ISA Transactions 53 (2014) 1404–1409

Contents lists available at ScienceDirect

ISA Transactions

journal homepage: www.elsevier.com/locate/isatrans

# On the engineering design for systematic integration of agent-orientation in industrial automation

Liyong Yu, Andreas Schüller*, Ulrich Epple

*Chair of Process Control Engineering, RWTH Aachen University, 52064 Aachen, Germany*

ARTICLE INFO

*Article history:*
Received 19 July 2013
Received in revised form
17 December 2013
Accepted 24 December 2013
Available online 14 January 2014
This paper was recommended for publication by Dr. Q.-G. Wang

*Keywords:*
Agent-orientation
Industrial automation
IEC 61131-3

ABSTRACT

In today's automation industry, agent-oriented development of system functionalities appears to have a great potential for increasing autonomy and flexibility of complex operations, while lowering the workload of users. In this paper, we present a reference model for the harmonious and systematical integration of agent-orientation in industrial automation. Considering compatibility with existing automation systems and best practice, this model combines advantages of function block technology, service orientation and native description methods from the automation standard IEC 61131-3. This approach can be applied as a guideline for the engineering design of future agent-oriented automation systems.

© 2014 ISA. Published by Elsevier Ltd. All rights reserved.

## 1. Introduction

With increasing complexity of automation systems, improving engineering methods consequently becomes a task that system designers must face. While decentralized networks are expanding more quickly, the diversity of functionalities and information processing is also rising. Furthermore, decentralized functionalities should be managed in a more integrated and flexible manner in order to keep up with market changes and ever shorter product life cycles. In conventional automation where component-orientation and object-orientation are generally applied, software modules react passively. They can merely perform predetermined operations in an inflexible manner. Collaboration and interaction among modules should be coordinated by users. Due to high engineering workload, traditional technology used in industrial automation is gradually developing towards its limits.

In this circumstance, multi-agent systems (MASs) appear to be a feasible approach for effective and flexible management of automation functionalities. MAS originates from distributed artificial intelligence (DAI), and is a central and rapidly maturing paradigm in computer science. Many researchers even refer to MAS as the dominant approach in future software engineering. Agent-orientation has shown significant potential in various particular automation domains, e.g. energy management [1], production scheduling [2], embodiment of product design [3], and reconfiguration of faulty field devices [4]. An overview together with a brief evaluation of the ongoing work in this area is illustrated in [5]. Elementary software modules of MAS are agents which are encapsulated with specified objectives and autonomous goal-achieving abilities. By using their local knowledge base, single agents can correctly evaluate the environment, and actively find proper solutions within a permitted scope of action. Besides manual administration, agents can automatically set up dynamical collaborations, and solve complex tasks through mutual coordination and services. Together with the intelligent support of agents, complex tasks can be solved more efficiently and flexibly.

In comparison with common application fields of agent-orientation, e.g. e-business, telecommunication, logistics and remote education, industrial automation has higher requirements on engineering design. In addition to normal use of encapsulated functionalities provided by agents, users are also actively involved in developing automation agents. For instance, users should re-engineer the operation procedure of a "start-up agent" when the plant requires an alternative start-up. Criteria and algorithms of an "energy optimization agent" should also be defined in detail by the users. Due to role crossing and overlapping of the user and developer, MAS must be defined in an open manner to support manual engineering. More specifically, MAS as well as single agents should allow exploration, optimization and extension during the operation phase.

Engineering of automation agents involves multiple concrete design-decisions like description methods for modelling and

* Corresponding author. Tel.: +49 241 80 97703.
*E-mail addresses:* yu@plt.rwth-aachen.de (L. Yu), a.schueller@plt.rwth-aachen.de (A. Schüller), epple@plt.rwth-aachen.de (U. Epple).

0019-0578/$ - see front matter © 2014 ISA. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.isatra.2013.12.029

implementation, communication solutions, user-friendly operability, etc. After decades of development, industrial automation has established an ecosystem that is composed of application characteristics, standards for functional description and communication, best practice for development and engineering, system architecture (software and hardware), etc. By making design decisions, compatibility with existing automation ecosystem must be sufficiently taken into account. The chemical and metallurgical plants have an operational life span of multiple decades. Considering the technological sustainability and maintainability, novel paradigms and description methods are usually not preferred. In this case, common MASs using Java are not yet acclimatized.

