Pick-n-Mix Approaches to Technology Supply: XML as a standard "glue" linking universalised locals

Mark Hartswood[1], Alexander Voß[1], Rob Procter[1], Robin Williams[2]

[1]Institute for Communicating and Collaborative Systems, University of Edinburgh

[2]Research Centre for Social Sciences, University of Edinburgh

av|mjh|rnp@dai.ed.ac.uk, robin.williams@ed.ac.uk

Abstract We report on our experiences in a participatory design project to develop ICTs in a hospital ward working with deliberate self-harm patients. This project involves the creation and constant re-creation of sociotechnical ensembles in which XML-related technologies may come to play vital roles. The importance of these technologies arises from the aim underlying the project of creating systems that are shaped in locally meaningful ways but reach beyond their immediate context to gain wider importance. We argue that XML is well placed to play the role of "glue" that binds multiple such systems together. We analyse the implications of localised systems development for technology supply and argue that inscriptions that are evident in XML-related standards are and will be very important for the uptake of XML technologies.

Introduction

Although XML is a relatively new set of technologies[1] (the basic standard was set in 1998) there is already evidence of a large market of XML-related products and a large number of XML applications are being developed. At the time of writing xml.coverpages.org lists some 450 proposed applications and projects ranging from a format for digital business cards to industry-wide data interchange. What are the reasons for the rapid diffusion of these technologies? We wish to discuss one possible answer: there are inscriptions in the XML standards that make them ideal tools for building successful sociotechnical ensembles in complex environments involving configurational technologies (Fleck 1992), technologies that have to undergo significant adaptation and transformation before they can be useful in a given local context. There is a trend towards new forms of technology supply that go beyond the

[1] We speak of technologies rather than using the singular, technology, for two reasons: first, XML is used as an umbrella term denoting a number of standards and, more importantly, we wish to point to the fact that the meaning of the term is constantly being renegotiated. There may, for example, be disagreement as to what constitutes a further XML standard and what is "merely" an XML application because many standards are themselves written in XML (witness XML Schema).

traditional make-or-buy alternative and take the form of "picking and mixing" components from various sources and assembling them to form a working ensemble. XML technologies provide a form of "glue" that can be used to link such components together, to integrate them with other systems and to enrol the support of a large number of related technologies that are widely available, such as Web-browsers and XML editors.

We present experiences from a participatory design project that has a focus on the development of systems that are *developed in locally meaningful ways* but nevertheless have the potential to gain wider importance through processes of *social learning* (Williams, Slack, and Stewart 2000). We call such systems *universalised locals*, a term inspired by – and complementary to – the notion of *local universalities* (Timmermans and Berg 1997). Timmermans and Berg describe the process by which universalities (standards, generic components, etc.) are reshaped to match a local context. Only through this link with local contexts are universalities meaningful, without them they would not survive. Extending this argument, we look at the way that *universalities emerge from locals* (local practices, technological innovations, etc.), how locals are re-shaped to make them more widely applicable through distributed learning processes and how they are linked to other locals. These processes are closely related to and, we argue, form the basis of the successful deployment of large-scale, infrastructural ICT systems.

We begin by reviewing progress in the achievement of the integrated electronic patient record (EPR), one of the application domains in which we have been studying these issues. We then present material from a case study that illustrates current medical record keeping practices, the possible interplay between local practices and universalisation, and their implications for the introduction of an EPR within the case study setting. We present the notion of locally meaningful information management as a means to conceptualise this interplay and to enrol it in the process of creating working ensembles not only locally, but on a wider scale. The pattern that we see emerge from this is one of integrated heterogeneous components. We will discuss how XML technologies carry inscriptions that are relevant to the integration process. This leads us to the conclusion that XML technologies are successful because their inscriptions are very much aligned with current problems and trends in the IT industry.

The Electronic Patient Record

Current health and social care policy initiatives in the UK, and elsewhere, make significant claims about the desirability of integrated services for better health and social care, i.e., more patient-centred healthcare delivery, improved resource utilisation and management of information (e.g., O'Hagan 1998). Plans for implementing these initiatives appear to be largely predicated on information integration being a precondition for service integration (e.g., Health Select Committee 1999; NHS Executive 1998). A key element of any healthcare information integration strategy is the electronic patient record (EPR).

Although the picture world-wide is by no means uniform, it is nevertheless fair to say that progress towards the introduction of the integrated EPR has so far fallen far short of expectations (Hanseth and Monteiro 1998). Though the EPR is now common in the primary care sector in a number of European countries, such as the UK, in the secondary care sector, clinical records are still largely departmentally oriented, and not patient-centred (Schoeffel 1998). Even more rare than the within-sector EPR is the fully integrated EPR, bringing

together the complete set of patient information held across the healthcare sectors. Various studies have highlighted a number of factors that may account for this situation (e.g., Berg 1998, Ellingsen and Monteiro 2000).

Some of the impediments to the creation of the integrated EPR simply reflect the scale of the organisations and services involved. For large organisations with complex information systems, achieving even modest levels of integration can be difficult in practice (Fincham et al. 1994). The evolving nature of the services being provided leads to difficulties in providing technical support that can evolve to match organisational change. Large organisations exhibit further complexities related to scale, numbers of distinct roles and processes, and the richness and inter-relatedness of information in the organisation. Information exchange practices and systems are rooted in local work processes as well as wider patterns of co-ordination and communication. Attempts to change practices, and redefine roles and relationships may lead to resistance, if those involved have different commitments and understandings of organisational processes and service provision. Issues relating to different commitments, cultures and perceptions are further compounded in relation to integration across organisational boundaries, – e.g., between primary and secondary healthcare providers. As Berg and Bowker (1997) argue:

> "When it is acknowledged that the medical record is interwoven with the structure of medical work in fundamental ways, that different medical record systems embody different notions of how work is organized, different modes of configuring patient bodies, and so forth, we are in a position to better understand and intervene upon the issues that are at stake."

