2. DEPT. FOR EYEDISEASES: STABILITY AND SPECIALISATION

The Dept. for Eyediseases has ten affiliated physicians and is fairly self-contained. There is little need for laboratory results and X-ray examinations. Typical patients groups are those related to age, diabetes and circulatory disorders as well as lens disturbances such as cataract, a disease often leading to surgery. Again, we present a vignette to illustrate the work.

After having seated the patient, an elderly woman, in the examination chair the light is turned off. Two physicians are present, the head physician and an assistant physician. In preparation, the head physician has read the paper-based letter of referral as well as the patient's paper-based patient record. He has interviewed the patient and obtained relevant background information.

A digital retina camera is placed between the patient and the physician. The camera is connected to a near-by computer, which runs a digital image processing system called OcuLab. OcuLab is used to process black and white pictures that are transferred from the camera and subsequently stored on a networked server (Figure 2).

Behind the patient, there is an archive of negatives of colour pictures. The use of this archive has been reduced after the introduction of OcuLab. But it is still in use, especially in situations where a colour photo may explain more than black and white photos, for instance, in identifying leakage from the blood vessels.

The patient's pupils have been pharmacologically enlarged to ease the inspection of retina. On her right arm is placed a syringe in which the assistant physician injects contrast fluid. After approximately 10 seconds, the fluid reaches the eyes. The head physician studies the patient's pupil through the camera. He starts taking a sequence of pictures with intervals of one second. After a while, the pictures slowly appear one by one on the computer screen. Already in the first picture it is possible to see abnormal blood vessels. They briefly discuss if they need to proceed but quickly agree that it is unnecessary.

Up till now the computer has processed about 40 pictures. Just a few of them need to be stored for future usage. The head physician makes his selection, stores these and discards the rest.

He logs off OcuLab and the examination is over. Had it been necessary, this is when colour pictures would have been taken, but with a different camera. He immediately dictates the result of the examination on his tape recorder. A secretary will subsequently type this into DocuLiveEPR, for the physician to electronically sign afterwards.

A possible further action for the patient is to receive laser treatment in the adjacent laser room. In these situations, the physician will use OcuLab to retrieve the pictures of the patient on the computer screen. To burn the laser marks correctly in the retina, he would be aided by the pictures from OcuLab.

In the laser room, the patient's record is usually placed on the shelf right behind the patient. Next to it, there is a large logbook that contains information about patients treated with this equipment containing date, type of treatment, anaesthetic used, result and responsible physicians. In addition, there are corresponding logbooks in the ward's other laser room and the surgery room. This information is used on a regular basis to report the activity in the ward, both internally and externally to the administration of the hospital. The information in the log-books overlaps with corresponding information in the patient record, but formatted to promote the readability of accumulated data.

If a cataract operation is necessary, an artificial crystalline lens is placed over the eye by the surgeon. Attached to each lens is some technical information (producer, model, length and serial number) about the same size as a post-it note, which will be glued to the patient's record to document which type of lenses was used.

The Dept. for Eyediseases participates in an international cataract research project. In connection with cataract surgery, a special paper form is filled in and archived. The ward is in the process of developing a new database system in collaboration with the IT-department. The system is to handle information obtained prior to, during and after cataract surgery. Printouts from this system will be placed in the paper based patient record. The chief physician in the ward emphasises the local context of use:

> The cataract record is made for specialists, which means that this information is meant for insiders and nobody else. And unlike an ordinary free text note in the patient record, the cataract record contains predefined categories for 'no remarks', 'ok' and numbers. This information is possible to measure and process statistically afterwards.

4.3. THE DEPT. OF RHEUMATOLOGY: THE COLLECTIVE EFFORT

Dept. of Rheumatology is a medium-sized ward at RiTø consisting of 23 beds served by cross-functional personnel: physicians, nurses, physiotherapists, ergotherapists and social workers. There are a vast number of different rheumatological diseases, which combined with its gradual character and fluctuating symptoms often prohibits exact diagnosis at an early stage. This implies that the personnel have to deal with uncertainty. The ward has a lot of chronic patients. The vignette that follows illustrates the mode of work in the ward.

This Friday morning, 10 physicians are present at the previsit meeting. Everyone brings their paper notes and makes additional ones as they discuss the latest about the patients. On the table, there are stacks of patient records. Some of the records are very thick, up to 15 cm each, as the ward has a lot of chronic patients. Some of the physicians skim through the patient record. There is also a book containing nurse documentation on the table. A nurse brings in a booklet with laboratory results.

