



IMC-AESOP Project

Architecture for Service Oriented Process



ArchitecturE for Service-Oriented Process (AESOP)

- Monitoring and Control

We are witnesses of rapid advances in the industrial automation, mainly driven by business needs towards agility and supported by new disruptive advances both on the software and hardware side, as well as the cross-fertilization of concepts and the amalgamation of ICT-driven approaches in the traditional industrial automation systems.

Multidisciplinary in nature, future real-world industrial processes, social life and infrastructure domains appear as a new dynamic Cyber-Physical Infrastructure, which links many component systems of a wide variety of scales, from individual groups of sensors and Mechatronic components to e.g. whole control, monitoring and supervisory control systems, performing e.g., SCADA, DCS and MES functions. The resulting combined systems are able to address problems which the individual components alone would be unable to do and to yield management, control and automation functionality that is only present as a result of the creation of new, "emergent" information sources, and results of cooperation, composition of individual capabilities, aggregation of existing and emergent features. Such systems, configured and managed from architectural and behavioural viewpoints under the Service-oriented Architecture paradigm, are virtualized by the

services generated and exposed by their components (HW and SW). One of the main results of this virtualization is then the complete mapping of the physical system into a "Cloud of Services". Next generation industrial applications can now rapidly be composed by selecting and combining the new information and capabilities offered (as services in the cloud) to realise their goals.

ArchitecturE for Service-Oriented Process - Monitoring and Control is the title of the Collaborative Project IMC-AESOP, granted by the European Union under the 7th Framework Program. It started in September 2010 and is running for almost 3 years, with the contributions of 18 partners, important ICT stakeholders of the industrial value chain, like Schneider Electric, SAP, Honeywell, Midroc, Microsoft, FluidHouse, etc., and research institutions and universities like Lulea in Sweden, Tampere in Finland, Warwick and Loughborough

in the UK, ifak and Emden in Germany, among others. The IMC-AESOP consortium has investigated and successfully developed the first set of intelligent monitoring and control functions exposed as "Services" in automation clouds, making the first steps towards the Next Generation SCADA and DCS Systems of very large Systems a reality.

The results of 4 prototype implementations, both in real-world industrial process and the society life and infrastructure domains, are very promising. They show that the penetration of the Service-oriented, Cloud-based, Cyber-Physical System technologies and paradigms in the daily life is one of the most promising engineering approaches conducting to the implementation of efficient energy management systems composed of heterogeneous systems.

The outcomes of IMC-AESOP are already having a deep effect in the realization of cloud-based

integration of cyber-networked physical embedded systems in real applications. The business value is expected to growth to at least €500Bn till 2020. Under this light, the impact of IMC-AESOP is significant and multi-domain. Thus enabling Europe to improve its position as a technology-leader in Service-oriented cloud-based automation and the world-wide trend towards very large Systems-of-Systems e.g. smart grid, cloud production, smart cities, intelligent networked transportation systems, etc.

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FACTS

The IMC-AESOP project started in September 2010. It is part of the European Union 7th Framework Program, with a total duration of 40 Months. The IMC-AESOP Consortium has been made up of 18 partners from 7 European countries, it has been led by Schneider Electric, it includes some of the major European stakeholders of the industrial automation value chain and the participation of world-known research institutions and universities. The project is coordinated by Prof. Dr. Armando Walter Colombo, Schneider Electric Automation GmbH and University of Applied Sciences Emden/Leer, Germany.

Europe can be more efficiently networked

-Service-oriented Architectures, Cloud Automation and Systems-of-Systems Engineering give us the tools to build a better future

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But a lot of the European infrastructure is old, and the industry has production units and systems that have been around for a while as well. Do we need to start over and build new infrastructure and a whole new European industry? And could we afford that?

The European Union project IMC-AESOP has been working for almost three years to find a way to solve at least one part of this problem: how to make automation for industry and infrastructure more efficient, to get us a technology that could be expanded and updated over time. Instead of “rip and replace” technology, we could perhaps create a situation where we can “wrap and reuse”. Using Service-oriented Architecture, SOA, combined with cloud technology, open protocols and open system architecture, systems can be made to grow and improve. This would make it easier and faster to create new services and functions, and we can allow for systems to talk to other systems.