Our work aims to explore the possibilities of creating an integrated EPR from the 'bottom up', as an ensemble or 'patch work' (Ellingsen and Monteiro 2000)). That is by capitalising on progress in the local adoption of this technology in such a way as to achieve a level of integration without sacrificing local meaning and practices. To this end, we are working with staff members of a clinical unit within an Edinburgh hospital to develop a local EPR system (Hartswood et al. 2000).

The Study and Its Setting

The setting for this work is the toxicology unit within a large Edinburgh hospital, known within the hospital as Ward 1A. The unit is a specialised inpatient (secondary healthcare) service that allows for joint medical and psychiatric assessment of patients following a suspected self-harm incident. Its main function is to provide necessary medical treatment and determine the need for further psychiatric and social care, referring patients on as appropriate. Because of its referral role – in effect negotiating the transfer of patients to other care providers – the function it performs is commonly known as a 'liaison service'.

Ward 1A is an especially relevant setting in which to investigate the benefits of the EPR, especially its potential impact upon healthcare integration. Its caseload is typified by a high turn over, emergency admissions, short average hospital stay and high rate of re-admission. Treatment of self-harm incidents may involve complex care pathways that call upon the services of acute medicine, psychiatrists, toxicologists, GPs, social services and community healthcare agencies. Yet, a succession of independent inquiries has concluded that

communications with, and between organisations involved in the provision of mental health care, are often very poor (e.g., Ritchie, Dick and Lingham 1994).

The observations reported here are drawn from extended ethnographic (Hughes et al. 1993; Hughes et al. 1994) fieldwork in Ward 1A. Interviews and discussions with members were recorded and notes made of activities observed and artefacts employed, e.g., clinicians' notes, patient records, and referral letters. One aim of our study was to subject work within the Ward 1A to close empirical investigation. The method used, ethnomethodologically-informed ethnography, (Hughes et al. 1994) observes in detail everyday working practices and seeks to explicate the numerous, situated ways in which those practices are actually achieved, and the things that such an achievement turns upon. The method seeks to explicate the situated character of work, the work seen as a practical production by social actors performing their activities within all the contingencies of local circumstances, to portray the variety of activities and interactions that comprise the 'workaday' of working life and the ways in which these are understood and accomplished by those who do that work.

Our goal, however, was not just to understand Ward 1A work, but to create the circumstances in which we can engage local expertise and experience to the on-going, participatory design and development of an EPR system tailored to the specific needs of staff within the unit. What we have been seeking to do is to turn the concept of user involvement on its head: our aim is not greater user involvement in IT design, but greater IT specialist involvement in user-led processes of innovation and social learning. Our approach to participatory design has been based upon 'being there, and doing IT' – taking the technical work of development into the users' workplace (Hartswood et al. 2000). The emphasis throughout has been on tightly coupled, 'lightweight' design, construction and evaluation techniques.

Information Management in a Hospital Ward

The Ward 1A patient record epitomizes the traditional, much criticized, departmentally oriented, paper-based record. It consists of a number of components that accumulate over the course of the treatment and subsequent discharge of a patient (Hartswood et al. 2001). It has previously been argued that the paper-based medical record is not a single distinct entity, but rather a heterogeneous and dispersed collection of materials (Fitzpatrick 2000). We find this holds for the medical record(s) examined in our study and that it is useful to classify the various record corpuses found on Ward 1A in the following way:

1. The hospital record. This is perhaps is what is typically understood by the term 'medical record'. It documents each of the patient's admissions to this hospital and consists of the paperwork generated during each inpatient stay. These are held centrally and requested upon re-admission.
2. The episodic record. This is used to document a patient's current admission. It is created upon admission to the ward, and appended to the hospital record when the patient is discharged.
3. Permanently located records. These are records that are held on the ward, either at the nurses' station or in the doctors' room, which may or may not be duplicated in the hospital record. They may be used for a number of purposes, for example, as a clinical record, for research, audit and so on.

4. Transient representations. These are representations that are generated during the patient's admission, but which are discarded without being integrated into the record corpus. Examples of these include the ad-hoc notes made by nurses, scribbled notes taken during a psychiatric assessment, details recorded on a whiteboard, and so on.

The episodic record used on Ward 1A contains a number of pre-structured paper documents, some generic to a number of hospital departments (drug prescribing forms, nursing short term care plans, monitoring forms and so on) and some specific to the work carried out on Ward 1A (the Toxicology/Self-harm Inpatient Record and the Initial Psychosocial Assessment). In addition to these pre-structured documents, there are progress notes, which afford free text descriptions. The episodic record provides a means for different specialities to document their involvement in the care of patients. Some of the documents it contains are tailored specifically for the use of particular disciplines (e.g. the nursing short term care plan and the Initial Psychosocial Assessment are completed by the nursing staff), whereas others are contributed to by a number of different disciplines.

