Modelling IoT behaviour within BPMN Business Processes

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Abstract

As the computational power of IoT (Internet of Things) devices increases, business processes can use them to provide information about real world as well as to execute part of business processes, reducing the amount of exchanged data and central processing. Current BPMN-based approaches already support modellers to define both business processes and IoT devices behaviour at the same level of abstraction. However, they are not restricted to standard BPMN elements and they generate IoT device specific low-level code. The work we present in this paper only uses standard BPMN to define both central and IoT behaviour of business processes. In addition, the BPMN that defines the IoT behaviour is translated to a neutral-platform programming code.

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1. Introduction

Nowadays, organisations use more and more business processes to capture, manage, and optimise their activities. In areas such as supply chain management, intelligent transport systems, domotics, or remote healthcare, business processes can gain a competitive edge by using the information and functionalities of IoT devices (sensors and actuators). Business processes use IoT information to incorporate real world data, to take informed decisions, optimise their execution, and adapt itself to context changes [14]. In addition, the increase in processing power of IoT devices enables them to take part in the execution of the business logic. This way, IoT devices can aggregate and filter data, and make decisions locally, by executing parts of the business logic whenever central control is not required, reducing both the amount of exchanged data and of central processing [13].

However, on the one hand, IoT devices are heterogeneous by nature. They differ in terms of communication protocols, interaction paradigms, and computing and storage power. On the other hand, business modellers define processes using high-level languages (such as Business Process Model and Notation version 2.0 [19], henceforth simply referred as BPMN), as they must know the domain, but do not need to have specific knowledge to program IoT devices, nor want to deal with their heterogeneity.

Current approaches allow modellers to define both business processes and IoT devices behaviour at the same level of abstraction, using, for instance, BPMN-based approaches [1, 2, 3, 4, 22, 23]. BPMN already provides the concepts to define the behaviour of various participants, by using different pools. The interaction amongst participants is specified through collaboration diagrams. Supporting the execution of these hybrid processes requires bridging the gap between high-level BPMN and the programming code that IoT devices can execute. These approaches use a three-step procedure: (1) translation of the process model to a Wireless Sensor Network (WSN) neutral intermediate language; (2) translation of the intermediate code to a platform specific executable code; and (3) deployment of the executable code into IoT devices.

Indeed, with these approaches, business modellers can define both business processes and IoT behaviour at the same (high) level of abstraction. However, they still use non-standard BPMN to integrate, for instance, IoT device information into business processes and they generate IoT device specific code, so that it must be generated again for each different IoT device.

In our work, we only use standard BPMN to define both central and IoT behaviour of business processes. We use the BPMN resource element to integrate IoT device information into the model, and we translate the BPMN that defines the IoT behaviour into Callas bytecode [15]. We use the Callas sensor programming language as an alternative to the target platform-specific languages taken by previous proposals, since it can be executed in every IoT device for which there is a Callas virtual machine available. This way, we abstract hardware specificities and make executable code portable among IoT devices from different manufacturers. Business process and IoT devices communicate via web services. In addition, Callas also supports remote IoT devices reprogramming, a feature that is the first step to support ad-hoc changes [21] in the parts of business processes that define IoT behaviour.

This paper is organised as follows. Section 2 presents the related work, while section 3 describes our proposal to model IoT behaviour within BPMN business processes and how we translate it to Callas source code. Finally, section 4 concludes the paper and hints for future work directions.

2. Related work

Business modellers define business processes with languages such as Web Services Business Process Execution Language (WS-BPEL) [18] or BPMN, which use an abstraction level closer to the domain being specified. At this level, modellers should not deal with IoT devices heterogeneity and specificities: IoT devices use different operating systems (e.g., TinyOS, Contiki [8]), different programming languages (e.g., nesC [10], Protothreads), and different communication protocols. Traditionally, web services are used to provide IoT information and functionalities, abstracting and encapsulating low-level details. More recent approaches take a step forward by supporting IoT behaviour definition within the business process [5, 16].

Zen, Guo and Cheng survey two approaches to implement IoT web services [24]. Some works provide web services directly in IoT devices: they simplify, adapt, and optimize Service-Oriented Architecture (SOA) tools and standards
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