IDEAS Newsletter #1

Editorial

Dear Reader,

We are glad to present you the first issue of the IDEAS news-letter.

IDEAS is a European project founded under the scope of the Seventh Framework Programme (FP7). The vision of IDEAS is to develop and to enable:

- Intelligent, self-configuring modules with advanced interfaces that enable social and emergence exchanges,
- Self-organising coalitions (functional clusters of equipment),
- Evolvable systems that self-diagnose and adapt to emergent behaviour,
- Modules developed on the basis of precise assembly process constraints,
- Highly distributed, dynamic control systems at both shop floor and systems levels.

In the first year of our project we were able to show the concept of pluggability (change the process unit configuration of the system), while we realized the pre-demonstrator. We could implement a multi-agent system in an existing and enclosed production environment with well-defined interfaces. The idea of the IDEAS concept could be transported with the pre-demonstrator. The next step is realising an industrial demonstrator.

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Content

www.ideas-project.eu

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SEVENTH FRAMEWORK PROGRAMME

IDEAS Mechatronic Multiagent Architecture (IMMA)

The IDEAS architecture explores the multiagent system paradigm applied to mechatronic components to introduce some unique features of self-organizing systems in production (figure 1).

To promote self-organization the IDEAS architecture relies in a set of generic mechatronic agents whose interactions ensure that their individual functions are decoupled. These agents foster group dynamics so that the individual contributions can be combined in order to implement, refine and adapt processes due to changing production requirements.

The IDEAS Mechatronic Multiagent Architecture (IMMA) is supported by four main agent classes: machine resource agent (MRA), coalition leader agent (CLA), transportation unit agent (TUA) and agent to machine interface (AMI). To achieve a coherent self-organizing response it is fundamental to ensure that the main architectural components are designed that way, when put together, the number of possible interactions is limited and the self-organizing response of the system fulfils its design goals. Conceptually the agents in figure 1 are extensions of the mechatronic agent (MA) concept that gathers the main descriptive attributes of all types of agents in the system. In this context, it provides the adequate support to ensure generic semantic interoperability including the following aspects:

Functionality Representation - Agents offer their functionalities as skills. The skill concept provides a method to describe the work flow executed by an agent. This includes the interaction with other agents towards the negotiation and execution of other skills or low level interfacing with system libraries.

Yellow Pages Service Interaction - the MA provides the data representation that describes each agent in respect to the hosted and available functionalities. This description can be made public.

Messaging - the MA implements two FIPA communication protocols: the FIPA Protocol Request for direct interaction during skill execution and the FIPA Contract Net for skill execution negotiation.

OMAC state - the MA harmonizes the agent state with the OMAC (organization for machine automation and control) state machine. It represents distinct machine states and covers different aspects and timings of the machine functioning.

The subsequent IMMA agents inherit and extend these basic behaviours so that different entities in the shop-floor can be supported and harmonized.

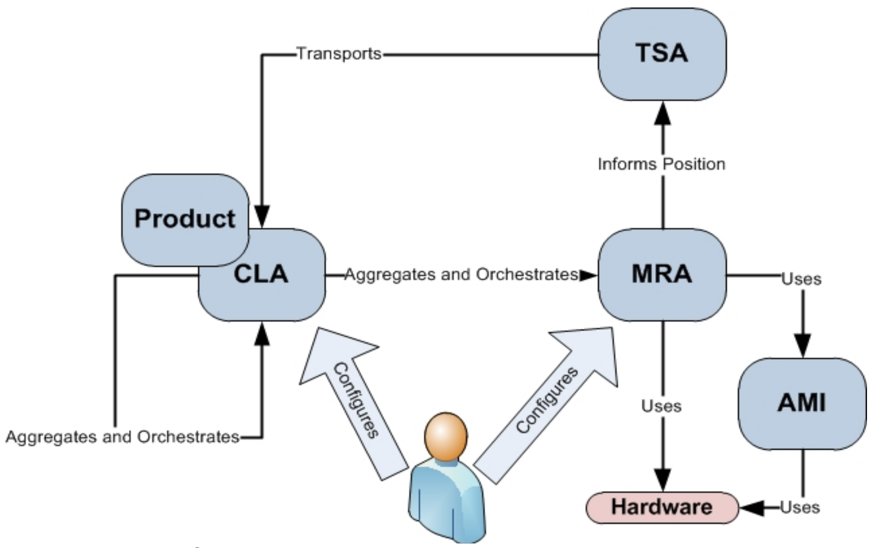

Figure 1: Main IDEAS agents and their relations

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First Running Platform: Pre-demonstrator

