DEVELOPMENT OF A SITUATED INFORMATION SYSTEMS ANALYSIS AND DESIGN METHODOLOGY: A HEALTH CARE SETTING

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Abstract

This paper advances the long term project of developing a situated information systems analysis and design methodology. Conventional approaches to information systems design are informed by the widely-held view that human purposeful action proceeds by deliberation on a mental model of the world of action. In contrast, situated information systems are informed by the view of situated action theory that routine action is largely non-deliberative and makes crucial use of structures in the action environment for attainment of goals. The expectation is that systems designed using this situated approach will be more effective in supporting routine activity than systems designed using the conventional approach. This paper reports on a case study conducted in the chemotherapy unit of a large hospital. The case study was conducted using the preexisting version of the situated systems methodology with the results of the case study informing further development of the methodology. The research provides further evidence of the ability of information systems informed by a situated model of action to effectively support complex but largely routine activity.

Keywords: systems analysis and design, methodologies, organizational change, health care

1 INTRODUCTION

This paper reports on a completed phase of case study research conducted as part of a long term funded research project to develop a new information systems analysis and design methodology. This methodology is explicitly informed by situational theories of human action and is for application in work domains where operational activity is largely routine. In broad terms, our 'situated systems methodology' involves analysing routine work practices in terms of action-centred constructs (actions, situations, activities, environmental structures, affordances) in order to identify their core goals, activities and environmental constraints. This enables reorganisation of these work practices in restructured environments so that system goals are achieved more effectively and efficiently using lighter-weight information system support.

In several publications (Johnston and Milton 2001; Johnston and Milton 2002; Johnston et al. 2005; Milton et al. 2005) we have argued that conventional approaches to information systems design are implicitly informed by the widely-held view that human purposeful action proceeds by deliberation on a mental model of the world of action. Consequently, these approaches privilege support for the more deliberative aspects of human activity in work systems such as planning, decision making and simulation. However, activity at the operational level in many work environments is largely routine and poorly supported by such information systems designs. Recent work in the cognitive sciences under the rubrics of situated action theory (Suchman 1987; Hutchins 1995; Agre 1997; Clancey 1997) and ecological psychology (Gibson 1979; Reed 1996) suggests that routine action is largely non-deliberative and makes crucial use of structures in the action environment for attainment of goals.

Our program of research, referred to above, uses multiple participatory case studies in an iterative

process whereby the current instantiation of the methodology informs the conduct of the case study as well as the analysis and development of the solution proposed for the case study site. At the same time, reflection on the problems encountered in application of the methodology in each new case study, together with evaluation of the nature of the solutions suggested by it, inform the further development of the methodology. The case study iteration reported here was the second in the methodology development program. Johnston et al (2005) reports the first case study and the resulting iteration of the methodology which was the starting point for this iteration. To further validate and refine the methodology, this second case study site was deliberately chosen using 'theoretical sampling' (Glaser and Strauss 1967) to be quite different from the first case study.

The aim of this paper is to present the learnings arising from the second case study and apply these in order to formulate a second iteration of the methodology. This second case study confirmed the usefulness of situated information systems analysis and design methodology in settings where work is complex but largely routine. In both the first iteration and this one, the ability of the methodology to identify the root causes of problems was confirmed through identification of a novel solution to a clearly identified problem. This case is also interesting for its own sake. It describes a class of problems in the health care industry for which there are currently few effective solutions.

2 CASE STUDY

The system under study was located in the Chemotherapy Unit of a large metropolitan hospital. This ward administered chemotherapy to an average of 40-50 outpatients each day and when the research began, patients were regularly experiencing delays of up to half a day beyond their appointed time to receive chemotherapy treatment.

Employing a situated methodology requires that the researcher be embedded in the work system. The systems in the Chemotherapy Unit were studied in situ over a period of approximately 18 days during the period March – June 2005. The researcher used a mixture of participant observation (researcher worked as a Ward Clerk), interviews and direct observation of nurses, clerks, doctors, pharmacists and patients. Actually working as a Ward Clerk and the extended period of data collection enabled the researcher to obtain a deeper understanding of the system than the traditional systems analyst who relies on a short period of observation and questions. The researcher made detailed notes of field observations and experiences using NVivo to assist in their organisation. Microsoft Visio was used to represent the existing system through the depiction of existing activities.

