STRUCTURING MEDICAL AGILITY

Christoph J. Stettina, Lucas P. J. Groenewegen and Bernhard R. Katzy
CeTIM / LIACS, Leiden University, Niels Bohrweg 1, 2333 CA Leiden, Netherlands

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Abstract: Technology is omnipresent in intervention rooms, potentially having enormous impact on workflows and on flexibility. Despite ICT systems' more flexible support of medical protocols, the styles of collaborating do not really match. Intervention support systems are as yet stand alone and not sufficiently interoperable. Taking an ICT perspective, we seek to understand medical work, how to view the way it is organized and how to improve its integration with intervention support systems, driven by highly dynamic coordination models embedded in the framework of clinical pathways.

1 INTRODUCTION

New technologies enable new possibilities in medical operating rooms. They make interventions noninvasive and less risky. Technology in fact is omnipresent in intervention rooms, having enormous impact on workflows and their flexibility. However, despite improvements in medical support systems and in medical protocols the styles of collaborating do not match. Intervention support systems are as yet stand alone and not interoperable. They lack the support for collaboration agility in the medical domain. CT images from different vendors require different viewing software; they regularly are being transferred on portable media. Complex patient data rendering requires an approach tailored towards relevant caregivers, either present at intervention or being elsewhere.

Within the EDAFMIS project the authors investigate the introduction of state-of-the-art medical intervention support systems in medical operating rooms. A minimal intervention cockpit is being developed to support automation and navigation of noninvasive interventions in line with a new generation of imaging systems. The project targets at real-time interoperability and user interaction, thereby flexibly integrating medical skills with systems rendering patient data. Within the part of the project described here, we want to grasp flexibility in medical work, how it is or could be organized in view of its integration with ICT, driven by highly agile coordination models embedded in clinical pathways.

2 PROCESS MODELING AND MEDICAL WORK

During a medical intervention, several specialists are involved in different roles; also, various views on patient data and on treatment workflow are needed. This is knowledge work, requiring new forms of organizing. However, the standard concepts of work come from bureaucratic and hierarchical organizations in the industrial era and little agreement exists on how post-bureaucratic organizing could be conceived.

As opposed to industrial work, knowledge work is valued for the ability to interpret information instead of performing manual labor. Knowledge work can especially be found in domains such as health care, law, education, science or engineering. Information technology increasingly allows physical operations to be performed remotely, thus shifting manual work towards knowledge work, done by people governing machines. This requires new approaches structuring and studying knowledge work.

Medical doctors and nurses do need agility. Their tasks include collecting and analyzing patient data in order to formulate and provide a corresponding treatment, while working under expanded responsibilities and strict time constrains. Medical agility is difficult to predict when developing clinical pathways. Quick reaction to changing information and smooth self-adaptation is obviously crucial in a life saving environment and should be embodied in system as well as in team processes. To meet clinical effectiveness, ad-

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justing has to be done smoothly, quickly and without quiescence. In view of achieving ongoing and smoothly changing medical collaborations, we want to apply a new ICT-approach in self-adaptive coordination.

EDAFMIS aims at extending intervention flexibility by integrating patient specific data and professional knowledge with an interoperable visual system. It aims at connecting medical workflow and specialist skills to the intervention support system. Here we aim at bridging the gap between medical pathways and ICT in terms of structured agility. Facing the challenges in medical work, we have decided to investigate the applicability of a highly dynamic coordination modeling language in the setting of clinical pathways in care planning.

2.1 Clinical Pathways

Clinical pathways first emerged in the 1980s in the United States aiming at organizational efficiency in hospitals by uniforming lengths of stay, standardizing treatment packages and thus enabling predictable costs (Zander, 1991).

Pathways usually consist of several forms combining the nursing care plan with medical notes, and some sort of a process diagram visualizing the process. The diagrams provide a global view, while the loose forms guide the respective medical journey and embed the reports. Implemented through broader national agendas, pathways aim to improve efficiency, quality and local flexibility (Pinder et al., 2005; DOH, 1997) by continuous improvement based on best practice while reducing variations (Campbell et al., 1998).

