Drivers of Knowledge Conversion in Socio-Technical Systems

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Abstract

Development and maintenance of an Information System to support operations of a socio-technical system, such as a manufacturing enterprise, is a demanding endeavour for IT professionals, who need to achieve a deep understanding of them. Socio-technical systems are complex adaptive systems with an interplay of social and technical aspects that aim at achieving goals in a competitive turbulent work environment. One of the main difficulties for IT professional is requirements collection since there is often a misalignment between the managerial perspective of the work (WAI: Work-As-Imagined) and the one as performed by sharp-end operators (WAD: Work-As-Done). Such misalignment is originated by several knowledge transfer acts between different system agents that could transform knowledge. We propose a classification of the main drivers of such knowledge conversion and we discuss them in the context of information systems engineering.

Keywords

Information systems development, Knowledge management, Knowledge creation, Knowledge conversion, Resilience engineering

1. Introduction

Socio-technical systems are complex adaptive systems characterized by strong interplay of social and technical aspects to achieve system goals [1].

Developing a new Information System (IS), or enhancing an existing one, to effectively support the processes of a socio-technical system, is a big challenge for an IT professional, who has to face the difficulty to understand those complex processes. Especially, the activity of requirements definition may be highly demanding when domain analysis models of the given socio-technical system have to be realized, as these models are essential to achieve a complete and valid set of requirements for the future IS. These domain analysis models are initially built from process descriptions derived from enterprise documents (e.g. standards, procedures,

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business descriptions, notes) and also completed and validated after direct interviews with managers. However, such information sources usually provide the managerial perspective on the functions of the socio-technical system, which, indeed, corresponds to the work as it should be realized (WAI: Work-As-Imagined). Therefore, the resulting analysis models of the socio-technical system processes may not represent the actual work in the way it is really performed in the system. Descriptions of the actual work, in case, could be derived from additional interview sessions with sharp-end operators, who are the activity operators (WAD: Work-As-Done). Misalignment between WAI and WAD in a socio-technical system hinders availability of reliable process models to be analyzed and may lead to flaws or inefficiencies of the future IS.

The problem of consistency and completeness of system requirements specification documents is well known in the software engineering research, where much effort is being devoted to approaches based on Natural Language Processing (NLP) to support content reviews, but also on formal languages for requirements specifications to avoid imprecise expressions or models and allow for automatic verification [2]. As a complementary research dimension still rooted in socio-technical analyses, this work follows the principles of Resilience Engineering [3], where the same problem is analyzed to the purpose of safety and, more generally, performance assessment of work processes. We are thus interested in analysing the misalignment between WAI and WAD by investigating how knowledge about work is created and shared by the various actors of a socio-technical system. We adopt the concept of knowledge conversion, which has been deeply analysed in the organization management literature [4]. So, we distinguish between explicit and tacit knowledge of an individual to analyse the activities required for knowledge creation (e.g. socialization, combination, externalization, and internalization). Our goal is to study motivations for knowledge conversions explaining the WAI-WAD misalignment, which are not just limited to ambiguity of text or communication with stakeholders and to formal modelling correctness by the analyst. We identify and analyze deliberative process deviation types due to ETTO (Efficiency-Thoroughness Trade-Off) principles, i.e. following local criteria of compromise efficiency-accuracy to achieve well-defined objectives in a particular context, possibly producing unexpected consequences [5].

We propose four types of knowledge conversion drivers. Any knowledge conversion may be driven by a combination of them. We deem that achieving a better understanding of these motivating factors may lead to implementation of knowledge-based methods to support the requirements analysis for an IS devoted to any socio-technical system.

The rest of the paper is organized as follows. Section 2 presents the related work in the area. Section 3 describes the drivers of knowledge conversion. Finally, Section 4 presents conclusions.

2. Related Work

According to Abera Yilma et al., socio-technical systems are those systems where humans and machines interact together with the aim of achieving a common goal [6]. Consequently, as suggested by Munford, a socio-technical design approach is the *one which recognises the interaction of technology and people and produces work systems which are both technically efficient and have social characteristics which lead to high job satisfaction* [7]. Sharing the same perspective

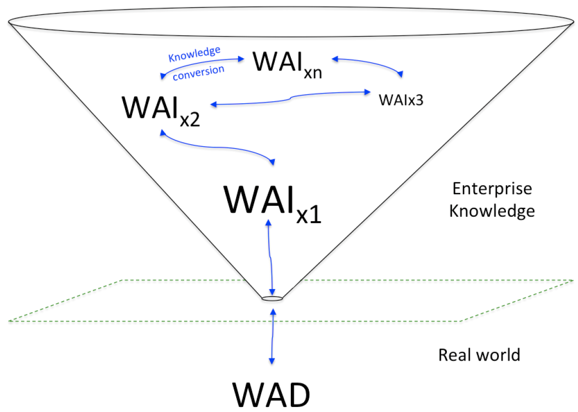

Figure 1: Knowledge conversions in an enterprise.

of these latter works, we aim to study how social relationships may influence knowledge transfers in the socio-technical processes of a business organization.

Then, we share with Moppett and Shorrock [8] and with Hollnagel [9] the distinction between WAD and WAI, and the need to understand this gap as a key to delve into socio-technical adaptability. However, with respect to them, we analyse the inherent reasons for this misalignment based on a knowledge management research dimension. This latter is largely based on the knowledge management framework presented by Nonaka in [4].

It is worth mentioning how the relevance of considering the misalignment between WAI and WAD has been discussed largely within the context of safety and risk management, as well as resilience engineering [10] [11], with implications in the practitioners literature [12], too.

