IMC-AESOP: ArchitecturE for Service-Oriented Process - Monitoring and Control

Seventh Framework Programme (FP7) Theme ICT - Information and Communication Technologies
Grant agreement no: 258682 | Project Co-ordinator: Armando Walter Colombo | Schneider Electric Automation GmbH

2nd EU Review Meeting

WP8: Management Coordinator Report

Honeywell Premises (HON CZ)
Prague, Czech Republic
22nd-23rd November 2011

Research Projects | Computing Systems

IMC-AESOP

ArchitecturE for Service-Oriented Process - Monitoring and Control

IMC-AESOP will (i) develop a System-of-Systems (S-o-S) approach for Monitoring and Control based on Service-oriented Architecture (SoA) for Very Large Scale Distributed Systems in Process Control Applications (up to tens of thousands of smart devices) and (ii) propose a migration path from legacy systems towards next generation SoA based SCADA/DCS systems and an infrastructure that will be the perfect legacy system from the integration viewpoint in 20 years from now.

KEYWORDS: Service-oriented Process Monitoring and Control, Next Generation SCADA/DCS, Very large scale distributed systems, SoA-Ready System of Systems

At a Glance: IMC-AESOP

ArchitecturE for Service-Oriented Process Monitoring and Control

Project Coordinator
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Project web site: www.imc-aesop.eu

Partners: *Schneider Electric Automation GmbH (Germany), APS Europäisches Centrum für Mechatronik (Germany), Europäisches Microsoft Innovations Center GmbH (Germany), FluidHouse Oy (Finland), Honeywell spol. s r.o. (Czech Republic), Institut für Automation und Kommunikation e.V. (Germany), Loughborough University (UK), Luleå University of Technology (Sweden), Luossavaara-Kiirunavaara Aktiebolag (Sweden), Midroc Automation (Sweden), Politecnico di Milano (Italy), Prodatec Oy (Finland), SAP AG (Germany), Schneider Electric Industries SAS (France), Tampere University of Technology (Finland), Honeywell Oy (Finland), University of Applied Sciences Emden-Leer (Germany)*

Duration: *30 months*
Start: *2010.09.01*
Total Cost: *€ 7.282.331*
EC Contribution: *€ 4.499.902*
Contract Number: *INFSO-ICT- 258682*

Main Objectives

IMC-AESOP investigates a Service-oriented Architecture approach for monitoring and control of very large scale Process Control Systems (batch and continuous process applications). Large process industry systems are a complex (potentially very large) set of (frequently) multi-disciplinary, heterogeneous, networked distributed systems that function as a complex system of which the components are themselves systems, i.e. S-o-S.

IMC-AESOP realises a SoA-based approach for next generation of SCADA/DCS systems targeting Process Control Applications

The future "Perfect Plant" will enable monitoring and control information flow in a cross-layer way. As such the different systems including SCADA/DCS will be part of a distributed ecosystem, where components can dynamically be discovered, added or removed, and dynamically exchange information and collaborate. This cross-layer and cross-enterprise collaboration will be driven by business needs and enable future factories to fulfil the set of Maier's criteria. To achieve this vision, IMC-AESOP will have to deal with key challenges such as operational and managerial independence of the service-oriented constituent systems, real-time web services, interoperability, plug and play, self-adaptation, reliability, energy-awareness, high-level cross-layer integration and cooperation, event-propagation and -management.

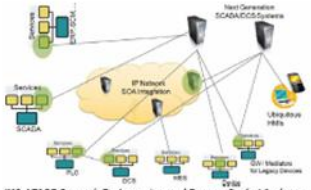
The SoA-based approach proposed by IMC-AESOP can, on one hand, simplify the integration of monitoring and control systems on application layer. On the other hand, the networking technologies that are already known to control engineers could also simplify the inclusion of or migration from existing solutions and the integration of the next generation SCADA and DCS systems at network layer. Moreover, engineering methods and tools are being investigated and highlights on the domain's future will be provided by research and academic partners.

IMC-AESOP will demonstrate the application feasibility in pilots, based on real-world industrial use cases provided from several end-users. The IMC-AESOP partnership among important ICT stakeholders of the industrial value chain is a key aspect of the project that allows foreseeing important contributions to relevant standardization bodies.

Technical Approach

IMC-AESOP envisions a SoA-based SCADA/DCS infrastructure that enables cross-layer service-oriented collaboration not only at horizontal level, e.g. among cooperating devices and systems, but also at vertical level between systems located at different levels of an enterprise architecture. The major scientific and technical objectives of the approach behind that infrastructure are:

- Propose a system-of-systems approach for distributed dynamically collaborative monitoring and control based on Service-Oriented Architecture (SoA). Application for very large scale distributed systems in Process Control applications (up to tens of thousands of devices and systems exposing/consuming and processing "Services").