The Toxicology/Self-harm Inpatient Assessment record draws together the assessments made of the patient by nursing, medical and psychiatric team members, and is divided into sections correspondingly. Progress notes are the loosest structured of the documents present in the episodic record, and correspondingly are contributed to by the widest selection of specialities, including those not routinely involved in the care of every patient (for example, social workers, mental health officers, alcohol liaison nurses and members of specific medical specialities). Viewed as a heterogeneous collection of more or less strongly typed paper documents the episodic record affords a flexible means of documenting each patient's care. Its structure reflects both the specific practices routinely involved in the patient's care as well as allowing for the atypical.

There are a number of documents created by members of the psychiatric assessment team (PAT) that are specifically tailored to inform relevant others about the care the patient has received, for example, discharge letters[2] (typically for GP's), transfer letters (to an admitting doctor if a patient is transferred to another hospital for care), referral letters (to engage the patient in out-patient services), 'frequent attender' letters (to inform others of a decision not to routinely admit a patient for the purposes of a psychiatric assessment). These documents are both archived on the ward and also transferred to their intended recipients, serving as a link between distinct record corpuses. Thus the clinical staff in the Accident and Emergency department do not have to deduce from an examination of the entire record corpus that a patient should not be admitted for psychiatric assessment, this decision and its rationale is made explicit for them in the form of a letter available from a specific physical location.

Other sorts of selections are made from the clinical record corpus and maintained permanently on the ward. For example, records are maintained of each patient admitted into the ward in an admissions book and in the daybook, both of which are either kept at the nurses' station or archived in the doctor's room. An index card system is maintained containing a subset of details (name, date of birth, overdose taken/method of self-harm and date of admission) concerning every patient admitted to the service since its inception. These

[2] Members of the assessment team acknowledge that some 'tailoring' is required to make the discharge letters useful to their intended recipients, pointing our their dual purpose as representations of the patient's admission for other medical professionals subsequently involved in their care and as a record for their own purposes should the patient re-attend. It is sometimes suggested that the letter is 'as much for ourselves' and speculate whether the recipient always benefits from the level of detail recorded.

permanently located documents allow an enduring historical representation of a selected cross section (or view) of clinical and demographic information that can be drawn upon for a number of purposes. The daybook is principally used as a tool for coordinating nursing activity with psychiatric and medical decisions. It provides at the nurses' station an overview of salient details available at a glance that would otherwise have to be culled from each individual record as the need arose. The admission book provides a log of patient admissions that can be consulted should a query about a previously admitted patient arise. It is also drawn upon as a resource for conducting studies of various sorts concerning the nature and character of patient admissions.

It is notable that members consult the episodic record, the Ward 1A archives of previous letters and index cards as a matter of routine, but more rarely consult the hospital record (usually when the patient has a medical problem that has some bearing on their self-harm - also, the hospital record may not yet be available when the assessments are conducted.) Moreover, it is often the case that records held by other hospitals – typically psychiatric hospitals where the patient has been admitted as an inpatient – that are of particular interest to members of the PAT. In such cases little interest is shown in the entire record corpus – PAT enquiries focus on those components that have the most direct and clearest bearing on the assessment at hand. For example, they will often ask that the patient's 'most recent discharge summary' be faxed to the ward, or make a telephone enquiry requesting specific details – typically diagnosis, date of last contact, whether the patient is still 'linked in' with that service, and who they are seeing.

Various sorts of work are involved in the extracting, collating, organising, grouping and making visible various components of the record corpus into locally relevant permanent representations – whether they are made locally available on Ward 1A or to some other clinical speciality. Furthermore, an examination of the record corpus often involves the expectation and selection of specifically tailored representations, rather than a perusal of the record's entire contents.

End User Development of the Ward 1A record

During the course of this study the Toxicology / Self-harm inpatient record underwent a process of revision involving a collaborative effort between the psychiatric and toxicology services. Part of the motivation for this revision was the desire to collect and collate data that could be used for research and audit purposes. Initially the goal was to develop the form so that it could be scanned and the data extracted directly into a database. However, with the advent of a project to develop a hospital information system (HIS), the aim of developing the form became one of finalising a 'data set' that would be included in the HIS system.

In the following extracts the consultant toxicologist describes how the form was initially put together:

Simplified transcript from interview with the consultant toxicologist (CT) and fieldworker (MH)
*MH: I was wondering of you could just tell me how you'd gone about developing [indst].
CT: okay well, we sat down with the em, original documentation.
*MH: right that's the original ward stuff.
CT: em.
*MH: toxicology [indst].
CT: yeah, on the stuff that I put on wanted which pulled off a variety of sources.
*MH: Right, what sources did you use?

CT: I used the Australian sources, I used our sources here, and what I'd, and I did and just thought about it. Because I've done this before elsewhere this in a short, a smaller form. […] So we then got a first version of that and went through it and talked with psychiatrists, we also gat a psychiatry version their previous database so that was, that was sort of, the main starting points to be honest were the admission database from here, for the medical patients, and there's an old psychiatry database they'd used in the past, and amalgamation of those and then fiddled a bit. That was, that was, really what we used to be honest.
*MH: Can, can you point to anything on there that say came from Australian or…?
CT: no, not directly […] it's just what they had in their system that we thought about, but to be honest most things probably there already. I can't think its anything that's coming from overseas to be honest.
*MH: was there anything that you brought up with you from Newcastle that's gone on there?
CT: Only the concept of having it all together, because before it was all bit all over the place, the paracetamol graph was separate. […] …and use of antidotes, I used this use of antidotes I think that was one thing we had in Newcastle which is, I think [indst] is in here somewhere, an I can't find it, yes, here, with these, this, this, this was a new, it may have been in somewhere else but this is, this, that was literally from Newcastle. […] …so the concept was, I mean its very much based on 3 those 3 those 3, the Australian thing was just a sort of eh, was, it was, was to show just look at how another system worked, and that we actually used. […] …and I think the psychiatrists and us decided there was to much in the original draft to cut it. Because there's a temptation to be totally inclusive and until you start using these you're not quite sure in practice what you actually want.

