Conceptual Design of an Engineering Model for Product and Plant Automation

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Abstract. Common engineering approaches and modelling approaches from software engineering are brought together. For the domain of process automation, i.e. product and plant automation, an implementation oriented approach for an object oriented software development for heterogeneous distributed systems is introduced. Model elements for control are added to UML as well as small-scale patterns for plant automation. Besides large-scale patterns are introduced as well as implementational models. The adoption of UML regarding applied diagrams and stereotypes for process automation will be introduced and structured components, an idiom for product automation software development, will be compared to other software engineering notations.

1 Introduction

Engineering approaches from the domain of engineering will be merged with advancements in modelling from software engineering. On the one hand process automation traditionally has focussed on implementation issues and on the other hand computer science has neglected the application domain to some extend by focussing on embedded systems in automotive and avionics.

Software development in process automation (plant and product automation) has many deficiencies in procedures, notations and tool support. As a result, modern software engineering concepts and notations, like object oriented approaches or UML, are not wide spread in this field. Hence, drawbacks regarding start-up times, additional costs and low software quality are immense. This paper will derive a draft for an object oriented approach for this domain focussing on implementation aspects. This approach includes UML stereotypes. Besides, constraints for real time applications are necessary. For embedded systems, an implementation oriented approach will be discussed with restrictions of the object oriented constructs to meet constraints in storage and timing.

2 Characteristics and Requirements of Embedded Systems

The general requirements of embedded systems in process automation will be discussed. According to [1] embedded systems are automation (computer) systems,
which are integrated into a technical process. With this definition, every computer system ranging from tiny microcontroller units up to powerful multiprocessor servers is an embedded system as long it is integrated into a technical process. Examples for embedded systems in product automation are electric razors, washing machines or digitally programmed machine-tools as well as plant automation systems.

In product and plant automation embedded systems are used, which differ from standard (industrial) PCs. It is examined what has to be considered when designing software for embedded systems. In [2] embedded systems are characterized by

- the environment they work in,
- the performance expected of them, and
- the interfaces to the outside world.

This article will only consider environment and performance of embedded systems, because they determine the constraints to software for these systems. An important aspect of the environment of an embedded system is the size and weight admitted to the system. For product automation system engineers, these can be the crucial issue to deal with. These factors are also limiting factors to software design, because they may result in only very few memory and very low computational performance of the device to use. Figure 1 shows the general purpose computing elements of embedded systems. Opposed to general purpose elements, there are also specialized computing elements (e.g. digital signal processors, mixed signal processors, or special system-on-chip designs), which are not covered by this paper.

**Fig. 1.** General purpose computing elements of embedded systems

An overview of requirements of process automation is listed in table 1. The criteria can be structured regarding process requirements, automation system architecture, and project. In process automation, different kinds of processes are possible. In the following, a brief overview of those categories is given. A process automation system represents a type of process, e.g. batch, continuous, or discrete. Sometimes processes are composed of different process types. They are called hybrid, due to the fact, that they consist of different process kinds. These process types require different control strategies (closed and open loop control) and by that they require different modelling notation features, e.g. block diagrams or state charts.

In addition overall requirements are real time requirements, including timers, the integration of I/O peripherals directly via a backplane bus system or a field bus, interrupts from the process and the necessity to describe the automation architecture