

Software Agent Based Monitoring for a Micro Milling Spindle

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Abstract

The idea of Industrial Product-Service Systems (IPS²) describes an innovative approach to meet the increasing customer demand for complete solutions instead of just buying the tangible product. IPS² are characterized by the integrated and mutually determined planning, development, provision, and use of product and service shares including their immanent software components [1].

Guaranteed availability of production systems is one of the strongly upcoming customer requirements that providers of capital goods have to face. To implement such an offer, machine manufacturers have to be aware of changing machine condition at any time. The authors present a concept of an availability oriented IPS² based on condition monitoring and software agents as key enabling technologies. Furthermore a prototypical realization of this concept for monitoring the condition of a micro milling spindle is given in this paper.

1 Introduction

In time of global markets, manufacturer of industrial goods have to introduce new business models that go beyond the traditional concept of just selling the tangible product and offering optional services. In recent years methods like Total Cost of Ownership and Life Cycle Costing became popular to estimate the actual costs of production systems during their use phase. To reduce these costs, non-productive activities like maintenance and repair have to be avoided. Therefore, the above mentioned new business models should focus on the availability of machine tools to fulfill this customer need. Especially in the field of micro manufacturing wear and tear of stressed core components may lead very fast to deterioration of accuracy and therewith to unacceptable product quality. Due to the special know-how needed for

technical service of micro production systems, the implementation of suitable supporting systems is a prerequisite to establish an availability oriented business model where product and service shares are integral parts of IPS².

The idea of an availability oriented IPS² is that the provider of the IPS² guarantees the technical availability of core components of a machine tool. He takes the full responsibility for all activities needed to maintain or repair these components. Therefore he has to continuously observe the condition of the components and to ensure fast reaction time in case of needed service measures.

2 Conceptual Design

In the first step of conceptual design the main roles involved in the process of ensuring technical availability and their interactions have to be defined. The *production system* degrades over time due to wear and tear. To avoid premature machine breakdown and to expand service life, well-timed maintenance is needed. A condition monitoring system is applied to it for early detection of degradation. Furthermore the production system has to be able to notify the IPS² provider in case of needed service. In an availability oriented IPS² the *IPS² provider* takes full responsibility for guaranteed availability. He acts as central communication node and coordinates all activities to ensure the guaranteed availability. The *customer* is the owner the production system. He provides staff to operate the production system. He is reliant on the availability of the production system. *Service suppliers* may act as sub-contractors within the IPS² network if technical service is not a core competence of the IPS² provider. They are authorized by the IPS² provider to carry out service processes.

As the above description shows, every object involved in IPS² operation has defined tasks and interactions. Based on a multi software agent system, these tasks can be supported and controlled by its high potentials within automated communication and autonomous action. Therefore it seems to be suitable to represent them by software agents. Each software agent has specific aims and an implemented behavior to achieve these aims. The principle communication architecture of an availability oriented IPS² is shown in Figure 1.

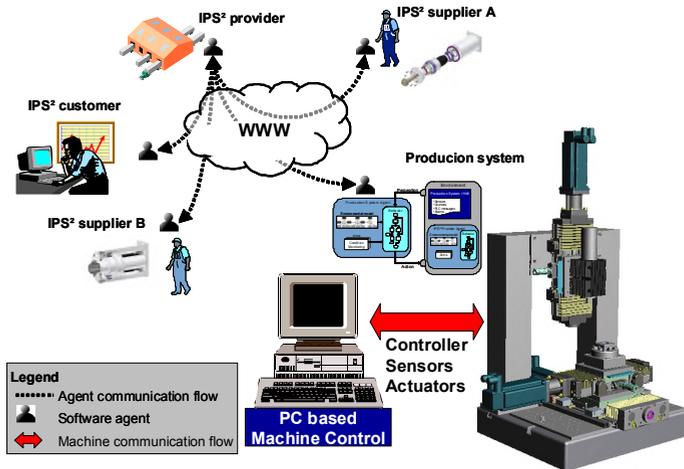


Figure 1: Roles and communication flow in an availability oriented IPS²

2 Scenario

The interaction of the software agents is shown within the following scenario. In this scenario a micro milling spindle, which is a core component of a milling machine, is equipped with sensors for condition monitoring according to [2]. A condition monitoring software agent (CMSA) collects and analyzes condition relevant data during the spindle's life cycle. Based on an implemented set of inference rules the agent detects critical trends of the condition of function relevant components, e.g. bearings or stator winding. When a critical trend is detected, the CMSA calculates the remaining time until an alarm limit will be exceeded. This information will be send by the agent to the IPS² network management software agent (NMSA), which is located on a server at the site of the IPS² provider. If available, more detailed information can be attached to the message, e. g. kind of expected failure. The NMSA then chooses the service supplier from a list that fits best regarding time, cost and quality and starts negotiation with its virtual representative, the service management software agent (SMSA). After contracting a service technician software agent (STSA) is initialized to control the actual service process. The STSA monitors the service process and to adapt correcting-variables if the actual process workflow differs from the planned one. Figure 2 shows an excerpt of the communication flows of this scenario in the style of an UML sequence diagram.

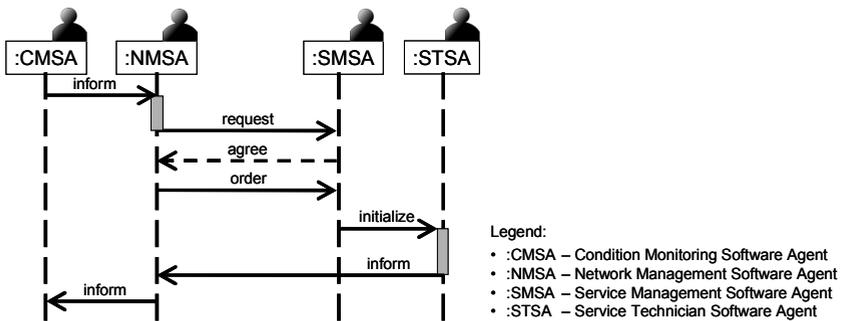


Figure 2: Principal sequence diagram of the scenario (excerpt)

3 Conclusion

Availability oriented IPS² business models aim at assuring availability of production systems. This implies that all availability related responsibilities shift from customer to provider site. Therefore, for the IPS² provider it is of great eminence to continuously monitor the condition of the system and to implement a strategy that takes into account product as well as service shares in an integrated manner. All objects involved in the process of assuring availability are represented by software agents. Thereby the implemented behavior of each software agent depends on its specific role. Their ability to perceive their environment, to communicate with other agents and to actively influence physical objects enables interactions between even distributed product and service shares and therewith the efficient operation of IPS².

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References:

- [1] Meier, H., Uhlmann, E., Kortmann, D.: Product service systems. In: wt-online 7/8-2005, 2005, pp. 528 – 532.
- [2] N. N.: Spindle Data Logging Unit. Installation guide and user manual. Walter Dittel GmbH, 2007.