After working through all the inpatients, it is time to discharge patients. Being predominantly a working day unit, most patients are discharged on Fridays. This creates a lot of work associated with discharges on Fridays with subsequent admittance the following Monday. Another nurse joins the group with a nurse patient record and they start discussing the cases more thoroughly. At one instance, they discuss what to do about a specific patient who regularly forgets to take her medicines. Based on their different information sources about this patient (the nurses' documentation and the physicians' notes), they discuss how to cope with the situation. One of the physicians underscores the importance of taking the prescribed medication while the nurse argues that pushing medication now is of no value since they are not able to follow her up after she leaves the hospital.

> Nurse: She forgets to take her medicines.
>
> Physician: But it's important that the she takes them!
>
> Nurse: Why bother? She forgets it anyway when she returns home.
>
> Physician: She has all signs of depression and has been suicidal.

The group studies the patient's chart containing important information during the stay of a patient (pulse, temperature, blood pressure, medications prescribed and given). They discuss the current medication. One of the physicians writes something on the patient chart. The nurse makes some notes on her own paper, which she later on will write into the nurse documentation. Explaining the role of nurse documentation, a nurse in the Medakis project points out:

> 'The nurses document continuously, 24 hours and from shift to shift. This distinguishes their documentation from the physicians' (...) The purpose of the nurses' running notes is to make the care of the patient in a dynamic process'. (U1)

After a while, the table is covered with paper from the patient records, or more specifically from the chart book. The chart book contains information about all the patients associated with this working group. For each patient, essential information from the patient's paper record is extracted. The chart book also contains the patient chart, abstract sheet and laboratory results. There are also copies of the physician's text notes that have previously been entered into DocuLiveEPR. When a patient is discharged, a letter is produced and sent to the general practitioner. The letter contains a description of the stay but also functions as a 'memory' for the physicians in the ward. However, due to incomplete information and lacking personnel resources, it often takes a week (sometimes even longer) before the discharge letter can be produced. To compensate, a preliminary discharge letter, a so-called discharge form, is produced before the patient leaves. The discharge form is an A4 paper sheet with several carbon copies. It is hand-written and very brief containing information to the patient, the general practitioner and the secretary at the Rheumatology ward. In addition, one copy is placed in the patient's record until the formal discharge letter is written.

Discharge letters from the Dept. of Rheumatology tend to be long due to the chronic character of the illness. However, detailed discharge letters seem to be only partially useful for general practitioners, which usually prefer to get answers as quick as possible prior to getting a complete discharge letter. This is illustrated by the fact that often the general practitioners only include the most important parts of the discharge letter in their own EPR system.

Let us return to the Friday's round of discharging. Physician A has three patients to be discharged. To support the writing of the discharge form, she uses information from the chart book (e.g., laboratory results), consultations written by other specialists, EKG printouts and physician's text notes. She frequently examines the patient-chart and the abstract sheet to get the proper information for the discharge form. The abstract sheet is an outline for a stay of a patient and as physician A expresses it:

> 'It is a tool for us (...) It contains information about the history of the case, reason for referral, patient diagnoses, internal referrals, test results, problems etc'.

The abstract sheet is also an important tool in the communication with the other professions in the hospitals, like nurses, physiotherapists, ergo therapists and social workers and used in interdisciplinary meetings both as a summarised version of the case and as a place where to put short notes. It is also used as a mean to provide continuity between shifts:

> 'The nurses will go through the abstract sheet in the evenings to check whether something has to be done' (physician B)

as well as continuity between the wards because 'when a patient is referred to another ward a copy of the abstract sheet will follow'.

5. Analysis

The lack of integration in hospitals is, and has always been, a principal motivation for the efforts into EPRs towards 'seamless' care (De Moore, 1993). 'The present inability to share information across systems', Grimson, Grimson and Hasselbring (2000, p. 49) maintain, 'represents one of the major impediments to progress towards shared care and cost containment'. We analyse the conditions for and strategies of integration at play around EPRs in hospitals. Two concerns are highlighted in our analysis, concerns which underlie strategies of integration. First, we distinguish between cases where the different *sources* of information are integrated or not. Second, we distinguish between the cases where the *contents* of the information (from the different sources of information) are identical from the cases where they are related, but slightly different. This gives rise to the following four types of situations:

		source	
		Integrated information	*Non-integrated information*
contents	*Identical information*	**compatibility**	**redundancy**
	Related, but different	**ambiguity**	**supplementary**

5.1. REDUNDANCY (IDENTICAL INFORMATION, NON-INTEGRATED)

The abundance of redundant information duplicated in different, non-integrated information sources is a major motivation for the pressure for integration. It has traditionally signalled potential consistency or communication problems (De

Moore, 1993). It represents the 'obvious' occasion for tighter integration. Before jumping to conclusions about the need to integrate, it is instructive to analyse how practitioners cope with redundancy. Only through an appreciation of this may reasonable strategies for integration be formulated.

