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Towards a socio-inspired multiagent approach for new generation of product life cycle management

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Abstract

The main goal of this paper is to describe new integrated methodology: Agent-based Reconfigurable Generic Organzation. This is an integrated approach which allows designing future product life cycle organizations as a class of learning, self-learning or adaptive distributed systems using high-level, sign-based communications across entire product life cycle environment named Product Related Semiosphere (PRS). The definition of PRS is a fundamental question of developing a new class of distributed semiotic systems with ability to communicate, identify and manufacture engineering artifacts with prescriptive characteristics.

The paper analyses different types of product life cycle management approaches and suggests overall approach for integration of business and engineering knowledge during the whole product life-cycles. It allows to understand the interrelationships of different life-cycle stages for acquiring and manipulating concurrent engineering knowledge. The authors proposed the idea of using socio-inspired framework based on applied semiotics and distributed artificial intelligence.

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1 Introduction

One of the most ambitious projects of German Government in the area of future manufacturing is Industry 4.0. As part of the long term strategy, the development of new generation of cyber-physical systems, M2M communications based on real data analysis, cloud based engineering [1] and manufacturing environments are amongst the expected achievements of the project. Despite the positive results of the project so far, significant barriers remain, including technical complexity, soft (human) factors consideration, inconsistency in describing of business processes, integration aspects with corporate information systems, etc.

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As a result, a question of development the comprehensive framework for autonomous, intelligent decision-making which will use an integrated business and engineering data supporting future product life cycle management [2] remains open. On the other hand, the increasing requirements for products quality and fluctuations in customer demand, as well as dynamic competition impose significant requirements on the ability of manufacturers to provide customers with products in the required quantity and for competitive price [2, 3].

Typically the high value products and infrastructure are technology intensive, expensive and reliability-critical requiring engineering services, such as maintenance support throughout the life cycle. The future product life cycle management should provide strong new level integration of product development stages based on socio-supportive level of communication between designers, manufacturers, intelligent software, M2M shop floor communication, etc [4, 5]. Through-life [6] engineering is an emerging area of development, which needs new approaches for supporting communications across entire product life cycle environment.

Also the Smart Industry, a key trend in manufacturing – is the ability of machines and devices to be self-organized, to communicate independently with each other and to provide agile and adaptive design and manufacturing environment. One of the main ideas proposed in this paper is a new approach of vertical integration of the engineering design, manufacturing and planning systems using self/semi adaptive and organized entities.

Furthermore, development of this approach is strongly associated with cyber-physical systems that integrate social and production systems. Existing formalisms (as complex systems approach) is not sufficient to model such systems [7].

It is obvious that the ability to expand the capabilities of the physical world through computation, communication and control is a key enabler for future technology developments. This paper proposes a framework for developing robust through-cycle engineering systems. This framework consists of several key features:

- Multiagent-systems approach
- Semiotics approach to organize communication across engineering and service environment
- Built-in agent-based modelling

1.1 Multiagent-systems approach

Multiagent architecture of the system is presented on 1. There are many approaches to use agents for design and manufacturing [8, 7, 9]. Using agents enables building self-organizing flexible systems. The main benefits of multiagent systems are their decentralization and simplicity of development of agents, the opportunity to use different type of agents such as reactive, cognitive, with hybrid architecture, such as embedded soft computing algorithms [7, 10], etc. Characteristics of entire system depends on characteristics of a single agent. Therefore, various architectures of agent were developed. We can develop agent's architecture that meets requirements of the system for different purposes and system levels .

One of the most appropriate technologies for developing large complex distributed systems is multiagent concept. One of the main benefits of multiagent systems is their decentralization and simplicity of development of the agents. Also synergetic effect of such systems can be achieved. Agents, responsible for small simple parts of the system with negotiation with each other, can