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Requirements Analysis for Context-oriented Systems

Manuele Kirsch-Pinheiro*, Raúl Mazo, Carine Souveyet, Danillo Sprovieri

Centre de Recherche en Informatique, Université Paris 1 Panthéon Sorbonne, 90 rue Tolbiac, Paris 75013, France

Abstract

Context-oriented systems are systems that observe and handle context information from the environment to guide their own behavior. Engineering such systems represents a complex task not only due to their complexity, but also due to the notion of context. Handling this notion involves tackling several challenges, demanding to system designers a certain knowledge and expertise about this notion. In order to help designers on this engineering process, we propose in this paper a roadmap on context management and a requirements elicitation process. This roadmap aims at sharing with non-expert designers the necessary expertise on context management allowing them to better understand the notion of context and its challenges. The elicitation process aims at guiding these non-expert designers across the roadmap, supporting them in their requirements elicitation process concerning context management. The proposal is presented on a running example that illustrates the approach.

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1. Introduction

The notion of context corresponds to a large concept that has been explored in many different ways and systems[1,2,3,4]. These systems, which we can call "context-oriented systems", have reached different levels of maturity in the way they consider the notion of context. Context-oriented systems are often distributed and composed of embedded systems, control systems, real-time systems, physical systems, and network and communication systems. They are seen in various application domains including irrigation, telecommunication (networks and communication devices like sensors and smartphones) and online-shopping. These systems have in common the need to be capable to run continuously under changing conditions. For instance, the price/furnisher of components can change, the requirements and deployment conditions (temperature, bandwidth, etc.) permanently change, and partial failures of

* Corresponding author. Tel.: +33 1 44 07 86 34.
E-mail address: Manuele.Kirsch-Pinheiro@univ-paris1.fr

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subsystems can arise. To compare with traditional systems, systems that are able to respond to context changes are more complex in terms of increasing modularity, functionality, integration and interoperability, growing importance and reliance on software, and increasing number of non-functional constraints (e.g., robustness, scalability).

The ability to manage the execution context of an application is largely required in various application domains. Qualities of systems such as *flexibility, dynamicity, modularity and extensibility,* are difficult to satisfy with *ad-hoc development* processes. Various research works exist for handling context and for separating the infrastructure from the application with context-oriented middleware. However, it is difficult to have a *global vision or a large expertise on context management* because these works come from various research domains, each of them promotes a specific view and treatment of the notion of context. It is then particularly difficult to identify the relevant requirements about context management for a specific system in various application domains by a non-expert.

The purpose of this paper are (1) to propose a roadmap on context management in order to share expertise on this topic and (2) to exploit it during the requirements elicitation process in order to support the identification of the relevant requirements on context management for a given system.

This paper is organised as follows: Section 2 introduces a running example that illustrates the complexity of engineering context-oriented systems. Section 3 exposes the roadmap. Section 4 shows its exploitation during the requirements elicitation process applied on the running example. Section 5 discusses results and conclusions.

2. Motivating example

The concepts presented in this paper are considered within the flood-warning scenario proposed by Hughes et al.[5]. That scenario, called GridStix, considers a Wireless Sensor Network (WSN) deployed on the Rivers Ribble and Dee in England and Wales, respectively, as shown in Fig. 1. The WSN is used for collecting data from the physical environment through a network of sensors that communicate by means of a wired telecommunication infrastructure and without access to fixed power supplier. Each GridStix node consists of depth and flow sensors where power for these devices is supplied by batteries, replenished by solar panels. Nodes are equipped with both 802.11b (Wi-Fi) and Bluetooth communications for inter-node data transmission, with a single GSM uplink node.

A stochastic model predicts flooding according to the information sensed by each active node. In addition to the different transmission and data collecting modes of each node, they can be activated or deactivated according to the power level of the corresponding battery and the state of the river. The model's accuracy is a function of the number and distribution of nodes contributing sensor data and of the resources committed to processing the data. WSN designers need to make assumptions about the QoS that will be achieved by deployed components. For example, "the terrain, weather and other factors affect radio signal propagation, which in turn can affect QoS properties such as resilience. This is a key point; that systems and their environment do not always behave as expected and self-adaptation is a means to tolerate the unexpected"[6].

Fig. 1. A GridStix node next to the River Ribble, taken from Sawyer et al.[6]

For supporting dynamic adaptation of the configuration of the WSNs, each system should be aware of changes in its context and responds in a reactive and proactive manner. For engineering these kinds of systems it is necessary to specify adaptation policies that state the actions required to adapt the running system to a configuration that better fits not just its current context but sometimes the future context for the proactive adaptations. In order to do so, the occurrence of context changes (e.g. the low level of a battery) should be predicted to allow the system to change