Industrial processes as well as many modern systems depend on SCADA and DCS systems in order to perform their complex functionalities. Cyber-Physical systems are moving towards an infrastructure that increasingly depends on monitoring of the real-world, timely evaluation of data acquired and timely applicability of management (control). The latter is becoming even more difficult when the prevailing Internet of Things is considered, where networked embedded devices are practically integrated not only in industrial domain but in every aspect of our life. As such the data points that need to be monitored and controlled increase rapidly, and so also the requirements for high performance monitoring and analytics as well as efficient management.

“This is a paradigm shift”, says Prof. Dr. Jerker Delsing, Luleå University of Technology and one of the coordinators of the IMC-AESOP project. “Using Internet and cloud technology to coordinate systems, creating a distributed and dynamic ‘system of systems’, we can update technology instead of starting from scratch and reconfigure systems instead of building new ones. This could mean we can make significant improvements with only hours of engineering time instead of weeks or months.”

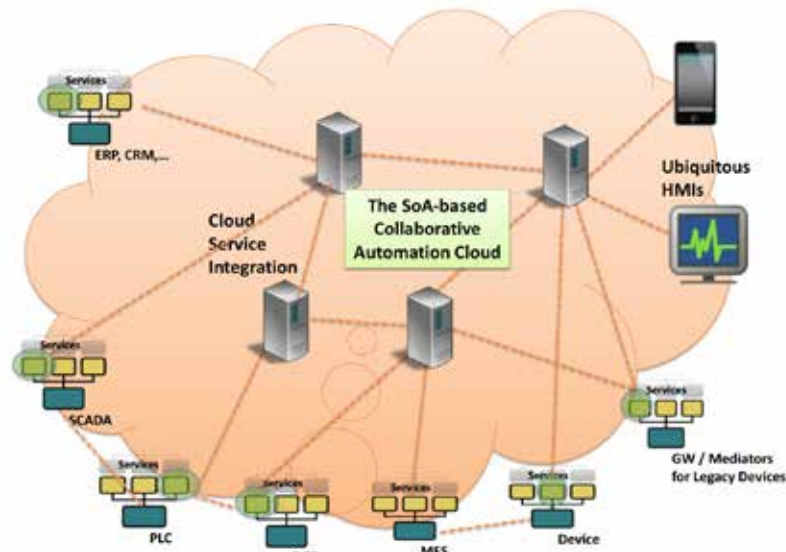
Making systems talk to each other also means new possibilities to use resources like energy, machines and human creativity more efficient. Production systems and maintenance systems processes the same kind of information. If they could talk to each other they could help to avoid shutdowns

and disturbances, and thus increase productivity. Collaborating units in large energy systems would make it possible to use energy more efficient and with less environmental impact.

“The IMC-AESOP project has been aiming at using the existing basic SOA and cloud technologies and prove that they can be used to create new solutions in industrial and infrastructural environments”, says Professor Delsing.

The ground-breaking work in IMC-AESOP has been done in cooperation between university scientists and industrial companies taking part in this project.

In the following short articles four realistic test runs within IMC-AESOP is described.



SoA interactions manage the behaviour of the whole Cyber-Physical System of Systems



More communication can lead to cost effective maintenance

Service-oriented Architecture, SOA, and cloud-based technology can be implemented in real industrial environments. This was proven in one of the use cases performed in the IMC-AESOP project. A test at the lubrication system in a pellet plant at the LKAB mine in northern Sweden showed a potential for increased efficiency.

Major Swedish mining company LKAB saw potential winnings in improved communication between the production system and the lubrication system in the pellet plant. But these machines are huge and too expensive to stand still. Could Service-oriented Architecture, SOA, cloud technology and a more open system structure be the way to improve system-to-system communication without disrupting production?