An important milestone of IDEAS was the completion of the Pre-demonstrator. The aim of the pre-demonstrator was to show, that a system, consisting of mechatronic agents, is working stable in an industrial environment. The pre-demonstrator was designed to present a first version of IDEAS multiagent system (MAS) in order to use it as a test bed for the MAS architecture to support the further development of the architecture. To save time it was decided to use an existing system from FESTO and integrate the multiagent system into that system. The selected system Miniprod (miniaturised production system) is a miniaturised production platform with pluggable process units and a flexible, two-dimensional transportation system (figure 2).

As controller platform the Combo200 a standard industrial PLC platform from ELREST was selected which is able to run JADE agents for the IDEAS MAS. Elrest further provided a library, which allows the JADE agents on the Combo200 to control the hardware I/O's of the controller directly.

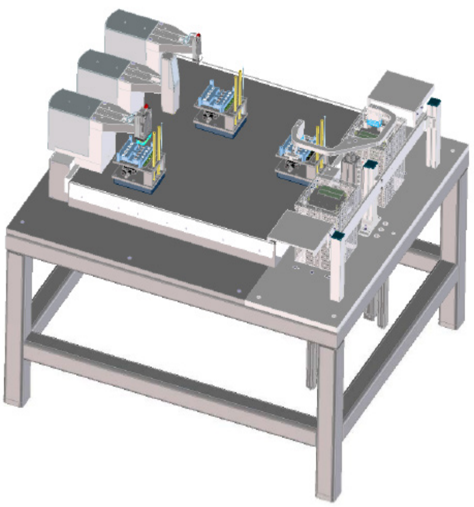

Figure 2: Design of the Miniprod platform

The multiagent architecture for the pre-demonstrator was developed by UNINOVA, Masmec, KTH, Elrest, University of Nottingham, KIT and FESTO. The agent state model was developed by Masmec and UNINOVA. Festo prepared the pre-demonstrator for the system integration and implemented the path planning agent and the PLC code for the pre-demonstrator transportation system. UNINOVA and KTH implemented the agents for the resources of the system and the agent user interface – an agent management system to control the multiagent system. This tool includes a graphical editor to prepare process work flow data by drag and drop. The single components of the system were put together in a final integration workshop in January 2011.

With the pre-demonstrator we were able to implement a multiagent system in an existing and enclosed production environment with well-defined interfaces. The system reacted automatically to changing conditions of the production system. Also the flexible usage of resources in the system needed to fulfil the process execution. Another conceptual point was a new way of engineering which is supposed to be one major outcome of the IDEAS concept: The pre-demonstrator was able to run production processes without any programming effort. Processes were prepared with the help of a graphical editor by drag and drop. The multiagent system then organized the execution of the process autonomously the process work flow data as the only input.

The outcome of the first demonstrator of IDEAS shows that usability of a concept like IDEAS in industrial applications is reachable and that soon we will be able to provide stable and innovative solutions for industrial customers.

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Industrial Demonstrator

To develop agents we use the platform JADE that provides basic middleware-layer functionalities which are independent of the specific application and which simplify the realization of distributed applications that exploit the software agent abstraction. A significant merit of JADE is that it implements this abstraction over a well-known object-oriented language, Java, providing a simple and friendly API. The LEAP (Lightweight Extensible Agent Platform) add-on, when combined with JADE, replaces some parts of the JADE kernel forming a modified runtime environment that we will identify as JADE-LEAP and that can be deployed on a wide range of small devices.