An immediately and striking first observation is the relative modest level of problems actually caused by redundancy. On the contrary, there are a rich set of artefacts and routines that perform the invisible work, fill in the gaps and glitches (Gasser, 1986; Bowker and Star, 1999; Latour, 1999; Atkinson, 1995). Users are highly competent in bridging these gaps. In her studies of control rooms, Suchman (1993, p. 119) underscores how collaborative work draws on different information sources as 'work in operations makes artful use not only of computer technologies, but of a range of other communications and display technologies as well'.

A particular instance of redundancy is that between paper and electronic form. There are several studies that focus on the physical properties of paper and the way this afford a number of effective and flexible capabilities in clinical work (Nygren and Henriksson, 1992; Luff, Heath and Greatbatch, 1992; Harper et al., 1997). At the Outpatient clinic in our study, the paper folder in the paper-based patient record integrates the various notes, texts, pictures and printouts in such a way that redundancy of information is worked abound by sifting through duplications.

Beyond working around redundancy in the manner outlined above, Hutchins (1994, p. 223) argues for a productive role played by redundancy as a principal reason for the robustness[10] of work because if 'one (...) component fails for lack of knowledge, the whole system does not grind to halt'. Going back to the Department for Eyediseases, the overlapping of (ordinary) colour pictures, electronic black and white ones, the notes in the logbooks, avoids making the work vulnerable to the failing of any one of these.

This all adds up to demonstrating that redundancy is not necessarily and automatically the kind of problem portrayed in traditional management information systems. This should not, however, be misconstrued as an argument that any redundancy is acceptable. It is merely the argument that the pros (largely bypassed) and cons need to be assessed before judgement is passed. The episode from the outpatient clinic (section 4.1) where the physician searches for the laboratory results demonstrates how redundancy of information – presenting the test results in DocuLiveEPR, in the paper-based patient record or in the laboratory system accessed through PAS – enables him to conduct his work even if he did not find the test results immediately. Turning around in his chair, logging onto a different non-integrated system he locates the information. After locating it, he prints the results and includes a copy in the paper-based patient record thus filling the glitch. Yet, the fact that he is able to bridge the gap and maintain the redundancy is not an argument for preserving the situation. As pointed out above, design decision regarding redundancy need to assess both costs and benefits. In the present case, the benefits (robustness) do not compensate for the amount of work involved in maintaining the redundancy. Hence it seems reasonable to require the laboratory results to be tightly integrated with DocuLiveEPR.[11]

5.2. SUPPLEMENTARY (RELATED INFORMATION, NON-INTEGRATED)

These types of situations resemble those analysed above but are distinguished by the fact that the information in the different information systems is not identical only 'related'. Obviously, there are problematic cases of separating these two situations. Typical illustrations of the present type include situations where the different professions have different versions of patients' trajectories or were one version is an abbreviation of another. The task is to pragmatically assess how users cope with information that is closely related, partly duplicated but distributed across different information systems or even within the same system. As in the case above of redundancy, we hope to demonstrate that supplementary information plays an often overlooked, productive role that warrants closer scrutiny. We accordingly need to analyse its role in collaborative work settings.

The Dept. of Rheumatology represents a typical illustration of the present type of situation where the physicians, nurses and physiotherapists work together discussing each patient. The different professions have their own documentation that slightly overlaps with the other professions' documentation, which they refer to in their spoken performances (Atkinson, 1995, p. 91). The episode outlined in section 4.3 with the forgetful patient illustrates the role of the related but different information (the nurses' documentation and the physicians' notes). It illustrates an important characteristic of the work at the department, namely how decisions are negotiated among (and within) the professional groups based on their related, but different written accounts. As one of the physicians pointed out:

> 'Rheumatology is a kind of oral and assessing profession (...) it is important to have meetings, discussing which treatment that is most important or correct [and] whether it should change or not'

This is closely related to what Nonaka and Takeuchi (1998, p. 230) denote 'learning by intrusion', a mechanism for promoting collaboration which implies the

> 'existence of information that goes beyond the immediate operational requirements of each individual. The redundant information enables individuals to invade each other's functional boundaries and offer advice or provide new information from different perspectives.