2.1 Current operations

Administering chemotherapy is a highly complex activity due to the many permutations in how treatment is delivered and the need to coordinate actions with real-time events, the timing of which is uncertain. There were at least 70 different chemotherapy treatments administered in the Chemotherapy Unit. Further increasing this complexity was the range of requirements associated with the treatment of individual patients. Figure 1 shows a schematic outline of a typical chemotherapy patient's journey through the hospital.

The exact route of a chemotherapy patient depends on the particulars of their treatment. In general, a patient needs to have blood taken, either on arrival at the hospital, or at a pathology laboratory the day before their chemotherapy appointment. A patient is often required to be reviewed by a doctor before their chemotherapy treatment, either in a clinic (located downstairs) or in a review room in the Chemotherapy Unit. Patients report at reception before taking a seat in the waiting room. The Observation nurse calls patients out of the waiting room and takes their observations in a small room adjacent. The patient returns to the waiting room until called by a doctor (if scheduled to have a review appointment first) or the Treatment nurse. If the patient is assessed as well enough to receive chemotherapy, the nurse takes the patient into the treatment area and administers the pre-medication and treatment (previously prepared by the cytotoxic suite). The pharmacist dispenses discharge medication to the patient, while the booking clerk gives the patients a card listing future appointments.

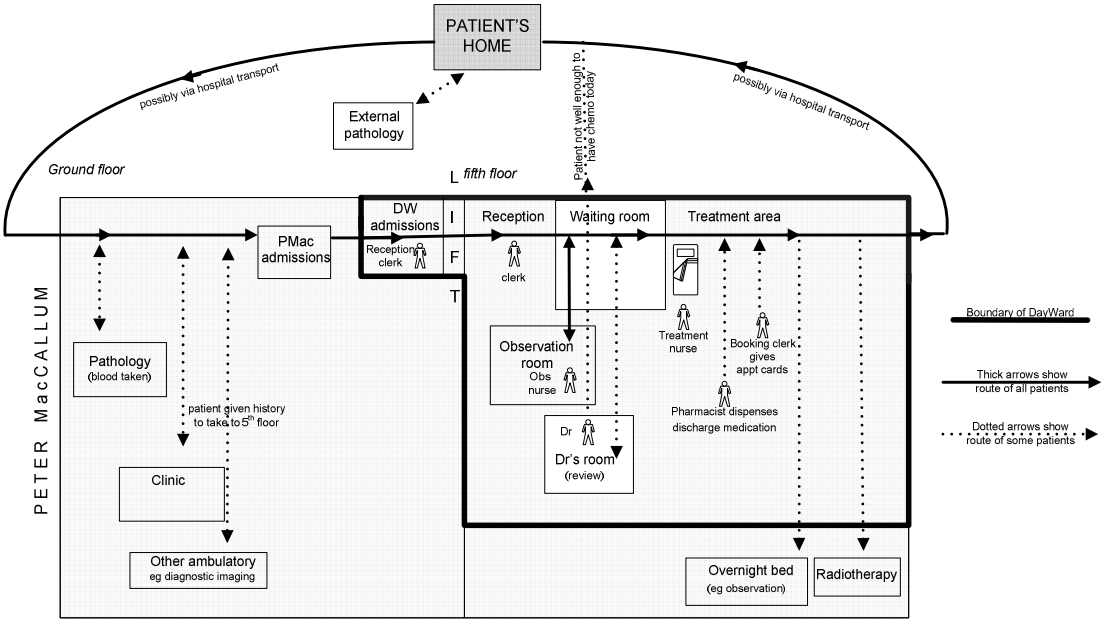

Figure 1: A chemotherapy patient's journey through the hospital

The goal of high quality patient care requires that the patient experience a smooth journey through the Unit with no waiting beyond their appointment time. For this to happen, several processes need to be coordinated and a range of information communicated to various Unit staff. Delays could occur at any stage in the process, often translating to increased waiting times for patients and always translating to increased running around, trying to find where the process is up to and attend to the delays. In the course of observing the Unit and talking to staff, it was apparent that the current system was not working efficiently or, in some cases, effectively. Although the information-related aspects of administering chemotherapy should be routine, various Unit staff described the current system as 'chaos'. As one staff member put it, 'At the end of the day, everyone has received their chemotherapy treatment, but there has been a lot of distress in the process'.

