Chapter 46
A Multi-Loop Development Process for a Wearable Computing System in Autonomous Logistics

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ABSTRACT

The chapter examines a multi-loop development process for a wearable computing system within a new paradigm in logistic applications. The implementation of this system will be demonstrated by an example from the field of autonomous logistics for automobile logistics. The development process is depicted from selecting and combining hardware through to the adjustment to both user and operative environment. Further, this chapter discusses critical success factors like robustness and flexibility. The objective is to present problems and challenges as well as a possible approach to cope with them.

INTRODUCTION

The use and development of mobile technologies was continuously accelerated during the last years. Especially in logistics, the application of new and innovative techniques has opened new perspectives for handling fast dynamic and complex markets. Based on the increasing number of corresponding hardware implementations, new process models, methods and approaches in logistics were introduced. In terms of planning and control of logistic processes, decentral concepts like autonomous control were investigated in

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science and industry. The idea and paradigm of autonomous control for example, is mostly built on the interaction of independent logistic objects, like storage areas, packages, containers, transport vehicles and human participants. Equipped with mobile devices for data acquisition and exchange, the logistic objects act autonomously according to their specific tasks and objectives. On the one hand, the shift from the established centralized control approaches to new control methods of logistic processes like autonomous control needs the development of robust and flexible mobile systems. On the other hand, the huge amount of available hardware components requires an accurate decision-making, which components are applicable to realize the needed requirements. Typically, the most difficulties arise during the realisation of such (mobile) systems.

As mentioned, mobile computing is connected with a fast adoption of new and efficient technologies Established product development approaches are often not flexible enough to meet the special requirements in this field. This is even more the case, when the computing system should not only be mobile but wearable. This special form of mobile technology is highly customized and subject to particular regulations due to the direct integration in work clothes. The dependence to the target process further leads to a high demand for adaptability during the whole innovation procedure. Therefore, the innovation and design process for those wearable systems is an important subject in today's research (Rügge, Ruthenbeck, & Scholz-Reiter, 2009). This chapter highlights the specifics in development and application of wearable systems. Well-known product development processes are discussed. Then a new control strategy for decentralized controlled logistic objects is introduced, followed by an examination of the general characteristics and requirements of wearable solutions as well as a software related concept for wearable computing. The special potential of wearable techniques for implementing autonomous proceedings is outlined. Afterwards the concept of a multi-loop development process for realizing wearable devices is introduced and further explained with a practical appliance in autonomous logistics.

THE PRODUCT DEVELOPMENT PROCESS

To stay competitive in today`s complex and fast changing markets, developing new and innovative products has become more and more important. Accordingly, the process of planning and constructing these products is a central research topic (Rügge, Ruthenbeck, & Scholz-Reiter, 2009). Varied concepts for product innovation have been developed, differing in their range within the innovation process and the products they can be applied to. In literature, those concepts are often roughly divided into heavyweight and lightweight models (Pomberger, 2006). The differentiation is made by the degree the processes are formalized. Most heavyweight models are descriptive and phase-oriented, which means they consider the design of innovations as a sequence of steps. This leads to less flexibility, as there are little possibilities given to cope with changing demands and requirements. The *Waterfall Model* (Royce, 1970) and the *Stage-Gate-Model* (Cooper, 2001) are typical exponents of heavyweight approaches. On the other hand, the *Spiral Model* (Boehm, 1988) can be seen as a lightweight approach. Lightweight approaches are less formalized and therefore more flexible than heavyweight approaches (Pomberger, 2006). Hybrid forms like the so-called "*V-Model*" (Boehm, 1979) and the *Pyramid Model* (Ehrlenspiel, 2009) combine properties of both. In the following the approaches are sketched.

The *Waterfall Model* was introduced by Royce in 1970 for developing large software systems. Royce defined a chain of single closed steps, leading from the requirements to the application of the product for the customer. Here, iteration is mainly intended between back-to-back sequences