3. Knowledge Transfer in Socio-Technical Systems

We distinguish between WAD and WAI types of work. WAD represents the work as performed by sharp-end operators and WAI the managerial perspective of the work. Figure 1 sketchily represents such distinction. The WAD concerns the process in the real world, hence, as actually done by the sharp-end operators, while the WAI reflect the different, and sometimes contradictory [13] views on the process of the different blunt-end operators (i.e., WAI_{xi} in Figure 1), which are part of the enterprise knowledge. Each of these work representations can be derived by another one by means of a process of knowledge conversion. In this section, first we present a running example concerning big data management and, afterwards, we investigate the reasons of the knowledge conversions that we named knowledge conversion drivers.

3.1. Case Study on Data Management

A typical knowledge transfer in a socio-technical system involves different agents and their perspectives on work. For the sake of simplicity, in Figure 2, we show a toy example rep-

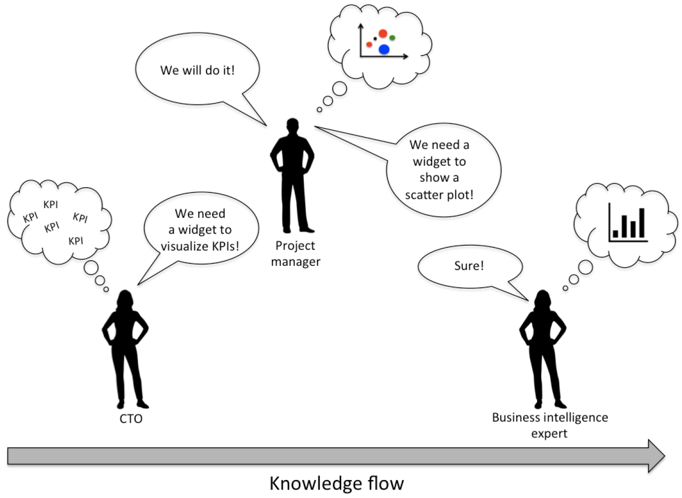

Figure 2: Example of knowledge transfer concerning big data management.

resenting a common situation in several modern enterprises. We imagine a scenario where the Chief Technology Officer (CTO) requests the project manager to add a data visualization functionality for making data concerning some specific Key Performance Indicators (KPIs) more understandable, user-friendly and significant for the customer. Then, the project manager asks the business intelligence expert to add a data visualization widget to show such information in a scatter plot. However, due to his/her experience in contact with similar customers, the business intelligence expert knows that such type of graph might not be meaningful for the task at hand. Therefore, he/she decides to include in the front end of the information system a functionality to display histograms.

3.2. Knowledge Conversion Drivers

Knowledge transfer is a very important topic in the field of socio-technical systems [14]. Knowledge conversion drivers represent the reasons why knowledge about a process of a socio-technical system is modified during a knowledge transfer between two agents. We identified four types of knowledge conversion drivers. These are: the *ETTO process driver*; the *ETTO modelling driver*; the *ETTO communication driver*; and the *entropic driver*. The simple case study proposed in Section 3.1 is here used as a reference for understanding the meaning and significance of such knowledge conversion drivers in a socio-technical analysis of a system.

ETTO process driver. This driver represents the motivating factor for a deliberative knowledge conversion due to ETTO principles with the aim to achieve a well-defined objective (e.g. neglecting an authorization request to deliver the activity's output faster). In the case study, the business intelligence expert decides to use a different data visualization widget, leveraging on her experience following previous contacts with similar customers.

ETTO modelling driver. This driver represents the motivating factor for a deliberative knowledge conversion originated by specific modelling choices (e.g., selection of a modelling formalism, choice of some modelling patterns, use of modelling best practices, choice of a model abstraction level) driven by ETTO principles (e.g. adoption of BPMN notation instead of Petri Nets to facilitate requirements collection). In the case study, the project manager collects the requirements of the CTO by using UML use case and activity diagrams while the business intelligence expert uses UML deployment diagrams for the detailed design of the information system.

ETTO communication driver. This driver represents the motivating factor for a deliberative knowledge conversion originated by the specific communication goals driven by ETTO principles (e.g. hiding parts of the process not compliant with the existing laws and regulations). In the case study, although a scatter plot was not explicitly required by the CTO, the project manager requires it from the business intelligence expert as he deems this is the faster way to get an outcome from her.

Entropic driver. This driver represents the motivating factor for an accidental knowledge conversion after an interpretation activity subject to information loss, misunderstandings, and subjective interpretations. In the case study, the project manager would like a colored figure to display scatter plots but, accidentally, he does not communicate this request. Hence, the business intelligence expert decides to work on a black and white widget.

Any knowledge conversion may be driven by a combination of the above types. In fact, in the case study, the WAI pertaining to the business intelligence expert is the combination of all the previously presented knowledge conversions.

4. Conclusions

One of the issues to engineer information systems for socio-technical systems is requirements collection. IT professionals have to cope with different, sometimes contradictory, perspectives on how business processes are and should be executed. A precondition for the development of more effective approaches and tools to support this knowledge elicitation phase is a better understanding of the mechanisms driving the knowledge flows that generate such different views. To this purpose, we have proposed a classification of the drivers of knowledge conversion in a socio-technical system that motivates the variety and complexity characterizing enterprise knowledge. This classification is expected to support the application of resilience engineering principles for design and analysis of socio-technical systems, through a deeper and more critical understanding of knowledge management processes.

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