The other important aspects of a nurses' daily work are to attend to patient needs, for example, talking to the patient and the patient's carer and liaising with other health professionals, as well as professional development, attending meetings and training. Many of the nurses felt that they did not have the time to do these things: "It's doing patients a disservice. We don't even ask the questions we should because we don't have time." Nurses considered that there was insufficient, if any, time for professional development and fostering links with other parts of the hospital, and that it was even difficult to schedule lunch breaks.

2.2 The main problems

Applying the situated systems methodology led to the identification of a number of issues with the current operations. This section describes the core problems.

Lack of timely and ready-to-hand information about when the next patient can be treated. Although administering chemotherapy is a complex activity, when stripped to its essential elements, there are four conditions that need to be met before a nurse can administer treatment. These are that the patient has to have arrived, a bed or couch needs to be available, the chemotherapy treatment needs to be prepared and the patient needs to be well enough for chemotherapy treatment.

Nurses were required to be by the side of the patients they were currently treating. While it was immediately (visually) obvious to a nurse when a bed or couch became available, information about whether the other conditions were met could only be obtained by leaving the side of the patient. A disproportionate amount of time was spent seeking this information, at the expense of attending to

patient needs. While treating other patients, each treating nurse had to repeatedly be checking whether other patients had arrived, whether blood results had arrived, and whether the chemotherapy treatment was ready until s/he knew that all conditions for treatment of a patient had been satisfied. This meant that while treating patients, nurses had to regularly walk into the treatment preparation room to check the treatment tables (where the chemotherapy treatments were brought to after being made up in the cytotoxic suite), walk to a computer to check the hospital computer system, visit the waiting room or walk to the reception area to ask about particular patients or to page a doctor.

A further difficulty was that a patient may arrive just after a nurse has looked up the mainframe computer system, the treatment may arrive just after a nurse checks which treatments are in the treatment preparation room, or the blood results may become available just after a nurse has looked up the relevant computer system. Each of these time lags, between the condition being satisfied and the nurse knowing that the condition is satisfied, contributed to an avoidable delay in administering the treatment which compounded to place severe limits on the quality of patient care delivered. So, as well as being spatially remote, the necessary information was not accessed in a timely way.

Missing chemotherapy orders. Handwritten chemotherapy orders, essential as an authorisation for treatment, were kept in a sleeve inside the patient's paper history file. In theory these histories for chemotherapy patients were meant to be brought up to the Chemotherapy Unit at least a day before the patients' chemotherapy treatment. In practice, some of these histories could not be located. If a patient had a downstairs clinic appointment before their chemotherapy appointment, the patient would be expected to carry their (often bulky) history up to the Chemotherapy Unit afterwards. Finding missing chemotherapy orders was a frustrating task involving much running around by clerks and nurses.

Inappropriate order of preparation of chemotherapy drugs. Chemotherapy drugs were prepared in the cytotoxic suite. Although the pharmacist tried to make up drugs in advance, this was not possible for expensive drugs or those with a short expiry period, and it was fairly common that the treatments for the day's first patients were not ready. Sometimes, they did not arrive until 11am, by which time all of the day's patients were backed up.

Inefficient division of labour. Before the cytotoxic suite could prepare the treatment for a patient, the Liaison nurse needed to have checked the blood results and marked them as OK on the chemotherapy orders. However, the nature of the Liaison's nurse's job (liaising with doctors, nurses, patients, their carers, the pharmacist and other hospital staff) meant that she was constantly interrupted and became a bottleneck in chemotherapy preparation. Thus, the existing division of labour meant that for no good reason, the Liaison nurse became a scarce resource in the system.

