Designing and Rationalising a Layered-Mapping Aid for Requirements Elicitation in Air Traffic Control

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ABSTRACT

The “Layered Map” is a simple, cheap and portable device used to aid the explanation of complex traffic management scenarios, between field practitioners and operators and during the process of requirements elicitation. It was developed for being adaptable to multiple semantic communities within and across different ontologies of work in air traffic control. The study identified a number of factors influencing the design of aids, namely: i) emerging knowledge coordination, ii) ontological compatibility, iii) jargon and linguistic interpretation, iv) cultural traffic management practices, v) software development, and vi) gesture-based interaction. The construction of the layered-map involves three layers of material: i) the base, ii) the modifier, and iii) the interactor. The layered-map utilises semiotics to define three different modes of knowledge coordination. The rationale used to represent these modes of coordination is the representational adaptability of the different physical layers of the layered map. Thus, a conceptual bridge is elicited as a means of generalising the mapping of: i) syntactic knowledge to the base layer, mainly for representation, ii) semantic knowledge to the modifier layer, mainly for learning, and iii) pragmatic knowledge to the interactor layer, mainly for transformation.

Keywords: Boundary, Coordination, Gatwick, Layer, Orly, Participatory, Requirement, TMA

1. INTRODUCTION

The study of controllers’ work performances within their natural work environment is an activity rewarded with innovative requirements which cannot be easily achieved from simulated platforms and controlled laboratory settings. However, a major hurdle in productive requirements elicitation is the a-priori lack of specialist knowledge concerning the operational environment, opposed to the necessity of ‘asking the right’ questions as soon as possible. Although it can be argued that an experienced practitioner in Air Traffic Management (ATM) should minimise this delay, variations in control room management strategies, work techniques and other matters can easily disrupt the productivity of the requirements elicitation process.

Requirements elicitation aids are available to a practitioner. However, they have the burden of providing sufficient adaptability as a
means of addressing the problem of unexpected changes in the target operational environment and during the period of a field study. We can illustrate the problem by imagining a practitioner utilising basic note-taking methods for collecting in-situ data. In the more conservative case, the practitioner enters the field using blank pages, which are then augmented using textual descriptions and graphical depictions of the work environment. However, the method is time consuming and might incur certain redundant information pertaining to stable features of the work environment. In the alternate extreme that the practitioner enters the field using a more prescriptive protocol, the problem is that of recording novel work practices which have not been structured a-priori, by the protocol.

Thus, a finer spectrum of recording methods is required for eliciting requirements in dynamic work environments. This paper reports on the parallel development of a physical aid to requirements elicitation, as well as the theoretical design rationale constructed within the context of field studies in ATM. We pose the following research question: what are the factors influencing the design of aids during requirements elicitation and how is the design process rationalised?

The specificity of this research question needs to be contrasted with similar initiatives. First, we are interested in the design as a purely emergent activity, as compared to a specified process. Thus, design as a consequence of a knowledge-sharing goal is of interest, rather than a central goal in itself. Second, the functions of design and usage are shared between the same actors, rather than dedicated. According to this treatment, the design activity is distributed. Third, the classical process of requirements elicitation, designing and validation, is tightly coupled in time, ranging from a cycle of a few minutes to a few days. This is contrasted with lengthier design methodologies engaging a cycle of weeks to months. While several concepts come close to those initial considerations, they do not satisfy all of them.

We make use of Computer Supported Cooperative Work (CSCW) framework as a means of characterising the development of representational forms between practitioners and operators (Schmidt & Simone, 1996). In CSCW, work is construed as a collective, social activity supported by technological means; workers are called actors given their integrated participation towards goals; specialised groups of actors whether specified or emergent are called communities of practice (CoP) (Wenger, 1998); interaction between such CoP are mediated by special artifacts called boundary-spanning or boundary-negotiating objects (Lee et al., 2005). The cooperation within and between CoP involve different information exchange processes, among which are ordered management of information exchanges, called coordination (Malone, 1988).

2. BACKGROUND

2.1. Supporting Requirements Elicitation in the Field

Numerous methods are available for eliciting requirements within different organisational environments (Alexander & Stevens, 2002, p. 19). Those applicable to operational field environments are a smaller subset, due in part to the dynamic and continuous nature of real operations, as compared to controlled study settings (Sharp, Rogers, & Preece, 2007, p. 214). Further, methods applicable to safety-critical field environments are even a smaller subset, due to the limited possibility of interactions with operators. Two such methods in the Air Traffic Control (ATC) domain are in-situ observations and interviews (Berntsson & Normark, 1999; Cox, Sharples, Stedmon, & Wilson, 2007; Koros, Rocco, Panjwani, Inurgio, & D’Arcy, 2003; McNeese, Bautsch, & Narayanan, 1999).

Beyond the constraints of safety and operational continuity, the ATC domain also consists of security and data confidentiality issues. Raw recording methods by external visitors, such as the video and audio taking are often prohibited. Due to these limitations, written-up techniques such as note-taking and diagramming gain in penetrability of the work environment, although
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