A group of scientists and technology suppliers set out to test if SOA and cloud technology was ready for implementation in a large-scale process industry like LKAB. The result was very encouraging.

“In April this year we did a test-run”, says Oscar Carlsson, R&D

engineer at Midroc. “The production was shut down, but everything in the run of machinery and systems were realistic. The lubrication system worked exactly as it does in production, and we managed to show that we could add units of new software without rebuilding the system from scratch.”

This may prove to be an important step on the road to a more flexible and dynamic development of industrial technology.

“A step-by-step dynamic development, using SOA and cloud technology as tools for constant improvement, is a way for industry to improve technology without long shut-downs or expensive rebuilds. One reason behind the trials at LKAB was to see if we manage to work in this way even in the environment of a very large process industry.”

Luleå Technical University, Schneider Electric, ifak (Institute für Automation und Kommunikation) and Midroc created units adding to the lubrication system. These units were mounted at the site and successfully run together with the existing systems at the test run in April. The communication with the production system was using all the real production data.

This use case has resulted in very encouraging results.

“European industry can achieve more flexibility in their endeavours to add functionality to existing systems”, says Oscar Carlsson. “A more open structure would mean possibilities to improve systems without starting over, and it would also make it easier to

choose the best technology without regards to the brand, type or age of their existing systems.”

After the successful test run at LKAB, the partners of this use case has been busy analysing the results and preparing for further development of the system, and work will go on beyond this. Communication standards for the future need to be identified, as a part of architecture for systems suitable for industrial use in a more dynamic future.

Collaborative Systems can save energy and decrease carbon footprint

In a private home close to Luleå University of Technology, LTU, researchers have built a distributed system with sensors and communicating systems for monitoring and controlling the indoor climate. Energy use has been made more efficient by enabling different heterogeneous systems to collaborate, i.e., to communicate and exchange data and information to each other, using Service-oriented Architecture (SoA) and Cloud Computing Technologies, Internet Communication and the Systems-of-Systems Engineering paradigm, SOA, and Internet communication.

When different parts of an energy system can talk, and extract data from each other, it is possible to better adapt energy consumption to human needs as well as to energy production.

“For example, if sensors indicate that no one is at home, the energy system can automatically lower temperature and ventilation”, says Jens Eliasson, research scientist at LTU.

A more complex example from this use case is the optimization of the total energy use for showers and indoor heating. In the mornings, say between 6 am and 8 am, a lot of people in a housing area take showers. This boost in energy consumption may lead to a need to burn extra fuel in the local energy plant, maybe even use more burners. This kind of peak is often met by using oil, which could have a severe negative impact on environment and carbon footprint.

“But if we could teach the system to give the house a little extra heating before 6 am, the system can then shut down heating during the hours when people take showers. With this routine, no one would feel any discomfort, and we could level out the energy consumption enough to avoid use of extra fuel in the energy plant. This would benefit costs, environme-

ntal impact and provide for a more efficient energy production”, says Jens Eliasson.

Another example is to use weather forecasts to calculate the demand for heating, and also to find the best time to distribute this heat through the district heating system. Such a calculation calls for input about factors like upcoming weather, energy price variations over time and the pattern for energy use in area.