This paper presents a reference model for automation agents with the goal of systematical integration of agent-orientation in industrial automation. This model is built on base of function block technology. The classic function blocks are extended with special interfaces, so that service oriented interactions can be supported. Furthermore, native description methods from the automation standard IEC 61131-3 [6] are applied to design the internal structure of agents in a modular and transparent manner. On this base, agents for specific application domains can be harmoniously embedded into the existing automation ecosystem. Furthermore, they can be flexibly engineered by their users.

The following discussions are divided into five parts: Section 2 introduces advantages of widespread adoptions of agent-orientation in industrial automation. In Section 3, the key aspects of engineering design are analysed, while the reference model is presented in Section 4. An overview of ongoing and future work in Section 5 concludes this paper.

## 2. Agents in industrial automation

Fig. 1 shows possible application domains of agent-orientation in automation technology. Learning about the characteristics of applications supports the decision-making of engineering design. In general, applying agent-orientation can significantly improve the usability of automation systems and their capability of solving complex tasks. Specific improvements will be discussed in the subsequent section.

### 2.1. Qualitative upgrade of automation

Manual and automatic operations often contradict each other in practical use. Most automatic functionalities are developed for the use in certain situations. When the actual execution differs from the ideal setting, automatic operations cannot always achieve their goals. As a result, in many cases, users prefer to shut down automatisms and operate manually. The rigid design of functionalities is becoming a development bottleneck of high-level automatisms in many application domains like:

- start-up and shut-down processes of plants,
- engineering of large-scale software applications for process control systems and manufacturing execution systems (MESs),
- product transport in complex plants.

However, agents can become intelligent partners rather than rivals for users. Users delegate operation tasks to agents with no need to specify all execution details. Agents can sense their environment, take appropriate actions in unplanned or critical situations, solve problems or look actively for alternative solutions. For instance, an archive agent can be hired, when a process value needs to be archived. The search for a storage data base, the configuration of network communication, and the treatment of breakdown of communication can be performed in an autonomous manner. Agent-orientation can be seen as a trigger for qualitative upgrading automation from rigidity to intelligence.

### 2.2. Unification of standard services

Different automation applications often request similar functionalities like reporting, alarming and archiving. These common functionalities are available on different automation layers like the process control or the MES layer. However, installations in different systems often request different operation principles and different formats of information exchange. Considering agent-orientation, special agents can be hired on any client terminal. They provide the required functionalities as standard services by supervising the interaction between client and target server. The afore-mentioned archive agent is a typical agent for standard service. Agent-orientation creates a flexible and simple access to standard functionalities across the border of systems and automation layers, while the standard services can be reused by developing new functionalities and systems.

### 2.3. Improvement of flexibility

In conventional automation, functional software modules are closely coupled by fixed signal connections. All possible module cooperations need to be predefined, before the plant starts its

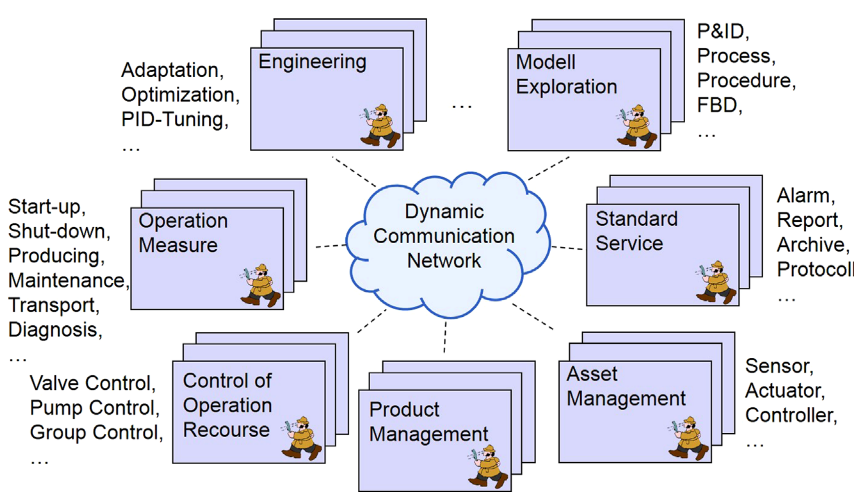


**Fig. 1.** Automation agents.

Download English Version:

https://daneshyari.com/en/article/5004703

Download Persian Version:

https://daneshyari.com/article/5004703

Daneshyari.com