The CT outlines a process of inscribing both the content and concepts inherent in previous instances of similar documents into a document suitable for use in Ward 1A. There is a temptation to view this adoption of form and structure as entailing unproblematic adoption of meaning. However, at the end of the transcript the CT states that there 'is a temptation to be totally inclusive and 'until you start using these you're not quite sure in practice what you actually want', suggesting that the purposes served by and meanings attributed to the various components of the form are somehow unclear apriori. Rather, getting 'what you actually want' is a matter to be decided 'in practice' – that the various components of the form achieve a local relevance only through their practical application.

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The processes of end user innovation are not limited to the development of the main components of the patient record, but also extend to more mundane information resources, for example:

Extract from field notes
A nurse is using the results computer in the doctor's room to create a 'form'.
The form has a list of drug names down the left hand side, and a list of tests to be carried out along the top. I ask if she is doing a study. She says no - I ask whether it is just routine paperwork - yes. She says that there are a number of tests that the consultant toxicologist wants to be completed routinely for a given ingested drug. Says that she is changing it because he now routinely wants ECGs to be taken with patients who are on Methadone.

I ask if all the tests are to be done for each drug - she says no, that she was going to put X's in the appropriate boxes by hand. Says that these routine tests "do change". Says that she though of doing it on the computer and that this would be neater - "It should have a title and it should be more <gestures with hands to indicate that the form should take up more of the pages>". But explains that she "wants to get home".

Paper documents afford end user development the medical record corpus using commonplace skills and tools. This enables team members to be responsive to the changing requirements for various sorts of representations – paper documents are continuously amended, introduced and phased out according to local needs. During the course of this investigation paper based forms have been developed for a variety of purposes including: a short-term study of the level of alcohol intoxication of patients on admission, the tracking and documentation of self-discharges, a study of violence and aggression towards nursing staff. These documents often do not become part of the hospital record (although some of the information may be

duplicated there), but are created, stored and analysed locally. A further advantage of using paper documents is control – members can choose to modify the sorts of representations available to them as they see fit. Control is also afforded over policy – local documents can be withheld from the hospital record, if, for example it is important to protect patient confidentiality (for example, the records of psychiatric outpatient appointments are kept locally in the department of psychological medicine).

However, there are limitations to paper as an information technology – paper does not easily afford the subsequent retrieval, collation, and analysis of data, and the process of verifying and recovering missing data (missing paperwork) can be cumbersome. It is likely that a centralised HIS may compensate for some of these shortcomings – but this chief advantage arises from the affordances of electronic representation, rather than its central and all embracing character.

The challenges of the universal

The goal of our work was to develop an EPR tailored to the needs of this specific clinical setting, using the input of clinicians and nursing staff to drive the design and development work. After the project began, however, the hospital announced plans to implement a hospital-wide EPR as part of a Hospital Information System (HIS). One of the aims of the HIS is to provide location independent access to all clinical information. The HIS incorporates several roles currently provided by several distinct systems, including a Patient Administration System (PAS) and a laboratory results reporting system, as well as supporting additional roles, including a clinical record and orders for various tests and services.

In the following transcripts one of the members of the HIS project is explaining to the fieldworker how they have been moving from paper documentation to the EPR:

> **Simplified transcript from discussion with HIS project member (HPM)**
> HPM: A patient assessment from a nursing point of view, now you can see eh, well maybe [indst], […] in the medical one we've got, we've only respiratory [indst] right, here, here you've got, you're a medic, you call it respiratory history, you're a nurse nurses you call it breathing. And within all of those categories there are certain things that have to be filled in, but you go to any completed one of these and you'll see different things under different categories… […] Cot sides, for example, the patient needs cot sides up, some people might put it in mobility, some people might put it in comfort and safety. The patient normally needs 2 pillows to sleep with or a nebuliser at night for example. A nebuliser at night is probably a good example - some people might put it under breathing. Because it's to do with your respiratory system, some people might put it under sleep because it's to do with you sleeping and other people might think its to do with comfort and safety. So where everybody puts it in different ways and it's been pretty much impossible to standardise where lot, and something's are more obvious but not, not always.

Here access to appropriate parts of the electronic record depends on an understanding of how the material in the record is organised. The project worker attends to the difficulty of standardising where to locate items in the record, whereas with the paper record these locations depend on local understandings of the meaning of a particular entry, whether it be sleep, comfort or safety. The following example illustrates a similar difficulty, namely that the paper medical record depends on a local understanding of practice for its interpretation:

> **Simplified transcript from discussion between HIS project member (HPM) and fieldworker (MH)**
> HPM: or, so we've gone through this folder and, and, and tried to do that, it hasn't always been, its not that easy to do I don't think, we haven't found it very easy to do.
> *MH: Is it difficult to sometimes decide which category things go into?
> HPM: yeah. […] partly because we don't know all of the systems well enough to know.

*MH: so that's the computer systems?
HPM: yeah […] and partly because sometimes its something that somebody has done, and sometimes it's something that they're planning to do an its just the way its written down or the place its written down that makes the difference between whether it's a plan or whether it's a task that has been done. So for example patient temperature - you would want, you potentially want to plan to take that patient temperature, but you might not you might just want to document that you've done, not even that you've done it, just the result of that temperature. So we've had, and we still are, there are some things that are obvious and some things that are not.