In her recent book, Knorr-Cetina (1999) makes a similar observation when she explains how knowledge work presupposes information in different, related formats to enable the necessary 'narrative encapsulation' of knowledge. Collaboration and mutual understanding presupposes 'the general strategy of mixing together [results] from very different origins in an attempt to come to grips with the limitations of specific data or approaches' (Knorr-Cetina, 1999, p. 76). Hence, both Nonaka and Takeuchi (1998) and Knorr-Cetina (1999) underscore the productive role in relation to collaboration of this kind of supplementary information.

Supplementary information, related but different versions that are not integrated, also allows for competing agendas as the case of discharge letters at the Dept. of Rheumatology illustrates. General practitioners often prefer rapid answers at the sacrifice of completeness, thus conflicting with the need for the physicians at the ward to use complete discharge letter in reconstructing the case when the patient reappears at the ward. Today, the discharge form functions as a convenient boundary object (Bowker and Star, 1999) serving both of the communities: rapid responses for the general practitioners and accumulating experiences for the hospital physicians.

Another example, also from the Dept. of Rheumatology, is their actual use of the abstract sheet in their daily operations. It provides supplementary – abbreviated, condensed – information. Given the vast volume of documentation associated with chronic patients dominating the ward, summaries represent essential, supplementary information, particularly across different communities of practise (or professions).

> 'The abstract sheet is very useful in achieving quick overview of the case. It contains an extract of the status from the patient record as well as brief notes from interdisciplinary meetings. Then we don't need to go back to the patient record (. . .). It also outlines what has happened and what is planned' (physician A)

Another aspect of supplementary information is that it allows collaborative needs and interests to be tailored to local, situated contexts of use as illustrated by the proliferation of local archives and indices. In the three wards, there were archives for quality insurance of a specific procedure (outpatient clinic), colour picture backup archive (Dept. for Eyediseases) and research related archives. For instance, the Dept. for Eyediseases is involved in developing an IT-based cataract surgery archive. The reason is that DocuLive EPR does not include the flexibility to manage all their special needs, especially regarding *accumulated* data, reports and quality assurance (see section 4.2).

Combining information from multiple, sometimes independent, sources of information permits consistency check of multiple representation with each other (Hutchins, 1994, p. 35) or 'framing' as denoted by Knorr-Cetina (1999, p. 72) as it serves to check, control or extend information from different non-integrated sources. This was the case for the cataract surgery research project at the Dept. for Eyediseases. The participants of the research team perceived the quality of the codes in PAS as not sufficient for their purposes and accordingly created their own research database maintaining their own diagnose and procedure archive.

In sum, we have pointed out and argued for the productive role supplementary information plays in facilitating robust, collaborative work configurations (establishing shared understanding, allowing local flexibility and performing consistence checks). These benefits, we argue, tend to override the costs associated with maintaining this supplementary information, implying that the inclination towards tighter integration should be curbed.

5.3. AMBIGUITY (RELATED INFORMATION, INTEGRATED)

A well-known aspect of technology is how it may be interpreted, conceived of or used differently across distinct local situations (Blume, 1991; Barley, 1986). Hence, notions like interpretative flexibility (Pinch and Bijker, 1989), boundary object (Bowker and Star, 1999) or situated action (Suchman, 1987) all, in slightly different ways, underscore this. To merely reiterate this for EPR is accordingly hardly news. We want to pursue this further by spelling out how these differences in use feed into the coordination, delegation and organization of work (Berg, 1999). This amounts to tracing the productive role of the ambiguity in interpreting and using this information.

Many have pointed out how medical work in general and patient record keeping in particular get caught up in an increasing number of roles (Berg and Bowker, 1997; Bowker, Timmermans and Star, 1995). Beyond a resource for diagnostic purposes, it functions as a vehicle for coordinating work, as a source for cost- and income generation and become relevant for insurance companies.

The example from the Outpatient clinic in section 4.1 of how ICD codes, appearing first in DocuLiveEPR before being registered in PAS, illustrates this. The difference across the communities of practise should be clear: the economical incentive of management vs. clinical-diagnostic motivation among the physicians. This explains why there are, as so compellingly demonstrated by Bowker and Star (1999), competing agendas and accordingly difficulties in making them unique. In addition, had the ICD/DRG coding been uniquely defined across the PAS and DocuLiveEPR, this would have generated additional work for the physicians. If the ICD codes were identical in both systems, any changes of coding would have to be carried over to patient record as well. This includes, for instance, the discharge letter that is sent to the general physician. This is by no means a straightforward task as nothing that is signed by a physician can be changed. The changed code would have to be written to DocuLive before sending new copies to the general physician with the updated codes. From a clinical point of view, this work is irrelevant as it only relates to economy.