2.3 Proposed Solution

To address the problems identified above, four main changes to the existing practices were proposed:

- Nurses carry devices which alert them in real time about the satisfaction of the prerequisites for patient treatment; that is when their patients arrive, when their patient's blood results arrive and when the chemotherapy treatment is ready. Specifically it was suggested that each Treatment nurse could carry a PDA which accesses a secure intranet over a wireless network.
- The chemotherapy orders be taken out of the history files and stationed in DayWard.
- Increased coordination between DayWard and the Cytotoxic Suite regarding the order of treatment preparation as well as the types of treatment to be booked in early. Because the proposed web interface would allow integration to existing mainframe systems and multiple modalities of access, the pharmacist could see on his desktop computer when patients had arrived and similarly the Liaison nurse could see when treatments were ready. Being provided with the same information allowed them to negotiate the order of preparation as necessary, depending on the current situation.
- Rather than the Liaison nurse checking the blood results and obtaining the chemotherapy orders for all patients, each Treatment nurse was to check blood results and obtain chemotherapy orders for their own patients. This changed division of labour shifted more responsibility for patients to the Treatment nurses and meant that the patient information was in manageable parcels for the

Treatment nurses, who were the ones who needed to use the information.

These proposals were arrived at by application of the situated information systems methodology described in Johnston et al (2005). Space does not permit full elaboration here but in broad terms, the first steps of the previous iteration of the methodology involved analysing existing activities into their constituent situations and responses as well as analysing the immediate environment of current activities. The next steps involved abstracting to the goals of the activities and the constraints in the environment. Hard constraints were those that would necessarily govern aspects of the redesigned system whereas soft constraints were those which were negotiable with the stakeholders. This led to the design phase where current practice was evaluated in terms of the goals, taking into account the constraints. The final step was to design new ways of doing things and restructure the environment.

The proposals arrived at were situated solutions to the identified problems because, they take explicit account of the constraints of the particular workplace in restructuring various dimensions of the work environment, new divisions of labour, alternative work practices and appropriate (minimal) IT support. The nurses' immediate environment was restructured such that the information, in a sense, came to them, removing the need for them to engage in searches for this information. It also came to them in real-time; in other words the time-grain of information availability now matched the rate at which situations changed. The immediate environments of both the Liaison nurse and the pharmacist were restructured so that they each had easy desktop access to the same information. This gave a better basis for negotiating the order of chemotherapy preparation. The relocation of chemotherapy orders involved a stabilisation of the physical environment (Hammond et al. 1995); the changed division of labour involved a restructuring of the organisational environment.

In summary, our solution involved restructuring the environment so that actors had ready-to-hand access to information they need in the course of their daily activities. This information assists them not only to know *what* to do next but also assists them to *do* the next thing.

3 REFINEMENTS TO THE METHODOLOGY

This section shows how the insights from the case study were used to refine the methodology. The previous version of the situated information systems analysis and design methodology is depicted in Figure 2. The following discussion shows how it was changed to the revised version in Figure 3.

The first case study was undertaken in a workforce management company involved in managing technicians installing telecommunications products in private homes. This second case study, undertaken in the Chemotherapy Unit in a large hospital, presented several theoretically challenging differences from the first case study. It was a not-for-profit organisation and the success or otherwise of the system had serious implications for people's health and wellbeing. It also presented an interesting new constraint - protecting the privacy of information about individual patients. The chemotherapy unit involved more complex coordination among a greater range of actors and there were recognised problems as effective routines had not been established.

The first step in the previous iteration of the situated information systems analysis and design methodology (Figure 2) was "Analyse existing activities into their constituent situations and responses". In the first case study the practices involved in the management of installation of telecommunications equipment were linear and ordered enough to know what was going on, who was doing what and why. In contrast, at the Chemotherapy Unit, there were a range of different types of actors (Liaison nurse, Treatment nurses, patients, clerks, doctors, pharmacists) involved in the administration of chemotherapy and there were a number of processes occurring at once. This meant that it required a deal of analytic work to decipher exactly what was going on. Hence, we have made explicit the step of analyzing the information that actors need. In the first case study, this was done after the analysis of existing activities, as the information needed was made explicit by the current activities. In the second case study, this was done in concert with analysis of existing work practices and analysis of existing environmental support. We believe that including the step of analysing the

information that actors need is a better conceptualisation of this part of the methodology.