There are two main approaches of pathway protocols in terms of their scope, see Figure 1. From the broader organizational perspective pathways define content such as discharge planning, nutrition management, pain management and patient education. Taking the clinical perspective, pathways deal with the sequencing and timing of care, specifying each step of a medical intervention (Hunter and Segrott, 2008). From a modeling point of view pathways aiming at the clinical scope are descendants of Critical Path Methods (CPM) and Program Evaluation Review Techniques (PERT) and Gantt charts (Zander, 1991).

Literature reveals quite some discussion regarding different pathway approaches and how they should be designed. Apart from the organizational scope of pathways and their tightly aligned goals, it is most notably the level of flexibility in the approach being discussed, as represented in Figure 2.

We understand such recent variants in pathway literature regarding nomenclature and definition (Hunter and Segrott, 2008; Vanhaecht et al., 2006) as a pointer at lacking standardization. Within this research we aim to bridge the gap between the existing medical pathways and ICT solutions, to improve our understanding of possibilities for integration. Thus, we hope to contribute to protocol improvement by incorporating flexibility into the skeleton of clinical pathways.

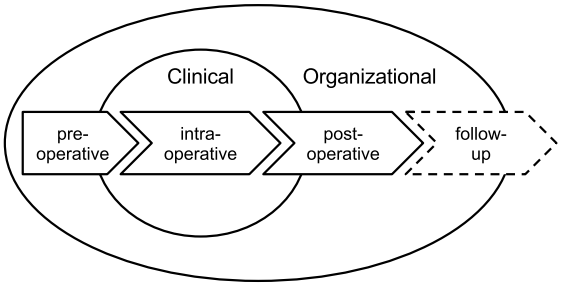

Figure 1: Different Scopes of Clinical Pathways.

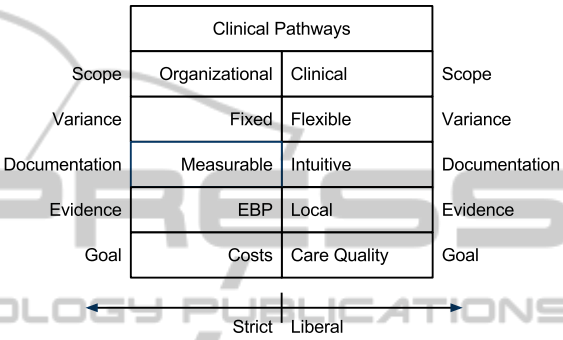

Figure 2: Aspects of Clinical Pathway Implementations.

2.2 Coordination and Self-adaptation

Dynamic adaptation, consisting of interactive, usually distributed components, heterogeneous and with a varying configuration, obviously adds significant complexity to the overall system. Dynamic adaptive systems (DAS) thus must be safety-critical: no failure is to be accepted, since it could result in loss of life. In literature adaptation is viewed conceptually as a three-layered architecture (Kramer and Magee, 2007; Garlan and Schmerl, 2002).

As many systems today, medical equipment is affected by dynamic changes in its operational environment. Such systems cannot be simply shutdown to be changed, updated or upgraded and restarted again. This is particularly important for a live saving environment in which adaptation has to be done smoothly, quickly and without quiescence to support ongoing collaboration and meet clinical effectiveness. We ar-

gue that clinical pathways as currently formulated, do not allow for agility needed within complex medical interventions supported by ICT; we however conjecture, such pathways can be used as a process skeleton suited for being enriched with agility.

The coordination modeling language Paradigm (Andova et al., 2010), as a possible approach, addresses coordination of collaborating components in terms of dynamic constraints. Its component McPal (Andova et al., 2009) allows the addition of new behavior, and, subsequently, gradually adapts the system dynamics without quiescence. We would like to model agile patterns observed in medical teamwork in this manner, thus enriching the existing process skeleton as provided by organizational pathways.

3 STRUCTURING AGILITY IN MEDICAL INTERVENTIONS

As outlined in the introduction, the goal of EDAFMIS is the development of a well-integrated ICT solution. This study contributes to the integration of the ICT system into medical practice and, more specifically, to the agile coordination of a medical team and its ICT-support. Thus, this research seeks to understand medical work: how to view the way it is organized and how to improve its integration with state-of-the-art medical equipment.