The coding of ICDs is not necessarily ‘wrong’, but has to be continuously updated according to new guidelines from the Ministry of Social affairs or misplaced main and secondary diagnoses. Often these aspects influence reimbursement. As the accountant explains:

> ‘We correct codes regularly (...) [and] the Ministry of Social affairs acknowledge that the hospitals can correct these codes going back the whole year. For instance, in September, new guidelines were issued that were supposed to be valid already from 1 January the same year’.

An observed example from RiTø is the sequence of the two ICD codes C91.0 and Z51.1. The former expresses a type of cancer while the latter expresses appearance to chemotherapy related to the disease. Before the change, with C91.0 as the main diagnose and Z51.1 as the secondary, no reimbursement was generated. After correcting, i.e., swapping the sequence of the two, the reimbursement produced 11952 NOK.

Another example has recently surfaced related to the surgical departments. Partly by luck and partly by chance it has been discovered that the hospital had missed reimbursement through the lack of coding of 'cutting time'.[12] Cutting time that exceeds 3 hours is entitled to a larger amount of reimbursement. Adding these procedure codes in retrospect will increase reimbursement with 1/2 MNOK a month.

In the Medakis project there has been a heated disagreement about how to make PAS and DocuLiveEPR interoperate. The issue circles around which of the two should be delegated the status as a 'reference system', i.e., which should dominate the other whenever inconsistent information existed across the two, integrated systems. This disagreement surfaced in one of the Medakis project groups in 1998 where the hospital participants wanted to maintain the role of the PAS as the primary repository for some part of the information to comply with earlier days. The memo from the working group states that:

> 'PAS is a reference system for defined patient administrative information, like demographic data, diagnostic codes and so on. This means that the information in the PAS system at any time is taken to be the most correct' (Workgroup II, 1999, p. 3)

To avoid being ignored, the hospital participants really pushed the integration issue. The resulting document underscores that PAS must be seen as a reference system (rather than DocuLiveEPR) and that access to this system shall be done by the use of a COM interface. The end result, however, has been to promote DocuLiveEPR as a centralised system, including its planned PAS module. This reiterates the theme outlined in section 2, namely that even if non-hierarchical integration is conceivable in principle, more often than not a centralised mode of integration is privileged.

This centralised approach to integration of information systems ban systems adapted to more local use, including the option to change coding scheme as illustrated above with DRG.

This example is not exceptional. Participants in clinical research often perceive that the quality of the diagnostic codes in PAS and even in the patient records are insufficient for their research projects and henceforth create their own clinical research databases where they maintain their own diagnose registers. These codes are also compared to the actual patient record text in order ensure the right quality. The former head of the clinical research department underscores this:

> 'If you base clinical research solely on diagnose codes from the patient record [and PAS] then the validity will be challenged as it is well-known that the quality of these codes is poor (...) it was bad also before DRG was implemented,[13] but has since deteriorated further (...) as the physicians are under pressure to code to maximise reimbursement'

This goes to the heart of their problems as it is essential to select patients belonging to certain diagnose categories in their research. This spawns local improvisation:

> 'You may wonder, then, how it is possible to locate the patients when it is not possible to use the diagnose codes! We cope by using the laboratory results (...) [as index and subsequently] read through the patient record text in order to see what this is all about'

An additional point that influences the perceived quality of coding and the danger of integration is changes over time:

> 'The categorising of the diagnose codes is in continuous change and the clinical picture for a disease get new definitions. For instance: what you define as a heart attack today is not identical with the definition 5 years ago'.

Counter-intuitive for many perhaps, ambiguity is often the basis for a sound division of labour. Referring to the case discussed above regarding the ambiguity of coding, the benefits are, we argue, greater than the costs, implying that forcing compatibility by flattening ambiguity is dysfunctional.

5.4. COMPATIBILITY (IDENTICAL INFORMATION, INTEGRATED)

These situations are represented by those instances where 'seamless' integration is indeed achieved. They are included for the sake of completeness. An illustration from the Outpatient clinic is when the chief physician logs onto PAS in order to check laboratory results. The laboratory system and PAS are distinct, integrated information systems with compatible data formats. The laboratory results are stored in the laboratory system but can also be accessed from PAS. The laboratory results are uniquely given, regardless of which information system you use to access them. In fact, laboratory values are regarded as 'facts' as demonstrated in the last quotes of the last section.