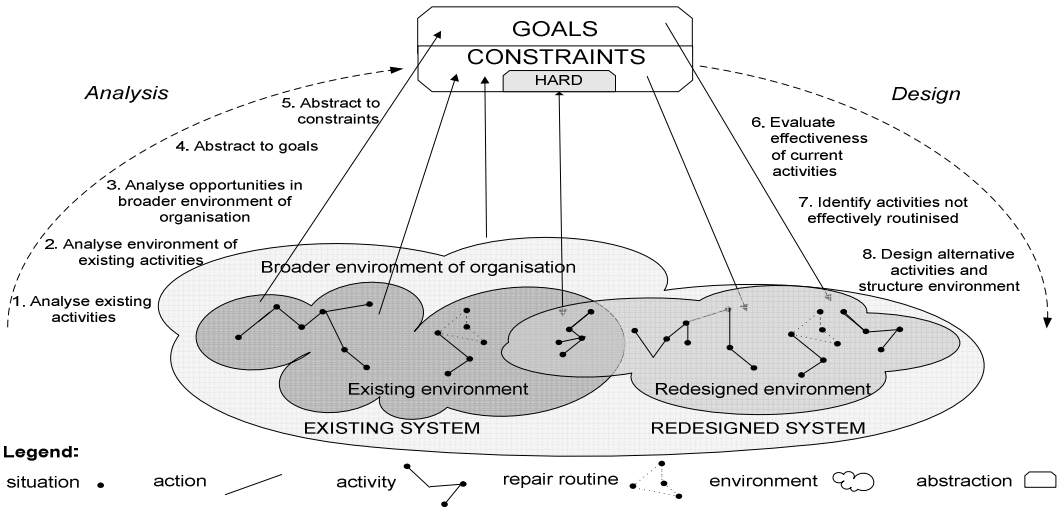

Figure 2: First version of the situated information systems analysis and design methodology

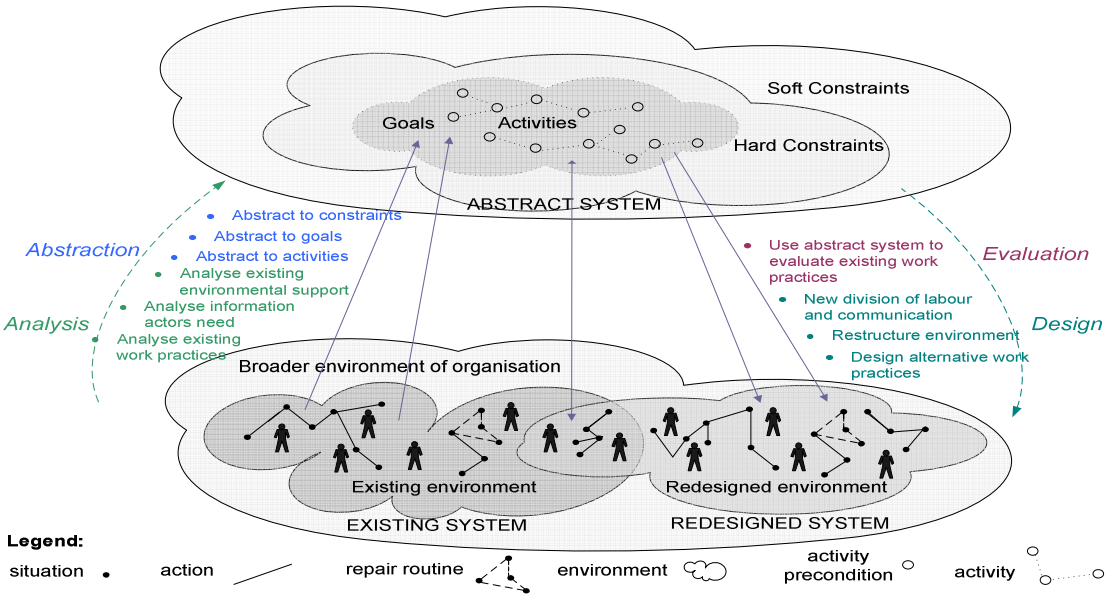

Figure 3: Current version of the situated information systems analysis and design methodology

The second and third steps in the first iteration of the situated information systems analysis and design methodology were, respectively, to 'analyse the immediate environment of current activities' and then to 'analyse opportunities in the broader environment of the organisation'. On further reflection, we recognized that the focus at this stage should be on existing environmental support for work, and that this was a more finely honed formulation than 'the immediate environment'. Moreover, analysis of opportunities in the broader environment of the organisation was really part of the design phase.