Here the apriori distinctions made by the HIS system of plans, tasks, and orders cannot be simply read off the paper records, but has to be interpreted in the context of locally understood practices. Furthermore, the categories of plans, tasks and orders are not necessarily members' own categories, so the work of constructing the HIS system becomes one of attempting to blend the system's own order with those inherent to a variety of local practices.

One of the stated goals of the HIS project is to eliminate duplication of recorded data. This again is found to be problematic in that notionally the same item of data may have a different meaning to different specialities:

Extract from field notes, HPM and fieldworker (MH)
HPM: But we're still in the process of, of trying to filter out some of these things and say okay you know which system should they go in, should they be managed by an, and which part of the system are they best managed by. So that's, that's what we've done - we haven't tried, what we'd hoped to do, and we will still do is then say okay in Ward 1A they collect patient surname or [indst] screen or whatever it is, and they write that down on this piece of paper somewhere else, call it something slightly different but effectively it's the same thing and record it on another piece of paper etc, etc, etc, etc try and identify where is they're duplication. […] There's perceived duplication from a system point of view I think, but there's also clinical duplication from a professional boundaries - different perspectives point of view. So for example you know we, we could just have mobility for example as a field on, on the screen and whoever chooses to, to fill in mobility first you would think and you know what people do think well that's just, that's the patients mobility, but a doctor's view of mobility and a nurses of mobility an OT versus a Physio's you know versus lots of other peoples views of mobility are very different and legitimately.
*MH: Could you say why they are different?
HPM: Because from, I know, physio point of view for example, what that physiotherapist care about is quality of the patient's mobility. On the ward eh, for example, and how, if they use any equipment to mobilise with, if they need assistance to mobilise with and, and the quality of, of that. From - so they might need to know the aid that the patient, uses, whether or not they need assistance and maybe the distance they can go for example. From an occupational therapist point of view they might need to know, whether or not that zimmer is the appropriate aid to use at home, cause using it in the ward is one thing, using it at home is another. Thing, from a nurses point of view what they are about is whether the patient can function in the ward, and they don't really care, well I, I don't mean in that point of view but they, they don't have view of the patient from how they're going to manage at home. Medical staff - if they're wandering around the ward then they definitely shouldn't be here so get them home.

Here 'mobility' is understood to have a different meaning for a nurse than for an occupational therapist or a physiotherapist. Rather than being an objective property of the patient, 'mobility' represents a series of categories that gain their meaning in relation to the particular sorts of work carried out by different actors within the hospital.

The imposition of the system's order can also be seen from the attempts to incorporate the Toxicology/Self – Harm Inpatient record into the HIS system.

Extract from field notes: HPM talking with Consultant Psychiatrist (CP)
Here came up against a couple of limits of the system. First, can only have one free text box per screen. Second, the number of characters that can be added is limited to 255. The CP remembered this limit as

the HIS project member asked another project worker working in the same room, who said that it works out at about 3.5 handwritten lines on an A4 page.

Another limit of the system - labels for tick boxes, headings etc have a maximum length, requiring that these labels (as used on the tox form) often have to be truncated or otherwise abbreviated. The CP queried whether users would understand what 'Non general hospital referrals' meant.
After some discussion, she suggested that people would have to learn about the system anyway. So this was not changed.

The CP then drew attention to another label that she feels might not be easily interpreted 'Violence (5yrs)' (Meaning has the patient been violent to others during the last five years).

CP: "Not immediately clear what the purpose of the question is" and asks whether it would be possible to put a 'less than' sign in there. The HPM suggests that she could shorten violence to 'viol' – and use the freed up space to make the 'over last 5yrs' intention of the question clearer. ('viol' had been used as an abbreviation in the 'category' heading – 'viol/criminal' that contains this sub-heading).

In the above examples, the configuration of the generic HIS system involves the dual process of attempting to objectify descriptions of patients, and the imposition of the system's order on the record. Both require that local meanings be stripped away in an attempt to achieve the goals of a universally accessible and intelligible record. The CP and HPM attempt 'workarounds' (e.g., to provide enough free text space for psychiatric diagnosis) where the generalising assumptions of the HIS were too far off the mark to support the demands of local practice. In response to another revealed limitation of the HIS, a different sort of workaround is used. The limits on the number of characters available for category headings make recipient design (working out how the headings might be (mis-)understood by others) difficult – and so this problem is deferred – 'people will have to learn how to use the system anyway'.

We do not reject the idea of an integrated EPR, but we do challenge the ability of the hitherto prevalent top-down approaches to deliver the seemingly irreconcilable goals of a maximally useful (locally meaningful) representation of practice that is simultaneously and unambiguously available to all. We also accept that 'bottom-up' or 'user-led' approaches may have their own particular problems in that tailored systems may become difficult for users in adjacent disciplines to navigate (Faber 2001). In general, there appears to be a tendency for top down development to strip out local meaning and organisation (the production of universalities) and for bottom up development to embed local meaning and organisation (the production of universalised locals). Rather than dismissing the possibility of providing shared representations that can be meaningful across discipline boundaries, we point to the work involved in generating such representations, for example, in the production of discharge and transfer letters. These documents are frequently part of more than one distinct record corpus and are authored specifically for the particular audiences who will attend to them in those contexts. One approach (within a user-led framework) would be to support the recipient design of views of locally held representations (in a similar way to authoring of transfer letters and so on) such that local corpuses can be presented in a meaningful way to others.