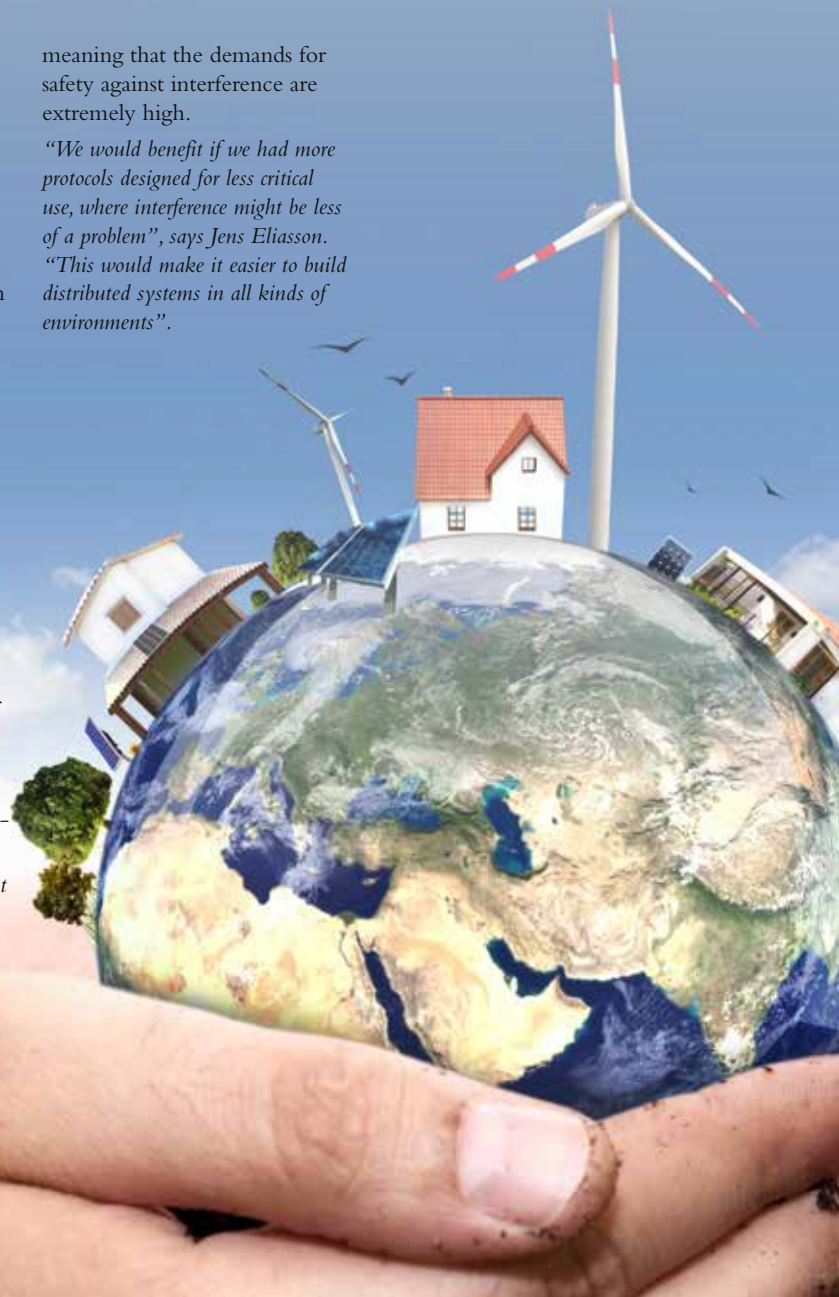
If you want to create large and economically reasonable wireless sensor system, sensors need to be extremely small and energy efficient. This is also necessary requirements for making them fully wireless, powered only by small solar cells or minimal batteries. A major challenge for this use case has been to find ways for these really tiny sensors to talk to large energy systems. In technical terms they need to use the same standardized protocol for communication.

“There has been a major development in later years to create protocols suitable also for small units like wireless sensors”, says Jens Eliasson. Within IMC-AESOP we have been scanning for such development projects.

Many communication protocols are developed for industrial use,

meaning that the demands for safety against interference are extremely high.

“We would benefit if we had more protocols designed for less critical use, where interference might be less of a problem”, says Jens Eliasson. “This would make it easier to build distributed systems in all kinds of environments”.





Large industrial sites can increase energy efficiency

Large process industry sites such as petroleum refineries or pulp and paper mills can become much more efficient with implementation of next generation control systems using principles of Service-oriented Architecture. To maximize the potential to increase energy efficiency a lot of information within the mill needs to be collected and kept updated.

In a modern refinery or pulp mill, huge amounts of energy is both used and produced. To be able to determine the optimal way to balance and use this energy, information need to be shared between very different, heterogeneous systems that traditionally have been isolated. Using Service-oriented Architecture, SOA, this can be made a reality. In one of the use cases in IMC-AESOP project, Honeywell, Microsoft, SAP and others worked together to create and test information models and engineering models for how this would work.