In the first case study we discovered the need to abstract away from the current work practices to *goals and constraints* to be able to imagine alternative ways of doing things. In this second iteration of the methodology, we additionally reconceptualised *activities* as an abstraction of work practices. The location of activities with goals and constraints as part of the abstract system in Figure 3 reflects this new understanding. This new understanding of the role of the activity system as an abstraction, which is both necessary for moving away from current circumstances and to inform an effective new set of practices, is the main conceptual refinement of the methodology.

The analysis stage has been clearly separated from the abstraction stage and evaluation has been recognised explicitly as a precursor to design. In addition, the proposed solution in the second case study involved a new division of labour and new lines of communication. These have been added as discrete aspects of the design phase of the methodology, as they are likely to be reflective of the general case. The numbering of each aspect within the four stages has been removed to emphasise that these are conceptual distinctions and do not imply a rigid temporal order.

4 RELATION TO PREVIOUS WORK

Given our theoretical commitment (Johnston et al. 2005; Milton et al. 2005) to situated action theories that reject a primary role for mental abstractions as an explanation for routine human action, it is interesting to discover the importance of abstraction in deliberate redesign of routine systems. The analyst, as opposed to the actors in the system must be able to "stand outside the action" in order to appreciate and evaluate the possibilities for change. This is the role of the abstract system in Figure 3.

This idea of a design abstraction is somewhat reminiscent of the distinction between the physical and logical system in traditional systems analysis (Avison and Fitzgerald 1995), so we should here point out some crucial differences in our conception of the appropriate abstraction. The differences reflect the differences in ontologies and theories of action which, as we have argued elsewhere (Johnston et al. 2005), underlie the two approaches. Firstly, our abstractions are not objective, in either sense of the word. They are expressed using action-centred constructs (activity, goals, constraints on action) rather than entities, properties, states, events etc. They express in a generalised form the purposes and key activities of the existing practices as they are enacted, rather than a model of the world "out there" which actors might refer to and deliberate upon in the course of action. Secondly, such an abstraction is not intended to be a model of an archetype of which the system in a given organisation is an instantiation, The abstractions we envisage are particular to an organisational setting – they are still situated in a sense - and are unlikely to apply to any other setting even in the same industry (another chemotherapy ward, for instance). Rather they are a temporary crutch with which to move from the current practices, which by virtue of their routinisation are to various degrees opaque, to new more effective reroutinised practices. Finally, they are not solutions in any sense; in the traditional method, arriving at the logical model is in a certain sense the end of the analysts work because the logical system then simply has to be translated into a more or less isomorphic computerised information system, a job that can be handed to database designers, programmers, implementers and trainers.

In some respects our notion of abstraction is similar to that advocated in Cognitive Work Analysis, CWA (Rasmussen and Pejtersen 1995; Vicente 1999) which similarly makes use of abstraction to goals. However, our situated systems methodology differs from CWA in both intention and detail. Our intention is to support routine operational activity rather than cognitive, decision-making activity, typically the focus of CWA. Our work recognises that routine action is situated not just in the physical surroundings considered by CWA, but also in an organisational and socio-cultural environment, the reengineering of which is also a point of leverage for creating more effective practices and lighter-weight information technology support.

5 CONCLUSION

This paper reports on a completed case study of the requirements for more effective routine systems in a chemotherapy ward of a major hospital. The case was deliberately selected for its potential to challenge the situated systems analysis and design methodology and thus allow it to be tested and refined by a reflective participatory research method. The long term project of developing a situated information systems analysis and design methodology has theoretical significance as well as practical significance for organisations. While contributing to an understanding of the unique nature of routine action, it also extends our conception of what an information system is. In terms of practical applications, as this paper has shown, the methodology has the potential for providing systems that are both effective and lightweight in areas where activity is complex and routine.

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Acknowledgements: We wish to thank the management, staff and patients of the Chemotherapy Unit for kindly making their time and facilities available for the design case study. This project is supported by Australian Research Council Discovery Grant DP0451524.