Locally Meaningful Information Management

The process of developing information systems necessarily involves the use and creation of standards on various levels (international to local). Numerous decisions have to be made as to where to store information, how to represent it, who may access it and how. In many domains such as in the case study above, there is a tendency to create systems that gather all relevant

information in a central place in a well-defined format. However, in the process of moving information from its local origin to a centralised representation its nature changes, local meaning and organisation of information is lost.

The fieldwork material presented above illustrates some of the localised information management practices that are evident in many settings (e.g., Timmermans and Berg 1997; Hanseth and Braa 1998). We have also pointed to the problem of translating these practices into central representations in an integrated EPR. Information is always created in a specific locality where it acquires a local meaning and work has to be done to achieve universality (Berg and Timmermans 2000, Timmermans and Berg 1997). For a central HIS to work, translations have to take place that first *de-situate* information and thus achieve universality and then *re-situate* information in order to make it useful for specific actors.

An alternative concept of information management would support local management of information that is translated into other localities as needed without a centralised instance to go through. This model of distributed information management has the following advantages:

- Information is organised and managed in locally meaningful ways and thus the usefulness at the source is maximised. Local adaptations are possible and remain local.
- Decisions about the information needs of potential remote users are deferred to the latest possible time. Because translations involve explicit contracts, people at the source of information can remain aware of who uses their information in what ways.
- Since information is kept locally, there is no need for a centralised data directory, making individual parts more manageable since they are not confounded with others.

Such models of locally meaningful management of data are evident in many organisations while efforts to create universalities have often failed. An example of this is the case of computer integrated manufacturing (CIM) which, instead of bringing about universalised computer support, has initially led to the creation of many "CIM-islands". Integration has later happened not by a grand master-plan but gradually, linking individual existing systems together in opportunistic ways (e.g. Milling 1997, Caputo 1998). Not only is it difficult to link IT systems together technically but interests of a diverse set of actors have to be aligned (Fleck 1988). Universalisation makes some things more visible, necessarily at the cost of others. There are costs associated with achieving universality, work has to be done every day to support a universality. Implementing a universality is thus a political process aimed not only at creating artefacts but also at enrolling the support of diverse actors whose interests are often contradictory (Timmermans and Berg 1997; Hanseth and Braa 1998).

These issues point to the problems of a top-down approach to building universalities, spelling out their locally constructed, negotiable and contingent nature. It is important to study the dynamics of technology development in a wider social and historical context to see how universalities emerge and how they come to be supported (Williams 1997). Studies of innovation have shown that processes of *social learning*, where local innovations are sedimented, crystallised within applications, can lead to the establishment of universalities (Williams 1997). This bottom-up approach has the advantage that it matches well the localised and social character of innovation. While the top-down approach focuses on expert knowledge and apriori specification, the social learning perspective accounts for the local experience-based and often tacit knowledge and the interplay between different actors.

Different Shades of Universality

Universalities emerge from the local and can live only as long as they are actively supported by local practices (Berg and Timmermans 2000; Timmermans and Berg 1997). Numerous adaptations are needed to make universalities work, deviations from standards are the norm in sociotechnical systems. This seeming paradox shows that universalisation is never complete and that in any real-world setting there will be *different shades of universality*. Various information management practices necessarily co-exist as the examples from our case study show. Information is represented in a wide variety of forms. Some information is stored in very strictly encoded form in central databases or on standardised forms while other information lives on local systems, on paper in local folders or on whiteboards. There is a mix of structured and semistructured documents that are linked with each other. A semistructured document such as the ward book may contain pieces of highly structured information (e.g., patient numbers) or may refer to such information (e.g., by mentioning lab results). Likewise, structured collections of information can refer to semistructured documents such as referral letters. Annotations are made to forms in ad-hoc fashion as situations arise that have not been pre-conceptualised and are thus not supported by what exists.

Another very important local practice is the creation of selective replications of documents to create multiple views both for different actors and for use in particular situations, according to the dominant interests. The daybook, for example, collects a particularly important set of details from each patient's record that has to be ready to hand for the nurses to refer to. It is thus kept in the nurses' station where it is readily accessible regardless of the location of the main patient record. When information is exchanged, for example with other hospitals, views are also created as only the information currently needed is transferred instead of the full record.

These information management practices are closely tailored to the specific needs of the various people in the ward, patients, psychiatrists, toxicologists, nurses, etc. They are the outcome of a process of mutual shaping between the dynamics and the structure of work, carrying inscriptions that link them with their past and with possible futures. Consider, for example, the sections that subdivide the Toxicology/Self-harm Inpatient Assessment into regions connected with different specialisations (nursing, medical, and psychiatric). The spatial arrangement carries information about the character and likely usefulness for specific purposes of the recorded assessment. Thus the artefact is linked to local working practices and social relations.

Creating Universalised Locals: Social Learning

Work practices and related artefacts are not stable but change in response to changing needs. Implementing new systems changes both the practices and, in an iterative process, the system itself. Similarly, users are forced to adapt, to use 'ad hoc' practices and, in so doing, the work also changes. Sociotechnical systems are thus mutually constituting and adaptive as organisations and work practices constantly evolve. This is an active process involving contributions from a wide range of organisation members as well as technical specialists.