There is ongoing discussion, calling for new concepts regarding working in flexible conformity to the knowledge dynamics. There is little agreement on how post-bureaucratic organizing should look like and we start looking back at work studies of Scientific Management (Taylor, 1911) and of detailed ethnographic studies of work (Barley and Kunda, 2001). Knowledge work is different from Scientific Management where every step of a worker can be measured according to quantitative criteria. To circumvent difficulties in registering and measuring knowledge work rather strictly, we investigate the suitability of a highly flexible coordination modeling language.

Process models for automation of work processes could be a possible direction for our research. Our particular goal is understanding flexible knowledge work were smoothly changing collaborations remaining ongoing. In addition this should be integrated with likewise smoothly changing as well as ongoing ICT support. Process models and ICT are natural partners, providing new opportunities to support knowledge work. Their common strengths, however, have not yet been fully exploited in practice (Giaglis, 2001). We aim at contributing to research how to structure knowledge-oriented medical work and its ICT support, while keeping flexibility via dynamically adaptable coordination models applied.

In the remainder of this section we explain the research method we have chosen to investigate the use of highly dynamic process models in the medical domain.

3.1 Research Method

In order to understand the co-evolutionary impacts of technology on human teamwork practice, a systematic approach needs to be incorporated into this research, capturing human behavior in clinical settings and its connection to ICT (Morrison et al., 2007). As it is difficult to predict all possible events within the initial development phase and as ideas materialize within ongoing development, we organize our research in an iterative manner. Thus we propose an exploratory study of five phases embedded in a case study design: Orientation, Investigation, Identification, Modeling and Verification. We outline the phases briefly.

Orientation: As a first step we discuss the problem domain. A literature review is conducted to review the current knowledge. It is important as a preparation and it helps us to stay focused during the next steps. Hereby we reflect on the current literature in a structured manner.

Investigation: To study human teams and their interaction with technology different sociological models and theories have been developed. Literature suggests ethnographic and other qualitative methods for detailed studies of work. Due to the exploratory nature of this research, we conduct participant observation accompanied by semi-structured interviews, in view of exploring the medical work domain on site, particularly its dynamics in intervention rooms.

Identification: In this step we prepare and analyze the data in order to be able to identify re-occurring routines. After having cleaned the data, we use it to find appropriate groupings and patterns.

Modeling: We research dynamic coordination models within a domain governed by tacit knowledge, and generally not well-aligned to ICT. Concerns of medical personnel need to be addressed (Lapointe and Rivard, 2005). Readability of models and flexibility and self-adaptation as perceived by the medical personnel, is very important. Here we investigate to what extent Paradigm can be used or has to be extended.

Verification: The process models we develop, are presented within focussed group sessions of medical specialist and interviews. The insights gained will be used to re-evaluate and to improve the models. Possibly, formal analysis might be carried out in combina-

tion with Paradigm, thus contributing to verification even further.

4 CONTRIBUTIONS

We contribute to the quality of medical teams by flexibly integrating medical support systems into noninvasive intervention activities.

Medical pathways for noninvasive interventions exist today and we extend their organizational skeleton with more detailed, but flexible descriptions, as provided by the Paradigm-McPal approach for self-adaptive coordination. Thereby we follow the iterative set-up of an ethnographic study, to improve our understanding of applying highly agile coordination embedded in clinical pathways. We conduct a detailed study of medical work and use recorded routines to gather data about and acquire insight into structuring medical knowledge work. Our findings will be used to refine the coordination approach towards highly agile medical team work, to be carried out in conformity to relevant clinical pathways and supported by well-integrated ICT systems.

In addition, this is related to coordination of knowledge work in general, so it will lead to new insight into knowledge work. We consider medical workflows and clinical pathways as a good empirical case and starting point to address highly dynamic knowledge work modeling. By establishing a bridge-head for understanding and supporting flexibility within medical team work, we see great opportunities for generalizing such insight towards non-medical fields.

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