Obviously we can agentify everything but, increasing the granularity, for example realizing a complex system with more agentified modules (major number of elementary skills), the system performance could be bad for a high network bandwidth required and for major difficulties to synchronize all the agents (figure 3).

Each agent will have adaptive behaviour, so it can modify its job considering both environment conditions and the information exchanged with others agents. We put our attention on testing and diagnostic procedures. Testing focuses on fault detection. Diagnosis consists of determining the nature of a detected fault, locating and fixing it. We have decided to use "quantitative models based" algorithm based on Kalman filter (figure 4) and neural network. The main advantages of this method are that we can reduce the number of sensors, minimize the disturbance effects, and estimate the same

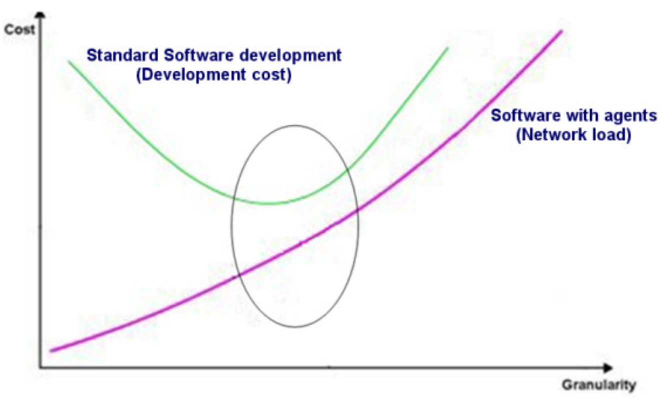

Figure 3: Software development costs versus system granularity

IDEAS Student Exchange

KIT, KTH, and UNINOVA have induced student exchange: three diploma students from Karlsruhe Institute of Technology (KIT) did their theses in the Royal Institute of Technology (KTH) and the Institute for the Development of New Technologies (UNINOVA).

IDEAS Student Projects

Various projects have been processed through the work of students. A great number of students conducted their theses within IDEAS. Interested students are welcome to apply to the respective project partner.

Kick-Off Meeting in Stockholm

in April 2010

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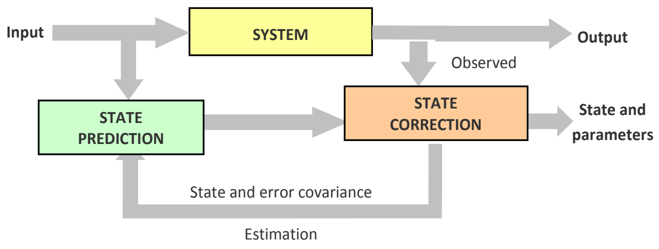
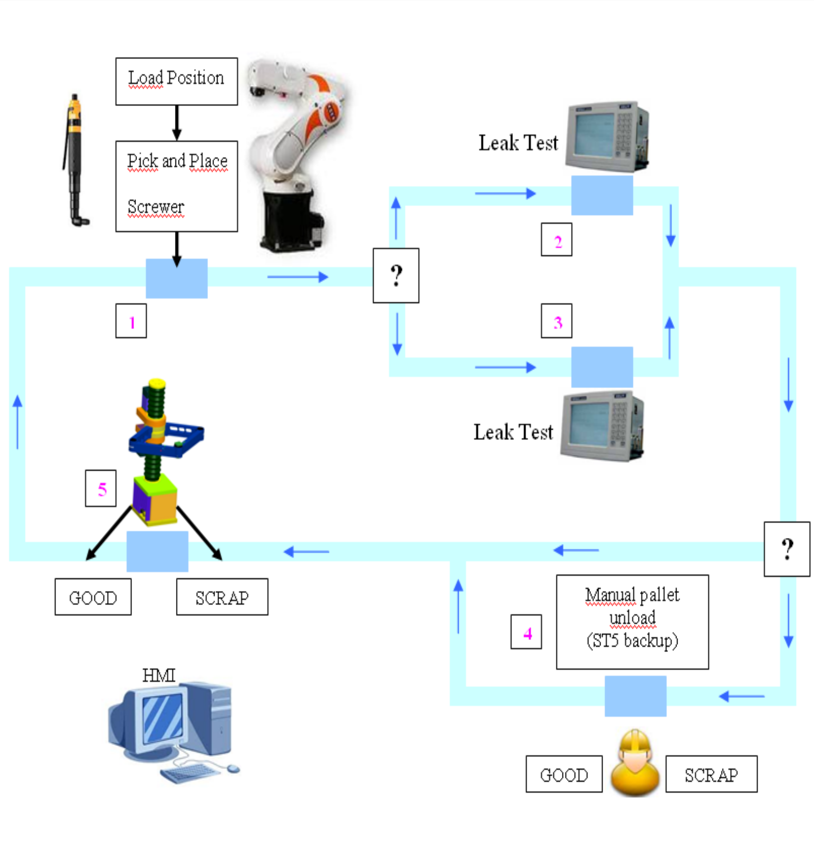