We have discussed above how members of the medical and psychiatric assessment teams tailored the record to their own needs in a collaborative effort. As they anticipated the introduction of a hospital information system, they also used this opportunity to inscribe their interests into an artefact that would find its way into the new system. Other instances of

tailoring are more immediate and opportunistic as in the example of the form used to document the consultant toxicologist's requirements for clinical tests. This was modified by a nurse to account for the new requirement for ECGs to be taken with patients who have overdosed on Methadone – a requirement might be temporary, needed for the consultant's research, or a response to new medical insights.

One could describe this process as a subsequent un-freezing and freezing of practice. At some point, "normal" practices will be resumed or, if there is enough support, the variation will be incorporated in general practices and thus become universal, potentially crystallised in an artefact, a *universalised local* as evident in the example above. Fleck has termed the process that leads from a local adaptation to its wider adoption *innofusion* (Fleck 1993). The concept can be applied on many levels: from local practices that are adopted in the wider organisation (Voß, Procter, and Williams 2000) to the interplay between organisational users and suppliers of technologies (Fleck 1993) and wider technological development.

Technology Supply

The problems of providing generalised solutions to complex organisational information processing requirements has led to new models of technology supply that explore new tradeoffs between specialisation and market size (Brady, Tierney, and Williams 1992). There has recently been a trend in technology supply to move beyond the traditional "make-or-buy" alternative and employ a "pick-n-mix" approach to information systems development (op. cit.). There is a growing market for general components (Szyperski 1999) that can be combined to achieve the desired specific functionality. Systems that would have been custom-built in the past are now configured together using generic packages readily available on the market. This changes the relationship between the supplier and the user of technologies as compared to completely bespoke systems the creation of the generic components is further removed from the context of use while the configuration, the adaptation to local contingencies, gains in importance and makes tight cooperation necessary (Williams 1997).

What makes XML standards successful?

There is a lesson to be learned for general standards-setting from the example of XML technologies. Why is XML such a celebrated standard, many years after its predecessor SGML was defined? Why is it so much more visible than other standards? One possible answer is that it has such a wide range of possible applications since it does not make presumptions about its context of use. In this respect, XML compares with the ASCII and Unicode standards for character representation that it builds on. In addition, while HTML merely provided a limited set of ways to format documents and thus provided only a weak and inflexible form of structuring, XML makes a more significant and general contribution: it is a *meta-standard* that allows application-specific standards for structuring data to be set. It is universal enough to be supported by a wide variety of generic components that make the adoption of the meta-standard attractive. Many application-specific standards lack just this form of support which may explain the large number of projects that aim to integrate existing standards with XML, for example BiblioML for bibliographic records or STEPml for the representation of product data (see xml.coverpages.org for more).

A World of Integrated Heterogeneous Components

Another reason for their success is that the XML standards appear at the right time and that they have inscriptions that resonate well with major current trends in many domains (from document management to distributed computing) such as the focus on reuse of existing systems and infrastructures. While some time ago there was a trend to "re-engineer legacy systems", i.e., to analyse their structure and rebuild them using current technologies, today many existing systems are "wrapped" in translation mechanisms that adapt them to other systems (Coyle 2000, Szyperski 1999). XML technologies are often used for this purpose. One central feature that makes them fit for this purpose is the existence of a *standard translation mechanism* (XSL) that allows data to be translated into many different representations and forms. We would argue that this translation component is the main added value that the use of XML provides today. A language providing more extensive facilities for rearranging and combining data is currently under development in the XML Query Working Group (W3C 2001a).

Views

We have discussed above how people create views as part of their working practices. Such views are *selections and rearrangements* of data for a specific purpose defined by individuals' roles or the situations they are in. The significance of these views is that they make the data needed more visible and that they provide a means to arrange other pieces of information (such as temporary notes and annotations) in a meaningful way. Consider for example the daybook that carries annotations that are particularly important in the nurses' station but will not be part of the overall patient record. Computerised information systems would have to provide means to structure information in similar meaningful ways. However, many efforts are predominantly aimed at de-contextualising information, ignoring the need to create views that are closely tailored to the needs of local users.

Technologies such as XSL and XML Query have the potential to change the ways that universalities are achieved. Rather than de-contextualising information, distilling it into apriori defined categories and storing it in centralised systems, information can be represented in locally meaningful ways at its source and translated into other representations as needed, be these representations locally or globally defined. The universalities can thus emerge from locals as the global is just another view on the local.

Local Adaptation: Enter XML Schema

One problem with the early XML standard for schema definition was that it did not allow variations of a schema. The extensible(!) markup language was less powerful than any other object-oriented programming language that allows specialisations of classes to be created. Various solutions to this problem have been proposed, new schema languages have been created and recently the W3C has released the XML Schema recommendation[3] (W3C 2001). With this schema language it is now possible to create variations of schemas by either extending existing types (adding new elements or attributes) or restricting them (increasing

[3] A "recommendation" in W3C-terms is a stable specification that has been reviewed by the W3C membership which recommends its use. It's the final outcome of the W3C activities.

the degree of specification)[4]. The creation of the XML Schema language provides a basis for implementing local adaptations that are still compatible with the universality. Many examples of application standards have shown a need for local variation, consider for example the case of MARC, a standard for communicating bibliographic records of which no fewer that 20 variations exist which are mutually incompatible. In order to make communication possible without defining translations between any two of these variations, the International Federation of Library Associations and Institutes (IFLA) in 1977 defined the UNIMARC format which is able to represent all data present in any of the 20 variations of MARC (IFLA 1999). There is reason to hope that XML Schema will help to avoid such problems as local variations of XML-based standards can remain compatible with the original standard, effectively reducing the cost of creating such variations.

