Chapter 51
Evolvable Production Systems:
A Coalition-Based Production Approach

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ABSTRACT

The purpose of this chapter is to provide broad view of the rationale, fundamental principles, current developments and applications for Evolvable Production Systems (EPS). Special attention is given to how complexity is handled, the use of agent based and wireless technology, and how economical issues are affected by having an evolvable system.

The rationale for EPS is based on current road mapping efforts, which have clearly underlined that true industrial sustainability requires far higher levels of system autonomy and adaptivity than what can be achieved within current production system paradigms. Since its inception in 2002 as a next generation of production systems, the EPS concept has been further developed and tested to emerge as a production system paradigm with technological solutions and mechanisms that support sustainability. Technically, EPS is based on the idea of using several re-configurable, process-oriented, agent-based and wireless intelligent modules of low granularity. This allows for a continuous adaption and evolution of the production system and the ability to explore emergent behavior of the system, which are imperative to remain fit with regards to the system environment.

INTRODUCTION

To obtain sustainability, an organism, organization, or system must align itself with its environment. For a company this means that it has to position its internal capabilities and capacity with regards to its competitors and customers, and naturally to the laws and regulations it is governed by. This act of positioning is a dynamical one, i.e. both the environment and the company are constantly changing, which means that a company's fitness with regards to its environment must continuously

DOI: 10.4018/978-1-60960-042-6.ch051

be assessed in order to remain fit. The process can in its simplest form be seen as an iterative Observe-Orient-Decide-Act loop: (1) observe both the environment and the internal processes and states, (2) assessed the internal and external possibilities, (3) decide what to do, (4) act on the previously made decisions, (5) observe the effects of the actions, et cetera. A company must continuously observe and orient itself and its environment to know what to do, weather it is internal or external.

Logically there are two ways to remain fit, either by internal alterations to the company and its internal subsystems, or by altering the environment, e.g. through marketing, purchasing and selling of companies, creation of new markets. The internal alterations are a key purpose for much of the manufacturing system toy, while the external alterations to the environment, although strongly interrelated, mainly belong to other scientific areas such as economics and marketing. The day to day work for production engineers is focused either on maintaining status quo in production or on aligning the production system to the changes that occur in its environment. For rigid systems and systems that operate in a non-dynamic environment, the difficulty of maintaining the status quo of the system is dependent on the complexity of the task that should be performed, which is strongly related to the internal complexity of the system. For dynamic systems that operate in a dynamic environment, the complexity is both related to the internal complexity of the system and the complexity of the environment.

Since the environment of production systems is becoming more and more dynamic with shorter product life-cycles and increased demands for customization, the production systems themselves must be able to answer to these requirements. There is consequently little room left for rigid manufacturing systems, and a strong demand for sustainable and adaptive production system that can change in accordance with its environment. As a result, the new generation of production systems must be able to handle the additional environmental complexity. This, in addition to the internal complexity, will challenge our already strained ability to handle system complexity, and may require a radically new structure for design and operation of production systems.

There is a strong correlation between complexity and cost, which means that the initial cost for a sustainable production system is more expensive than for more rigid system. In turn, this means that the payback for a rigid system will be shorter as long as the system does not become obsolete before it breaks even. However, the long term profitability of a system is decided by more parameters than the initial cost; key issues include for example the dynamical fit between the system and its environment; system set-up, implementation, maintenance and change over time. It is therefore imperative to advance the assessment of long term profitability of a sustainable production system to facilitate their implementation in a competitive industrial environment.

BACKGROUND

Problem Description

The root of key problems for manufacturing companies is complexity. Complexity is here strongly related to uncertainty and measured as the number of possible system states, i.e. the more variables there are in a system the more complex the system is. The complexity is also related to each variable, e.g. if it is linear, non-linear, true/false; which strongly affects the uncertainty of the system. In other words, this means that the complexity of a system is related to the number of possible system states, which doubles for each additional variable in a fully coupled system. This definition of complexity provides a transparent understanding of how the complexity increases in a system, but also some insight into how complexity can be dealt with.