Controlled Flexibility in Healthcare Processes:
A BPMN-Extension Approach

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INTRODUCTION

Since the early years of workflow management systems, they have been applied to the healthcare area to reduce costs and improve quality of care (Russo & Mecella, 2013).

Healthcare processes include both administrative/organisational processes and medical processes. Administrative/organisational processes handle administrative tasks, such as patient admission, discharge, transfer, appointment planning, and scheduling of resources. Medical processes support diagnostic and therapeutic procedures.

Administrative/organisational processes are quite predictable, repetitive and well structured. Exceptional behaviours are limited and can be often anticipated and managed according to predefined handling procedures. However, medical processes are loosely structured or unstructured processes, since they depend on clinical decision-making and case patient data. Clinical decision-making is highly knowledge-driven, as it depends on clinicians' expertise and experience, medical knowledge and evidence, as well as on case patient specific data. They involve frequent deviations to meet individual patient needs (Reichert & Weber 2012; Russo & Mecella, 2013).

Indeed, several studies corroborate that flexibility is an unavoidable feature that determines the success of using business process in the healthcare domain (Reijers et al., 2010; Reichert & Weber 2012; Lenz et al., 2012; Ruiz et al., 2012; Yao & Rumar, 2013). Reichert and Weber (2012) present an overview of several solutions that have been proposed to support exception handling, process adaptation and process evolution.

Since its release in 2004, BPMN (Business Process Model and Notation) (OMG, 2011) is becoming the leader and de-facto standard in business process modeling (Harmon & Wolf, 2014). BPMN has been used to model and execute various healthcare processes, both administrative and medical processes (Svagård & Farshchian, 2009; Rojo et al., 2010; Strasser et al., 2011; Scheuerlein et al., 2012; Cossu et al., 2012; Müller et al., 2014; Braun et al., 2015). Considering flexibility features in BPMN business processes, Yao & Kumar (2013) take advantage of standard BPMN elements, such as the ad-hoc subprocess BPMN element, to define more flexible business processes. In addition, Milanović et al. (2011) extend BPMN with rule-based languages to improve flexibility by design and Said et al. (2010, 2105)

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extend BPMN with versioning features to support flexibility by changes. The jBPM engine also supports flexibility by change, including the migration of running process instances.

Although flexibility is considered essential so that processes can cope with expected and unexpected exceptions, in the everyday business practice, process participants do not wish for total flexibility, i.e., changing processes without any restrictions or guidance. Instead, designers would like to define which changes can be applied, as well as performers would like to follow advices previously modelled on which and how they can change the elements that compose business processes (Bider, 2005; Borch & Stefansen, 2006; Martinho et al., 2008). Controlled flexibility can be defined as the ability to control which, where, how and by whom the elements that compose a business process can or cannot be changed. This controlled flexibility feature is also aligned with healthcare domain requirements (Weber et al., 2008; Reijers at al., 2010; Yao & Kumar, 2013).

In (Martinho et al., 2015), the authors present their initial work to define the CF4BPMN extension, a BPMN extension with Controlled Flexibility. They use the Controlled Flexibility Language concepts they proposed in Martinho et al. (2008, 2010) (for controlled flexibility in software processes).

In this chapter, the authors detail the CF4BPMN extension by defining its extension model as well as its XML schema. In addition, the authors describe how they apply the CF4BPMN extension to the healthcare domain.

Next section presents related work about flexibility in general and particularly concerning the healthcare domain. The CF4BPMN extension for controlled flexibility is detailed in section 3. In section 4, the authors apply the CF4BPMN extension to a healthcare process. Finally, sections 5 and 6 discuss future work and conclude the paper, respectively.

BACKGROUND

In the last years, an increased use of business process management methodologies and tools in the healthcare domain can be observed (Russo & Mecella, 2013). In particular, there are some experiences addressing the use of BPMN to model and execute healthcare processes, both administrative/ organisational and medical processes. For instance, Rojo et al. (2010) model anatomic pathology sub-processes within the programmed surgical patient process; Strasser et al. (2011) define and reconstruct clinical processes to track patients from admission to discharge with the purpose of controlling costs and quality; Svagård & Farshchian (2009) model chronic care processes; Scheuerlein et al. (2012) model colon and rectum carcinoma clinical processes; Cossu et al. (2012) defines processes for diagnosis and treatment of chest pain; and Müller et al. (2014) model a treatment process for stroke patients. Braun et al. (2015) extend BPMN with additional domain specific objects for modeling clinical processes.

Despite these efforts, among others, the use of business process management in the healthcare domain is not significant. The most consensual justification for this observation is the generalized lack of flexibility (Ruiz et al., 2012, Lenz et al., 2012).

The taxonomy that Regev et al. (2006) propose classifies business process flexibility according to three orthogonal (combinable) dimensions: the abstraction level of the change; the subject of change; and the properties of the change, which include extent, duration, swiftness, and anticipation. The *abstraction level of change* defines *where* changes can be made, i.e., at the *type* or *instance* levels (or both). Changing the process model (*type* level) implies changing the defined standard way of working, as it will affect all instances created there forward. However, change can occur only for certain instances of a process (*instance* level), in order to accommodate exceptional situations. The *subject of change* defines *which* modelling elements can be changed. For instance, considering BPMN, modelling elements would include

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