“There is information available to make process industry sites more efficient both in energy use and in production efficiency but today it is scattered, and individual control applications may not be well synchronized”, says Petr Stluka, Honeywell.

Combining and processing information about energy production

and energy demand within the site with price information and energy demand outside of the site can help large industrial sites improve energy efficiency and proactively participate in the electricity market. One scenario developed in this use case involves charging electric cars with excess electricity. If some of the work force at the mill would use electric cars and charge them during their working hours, this could be a valuable contribution for site’s economy as well as a way to lower its carbon footprint. To make such a system work, you need to input data like the working hours for the staff, alternative use of the energy (e.g. selling electricity to the grid at a dynamic price), site production forecast and energy demand within the site. This advanced scenario can be enabled by consistent use of information models, deployment of new control and optimization applications based on SOA.

The daily production at the mill and processing all of the related information can also be made more efficient by using Complex Event Processing, CEP. Another scenario addressed by the project partners is focusing on alarm management, and using CEP to detect specific events and presenting their causes in addition to individual alarms on the console.

“During abnormal situation, the operators should not be distracted by too many low level alarms, but be allowed to focus on what they really need to do to manage the production”, says Petr Stluka.

Significant savings can be achieved by optimizing production in units within a site. By combining data from systems not interconnected today, the best way to optimizing production can be found. This option has been facilitated by the use case in IMC-AESOP.

“With traditional automation technology it has been difficult to extract and keep consistent information about operational context, the information has been scattered. We have developed information models and methods that will make it much easier to optimize processes.

Service-oriented Architecture could mean that automaton vendors will need much less engineering hours to configure and maintain control systems, ensuring a smooth operation of the plant. In many cases, SOA can even make systems self-configurable, actually learning from experience in production. This would contribute to “the holy grail” of industrial efficiency, a low number of abnormal events and shutdowns.



Large machines, such as modern paper machines, can be made easier to run and maintain using Service-oriented Architecture, SOA, and cloud technology. In a use case within IMC-AESOP scientists emulated integration of cloud based services, as a way to increase communication between systems at the machine, making it easier to detect disturbances.

SOA and cloud technology can make large machines easier to handle

“Industry has realized the potential in technologies originally developed for private use, like Internet, pc technology and Ethernet communication. The development has unfortunately been slowed down by a lack of standards covering all levels of equipment”, says Andrei Lobov, Tampere University of Technology. “In this project we have taken web standards all the way to the low end devices.”

In this use case within IMC-AESOP, Andrei Lobov led test runs to see if SOA and cloud technology could be used to enhance the production and maintenance in such large and complex industrial systems as a modern paper machine.

“We ran these tests as emulations in the R&D department of a paper mill, and all the data used was taken from the production equipment and systems in the mill. The tests were made to prove the reliability of the service solutions we produced and hosted on the cloud”, says Andrei Lobov.

The implemented new services were bombarded with thousands of emulated events to check their reliability and capacity to handle any disturbances that might occur at the machine during normal production.

“The results were very encouraging. We tested if the cloud based services could handle situations like leakages

or bad oil quality, and it did”, says Andrei Lobov.

Lubrication oil quality is an important issue for industries using large mechanical systems, such as paper machines. The traditional routine has been to change oil with set intervals, which often means that you make the change either too early, which is costly, or too late, which can be catastrophic for the machinery. With SOA and cloud solutions it will be much easier to implement a service that measures and communicates oil quality and makes sure the changes is done at the exact right moment.

This is one of many possible examples of improvements that is much easier to do with SOA and cloud technology, which makes it possible to add services without taking the system apart or start from scratch. Reconfiguration instead of rebuild.

“The use case we executed within IMC-AESOP showed us that additions to a system, e.g. oil analysis, is quite possible to using SOA and the cloud, and that such solutions could handle difficult situation in an industrial environment”, says Andrei Lobov.



IMC-AESOP

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<http://www.imc-aesop.eu>

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