Figure 4: Standard Kalman state estimator

Masmec is developing a demonstrator (figure 5) to show the entire ideas concept from an industrial point of view. The demonstrator has a transportation line that transports pallets with memory tag which contain all the data related to the piece on it. The test case is given by CRF.

The concepts presented on the final demonstrator are:

- No need of written code for process design but only a simple workflow realization using a graphical tool
- Agentification of legacy modules (robot, screwed) and custom modules (SCARA, leak units) realizing a robust mechatronic agent architecture
- Adaptability and self-configuring concepts present during line production
- Use of simple and intuitive graphical interface (i.e. AUTOMATION ML editor) to configure an assembly line with DCS (Distributed Control System)
- Possibility to interface to other CAD/CAM tools using innovative XML standards (Automation ML) that uses COLLADA for 3D graphics and allows to interface with other XML standards



Station 1:
The operator loads the electronic unit with the already mounted but not tightened screws. The KUKA robot picks the unit with one gripper and places it under a screwdriver to tighten all screws. After the robot places the control unit on the pallet.

Station 2 and 3:
These stations perform leak tests directly on the pallet through a piston and a "Versa" device. Two stations are used to show the "plug and produce" philosophy.

Station 4:
This is a manual station. When station number 5 is out of order the pallet arrives in this manual station and the operator unload it. Red and green lights show the test results.

Station 5:
The MASMEC SCARA robot takes the finished piece and puts it in a good or scrap conveyor.

Figure 5: IDEAS final demonstrator plant and station operation

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IDEAS Project Partners

Royal Institute of Technology (KTH)
www.kth.se

Festo AG & Co. KG
www.festo.com

Institute for the Development of New Technologies (UNINOVA)

Electrolux Italia Spa., www.electrolux.com

University of Nottingham,
www.nottingham.ac.uk

Masmec SrL
www.masmec.org

Elrest Automationssysteme GmbH
www.elrest-gmbh.com

Teks sarl
www.teks.eu.com

Karlsruhe Institute of Technology (KIT)
www.kit.edu

Centro Richerca Fiat S.C.p.A (CRF)
www.crf.it

IDEAS Project at a Glance

Project title:	Instantly Deployable Evolvable Assembly Systems
Contract type:	Small or medium-scale focused research project CP-FP 246083-2
Coordinator:	Prof. Mauro Onori, KTH
Project status:	Execution
Project funding:	IDEAS is funded by the EU 7th framework program, nanosciences, nano-technologies, materials and new production technologies (NMP_2009_3.2.2 adaptive control systems for responsive factories)
Project start:	01/04/2010
Project end:	31/03/2013
Duration:	36 months

Organised IDEAS-Related Events

Special session at IECON 2011 37th annual conference of the IEEE industrial electronics society on "Evolvable production systems" November 7-10, 2011, Melbourne, Australia.

Special session at CARV 2011 4th international conference on changeable, agile, reconfigurable and virtual production on "Adaptability and emergence" October 2-5, 2011, Montreal, Canada.

For the full list of recent publications please visit our website www.ideas-project.eu

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