Successful integration of laboratory values, however, presupposes that it is possible to identify information related to the same patient from one system to the next. Normally, this requires conformity in demographic data (name, date of birth and personal identity number). An example of this is from the Outpatient clinic (section 4.1) where only one set of demographic data is stored as DocuLiveEPR imports this from PAS.

6. Conclusion

In terms of analysing how (lack of) integration influences conditions for and contents of collaborative work, the two situations involving related but not identical information (dubbed supplementary and ambiguity) are the essential ones. Counter-intuitively for many, they underscore how collaboration is undermined by centralised, 'seamless' integration. Supplementary (non-integrated, related but not identical) information fosters what Boland and Tenkasi (1995) call perspective taking, the backbone of the mutual understanding that underpins collaboration, communication and coordination.

Ambiguity (integrated, related but not identical) information plays a different but equally important role in promoting robust, collaborative work arrangements. In striving to eliminate ambiguity, one introduces a number of dependencies between communities of practise that imply considerable – and largely unanticipated – additional work. Ironically, tighter integration in these cases, aimed at fostering collaboration, end up (unintentionally!) producing additional work in stead (Beck, 1992).

The ideal of 'seamlessly' integrated hospital information systems relies on unwarranted purifications. An analysis of how users cope with duplicated, fragmented and related information provide guidelines for design. Design and intervention strategies for EPR need to balance on a tightrope: on the one hand, to avoid promoting unrealistic, futuristic aspirations, overly emphasising the potential of the technology, and on the other hand, to move beyond a description of the immense richness of medical practise that may easily infuse the impression that any intervention would necessarily upset this elaborate and delicate play. Intervention, then, need to take seriously the transformative – not merely the 'supportive' (Berg, 1999, pp. 391–393; Berg, 2000, pp. 500–501) – aspects of EPRs but proceed evolutionary (Atkinson and Peel, 1998).

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Notes

1. The OMG (Object Management Group)'s CORBA (common object request broker architecture) is a wiring standard that enables communication among objects that are programmed in different languages and supported by different operating systems (Szyperski, 1999, pp. 22–23).
2. COM (component object model) is a standard maintained by the Microsoft dominated Active Group, a part of the Open Group (Szyperski, 1999, p. 23).
3. The Norwegian health care system is a predominantly public one with marginal private services, mostly outpatient ones. There is a growing pressure, supported by a set of targeted efforts, in transforming the budgeting of the public health sector to a more production oriented mode, in an attempt to curb rising expenditures. On a trial basis, the Government reimburse about 20% of the hospitals' expenditures based on a DRG (Diagnosis Related Groups) coded account of their production. The health care sector is organised into three levels: primary health care, small hospitals and five regional hospitals (together with a couple of national ones). Our study covers two of the regional hospitals.
4. At one of the two hospitals covered in our study, paper records are estimated to occupy 16 km of shelves. The number of distinct information systems at the two hospitals is estimated to be 40–60 by the IT departments.

5. The National hospital and Ullevål – one of the largest hospitals in northern Europe – are different with only 15% and 30%, respectively, installed.
6. DocuLiveEPR imports demographic data like name, date of birth and addresses from PAS. In addition, the diagnostic and procedure codes may in principle be imported. This is seldomly used, however, as these codes are normally recorded in the patient record before PAS. The integration mechanisms are not based on standards like CORBA or COM, but are rather hardware and language dependent solutions.
7. International Classification of Diseases as worked out by the World Health Organization (WHO).
8. NCSP is an abbreviation for NOMESCO Classification of Surgical Procedures. The NOrdic MEdico-Statistical Committee was set up in 1966, following a recommendation by the Nordic Council. An aim of NOMESCO is to promote the coordination of health statistics in the Nordic countries.
9. DRG is short for Diagnose Related Groups. The DRG system divides hospitalised patients into groups on the basis of diagnosis and treatment. Based on the hospital's operating costs, an expected price per patient discharged is estimated.
10. This corresponds closely to the debates on fault tolerance as discussed in systems theory. E.g., Perrow (1984) argues that breakdowns regularly occur in complex industrial work systems but are usually efficiently repaired as a part of daily work.
11. This is exactly the direction taken in the next version (v5.0) of DocuLiveEPR.
12. Norwegian: knivtid.
13. The DRG reimbursement schema was introduced in 1997.

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