Chapter 37
Reliability of IoT-Aware BPMN Healthcare Processes

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ABSTRACT

BPMN (Business Process Model and Notation) has become the de-facto business process modelling language standard. Healthcare processes have been increasingly incorporating participants other than humans, including Internet of Things (IoT) physical devices such as biomedical sensors or patient electronic tags. Due to its critical requirements, IoT-aware healthcare processes justify the relevance of Quality of Services aspects, such as reliability, availability, and cost, among others. This chapter focuses on reliability and proposes to use the Stochastic Workflow Reduction (SWR) method to calculate the reliability of IoT-aware BPMN healthcare processes. In addition, the chapter proposes a BPMN language extension to provide processes with reliability information. This way, at design time, modellers can analyse alternatives and, at run time, reliability information can be used to select participants, execute services, or monitor process executions. The proposal is applied to an Ambient Assisted Living system use case, a rich example of an IoT-aware healthcare process.

INTRODUCTION

Business Process Management has been applied to the healthcare domain, improving several practical aspects regarding the quality of care services provided to patients (Reichert, 2011; Russo & Mecella, 2013). These aspects include, from a healthcare professional perspective, reduced number of procedures, cost optimizations, increased information availability in critical situations and better decision making,

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among others. From a patient perspective, they include reduced length of stay, decrease of evasiveness to treatments and a global care process-awareness.

BPMN (Business Process Model and Notation) (OMG, 2011) is becoming the leader and de-facto standard in business process modelling (Harmon & Wolf, 2014). Considering the healthcare domain, BPMN has been used to model and execute various processes, both administrative and medical processes (Svagård & Farshchian, 2009; Rojo, Calahorra, & Ruiz, 2010; Strasser, Pfeifer, Helm, Schuler, & Altmann, 2011; Scheuerlein et al., 2012; Cossu et al., 2012; Müller, Prüfer, & Stöhr, 2014; Braun, Schlieter, Burwitz, & Esswein, 2015).

In addition, the healthcare domain presents itself as an ideal playground for Internet of Things-related scenarios (Pang, 2013). Known applications include real-time location systems, patient flow management, remote health monitoring, fitness programs, chronic diseases, and elderly care. For this, there are several IoT-related solutions commonly based on smart devices, including mobile devices, sensors, imaging devices and electronic text tags. Together with communication gateways or through direct communication protocols, they can bring timely and up-to-date information to Information Systems and the Organization. IoT-based healthcare services are expected to reduce costs, enrich the user's experience, increase the quality of life, and the number of patients served (Islam, Kwak, Kabir, Hossain, & Kwak, 2015).

However, healthcare processes are highly time sensitive and critical due to the impact that an error may have regarding, for instance, patient safety or information security and confidentiality. In Islam et al. (2015) the authors identify several challenges, signalling the Quality of Service (QoS) as an important requirement that must be assured in the application of IoT in healthcare. In this context, measuring reliability of a certain healthcare process that uses smart devices, such as sensors, can prevent a number of issues. These can range from a simple medical appointment delay or absence, to a serious hazard involving medical prescriptions of wrongly identified patients, or inappropriate emergency assistance with potential fatal consequences.

Calculating reliability of sensors has already been proposed (see, for instance, Parente et al., 2011; Siewiorek & Swarz, 2014). Nevertheless, these proposals focus on a particular device or type of devices, lacking on the evaluation of a global reliability regarding the remaining process tasks and control-flow elements where they participate. Furthermore, decision making based solely on reliability information of certain sensor/sensor network is usually very limitative.

In this chapter, the authors propose an innovative approach to the calculation of reliability in IoT-aware healthcare processes. For this, the BPMN is used to first model the process. Then the Stochastic Workflow Reduction (SWR) algorithm from Cardoso (2002) is used to calculate reliability, based on the reliability information of each element of a BPMN process (including Tasks, and Events), and in the iterative reduction of these elements to a final process element representing the whole process's reliability. To be able to register reliability information for each BPMN process element, the authors propose the *relyBPMN* extension. A three-step method is detailed to accomplish it, using the native BPMN extension mechanisms. The authors apply then the approach to an IoT-aware healthcare process use case, in order to calculate its reliability, and simulate different scenarios to evaluate which conditions are necessary to ensure a given reliability level.

Using this approach of calculating reliability for a BPMN process model will allow better decision making. For instance, calculating reliability for a certain part of a process model (at design time) can help process designers to assess the need of modelling other alternative paths, or to foresee more instances of a certain type of sensors in a multi-instance subprocess, in order to assure better patient safety. At runtime (i.e., within a running process instance), a certain task resource can be selected taking into account the