The Problem with XML: Its Popularity

The success of XML technologies also has its drawbacks. The relative ease with which schemas can be created, the emerging wide support by tools such as browsers, editors, and parsers, as well as the media hype have led to a situation where XML applications abound. For any given application domain there seem to be many competing standards initiatives making the aim of interoperability difficult to achieve. The following example from a press release illustrates these concerns (Health Level Seven Inc. 2000):

> "We want to dispel the notion that XML alone offers an alternative to HL7," said Stan Huff, chair of the HL7 board of directors. "XML is an encoding that complements the semantic content provided by the HL7 RIM, allowing users to exploit all the possibilities of the Internet. The extensibility inherent in XML is resulting in an explosion of schemas and DTDs from diverse sources, which actually decreases the ability to provide plug and play applications. The development of a model-based, standardized and industry-accepted application of XML, as provided by HL7, will help decrease the cost of integration, and improve the reliability and consistency of communications between disparate systems and enterprises."

Paradoxically, the success of XML as a meta-standard may make it more difficult to achieve universality at an application level. With the spread of XML the idea of web-based grassroots standards initiatives that we are accustomed to in the Internet domain suddenly extends to application domains where standards-setting was formerly the preserve of powerful suppliers, alliances, or (inter-)national bodies. The question arises: why are there so many initiatives? Do they aim at the same goal? Are there simply so many goals and at what level and how could universality still be achieved? XML Schema reflects efforts to answer these questions. This technical response to the generic problem has, of course, to be accompanied by appropriate non-technical processes that shape application-level standards setting in ways that take account of the need for local variation and capitalise on the potential of social learning.

[4] Other forms of reuse are available but not of importance for the current discussion, see (W3C 2001).

Participatory Design in Ward 1A

The participatory design project in Ward 1A has been underway for two years. During that time the researcher has taken on the role of 'technical facilitator', thereby enabling the inscription of local information requirements identified by PAT members into configurations of 'off the shelf' technologies. To date, we have assisted the evolution of a resource database (providing various sorts of contact numbers to assist with their liaison work and also information that can be printed out and given to patients), a speech recognition system (currently used for the dictation of transfer letters) and we are about to deploy a medical records system designed in collaboration with PAT members. Our approach has been one of developing and deploying systems with the minimum of useful functionality and then continuing the development process in-situ so as to be maximally responsive to the requirements of the local setting. The latter two developments (speech recognition and an EMR) require degrees of integration with existing hospital systems. There is a requirement for the letters produced by speech recognition to be archived on the hospital PAS system – a legacy system that is not actively maintained, making a direct connection between the two systems impossible in practice. However, we have achieved a work-around using two de-facto standards – the rich text document format, and floppy disks. This was possible because the PAS system makes use of Word for input of discharge letters. This workaround is not an easy one – the version of Word used by the secretaries is disabled in a number of respects (presumably for security reasons) making it impossible to insert a file directly into a document. The secretaries themselves had devised a method for overcoming this – opening the document on the disk and cutting and pasting it into the PAS. The integration issues raised by the introduction of the EMR are of a different nature. Here the consultant toxicologist is interested in some of the data collected from the EMR to be incorporated into his own database (another user-led project, this time initiated and managed by the consultant toxicologist himself).

We already make use of XML as 'glue' for tying together the various components of the systems currently in use on Ward 1A. Using XSL and the XML DOM we can easily re-use the same representation (for example, of the organisation of a local psychiatric hospital - its structure, members and contact details) to support a number of different, but locally specific tasks (in a Word macro to facilitate the composition of a transfer letter and on a web page as a resource for making telephone contact). The requirement to interface with the consultant toxicologist's database and development efforts allows us an opportunity to test the use of XML in affording the sorts of sociotechnical collaborations we have discussed in this paper.

Conclusions

We have presented local information management practices in a hospital ward. The picture that emerges from this account is one of locally meaningful arrangements that are closely tailored to the specific needs of actors in the ward. While the information management practices are very locally meaningful, they also relate to the overall practice of medical care. We thus see them as *universalised locals*. Introducing centralised information systems such as EPRs is a difficult undertaking as they have a natural tendency to strip away local meaning, replacing it with universalities. In order for such a system to work, local interests have to be enrolled to support the universalities and keep them functional through day-to-day

interpretation (Timmermans and Berg 1997). We presented the concept of locally meaningful information management as an alternative to centralisation and discussed the way that XML technologies are tuned to support such practices. It can be argued that XML technologies carry inscriptions that link them with a world of integrated heterogeneous components. These inscriptions define their role in the world as a "glue" that connects various sociotechnical systems.

It is crucial for the success of XML technologies that practices of information systems development be reshaped. We would argue that while XML carries inscriptions of distributed information management practices, the current model of information systems development is still a very centralised one, with inscriptions of central expertise ("designer") and local ignorance ("user"). Alternative models exist and have for quite a while: participatory design (Clement and van den Besselaar 1993) and ethnographically informed design (Hughes 1994). Our current project moves beyond these approaches by turning the concept of user involvement on its head: our aim is not greater user involvement in IT design, but greater involvement of IT professional in user-led processes of innovation and social learning. The approach of 'being there, and doing IT' takes the technical work of development into the users' workplace with the aim of supporting locally meaningful practices. The emphasis throughout is on tightly coupled, 'lightweight' design, construction and evaluation techniques which makes XML technologies valuable resources in our efforts.

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