IMC-AESOP Concept: Far beyond current Process Control Systems
Towards a „Distributed Dynamically Collaborative S-o-S"

- Investigate how "deep in the enterprise architecture" is possible to go with SoA? Is it feasible to get SoA at the device level inside process control loops? How large is the percentage of devices that can reliably be incorporated in the SoA architecture?
- Build a foundation for predictive performance of such SoA architecture based on a formal approach to event based systems.
- Propose a transition path from legacy systems (e.g. a 20-year old machine) to a SoA compliant system.
- Propose a transition path from the new SoA-based SCADA and DCS to be an adequate legacy system in the next 20 years.

IMC-AESOP will not only design and implement this visionary infrastructure, but will also demonstrate the application feasibility in industrial pilots.

Key Issues and Benefits

The application domain of process control systems composed of very large numbers of systems poses several key issues:

- Distributed monitoring and control of very large scale systems (tens of thousands of interconnected devices are encountered in a single plant) enabling plant efficiency control, product quality control and production quality control.
- A multitude of plant functions requesting information and functionality due to continuously changing and increasing business requirements.
- Integration of existing devices which generates the data and information necessary for the multitude of plant functionalities like plant operation, maintenance, engineering, business and technology, i.e. S-o-S integration, operation and evolution.
- The very large spread in device and system performance requirements regarding e.g. response time, power consumption, communication bandwidth.
- Legacy compatibility (20 years old systems have to interoperate with modern systems).

When using IMC-AESOP to address those issues, the following benefits are expected:

- Proactive batch and/or process automation monitoring and control systems: they are able to expose their functionalities as Services.
- Open batch and/or process automation monitoring and control services that can be accessed by any other system of the enterprise architecture able to call for Services.
- Proactive batch and/or process automation monitoring and control systems: they are able to compose, aggregate and/or orchestrate services exposed by themselves and from other devices in order to generate new distributed SCADA and DCS functions (also exposed as "Services").
- Proactive batch and/or process automation monitoring and control systems at the shop floor, which are interoperable with SoA-based systems of the upper levels of the enterprise architecture (e.g. integrating ERP and MES with the SCADA and DCS).

Impact and Synergies

The IMC-AESOP project is looking at specification, development and prototyping distributed networked SCADA/DCS systems in automation devices and systems, by applying the SoA paradigm. As a matter of fact, Service-oriented Process Monitoring and Control as part of SCADA/DCS systems heavily depends on the integration of networked embedded systems, which is expected to grow reaching the e500 Bn in 2020. The results of IMC-AESOP will have a deep impact in that grow, expanding the potential applicability also to other domains like Energy Management, Logistics, Manufacturing, etc. Under this light the impact that IMC-AESOP would achieve might be significant and cross-domain, enabling Europe as a technology leader in Service-Oriented Process Monitoring and Control with strong synergies to the world-wide trend into System-of-Systems (S-o-S) Engineering.

IMC-AESOP Scope: Impact and Synergies

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IMC-AESOP
February 2011

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Seventh Framework Programme (FP7) Theme ICT - Information and Communication Technologies
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IMC-AESOP Objectives

- Propose a system-of-systems approach for monitoring and control based on Service-Oriented Architecture (SOA) for very large scale distributed systems in Process Control applications (up to tens of thousands of devices).
- Investigate how large is the percentage of all devices that reliably can be incorporated in the SOA architecture, i.e. how “deep” we can go with SOA? Are we able to get SOA at the device level inside process control loops?
- Build a foundation for predictive performance of such SOA architecture based on a formal approach to event based systems.
- Propose a transition path from legacy systems (e.g. a 20 years old machine) to a SOA compliant system.
- Propose a transition path from the new SOA-based SCADA and DCS to be an adequate legacy system in the next 5-10 years.

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IMC-AESOP The most challenging scientific/technological aspects

- Robust and predictable SOA based control and monitoring framework for system wide real time, flexible and autonomous multi purpose utilization of very large numbers of sensors and actuator devices. Achieved through:
  - Formal based high level modeling and SW generation approaches for event based system control and monitoring, supporting runtime analysis
  - Methodologies (and tools) allowing such SOA framework on low resources (cheap) devices
- Migration technologies for SOA framework integration to legacy system enabling. Achieved through:
  - Encapsulation of scan-based oriented subsystem processing in event based system processing
  - Interfacing of event based subsystem processing to scan-based system processing

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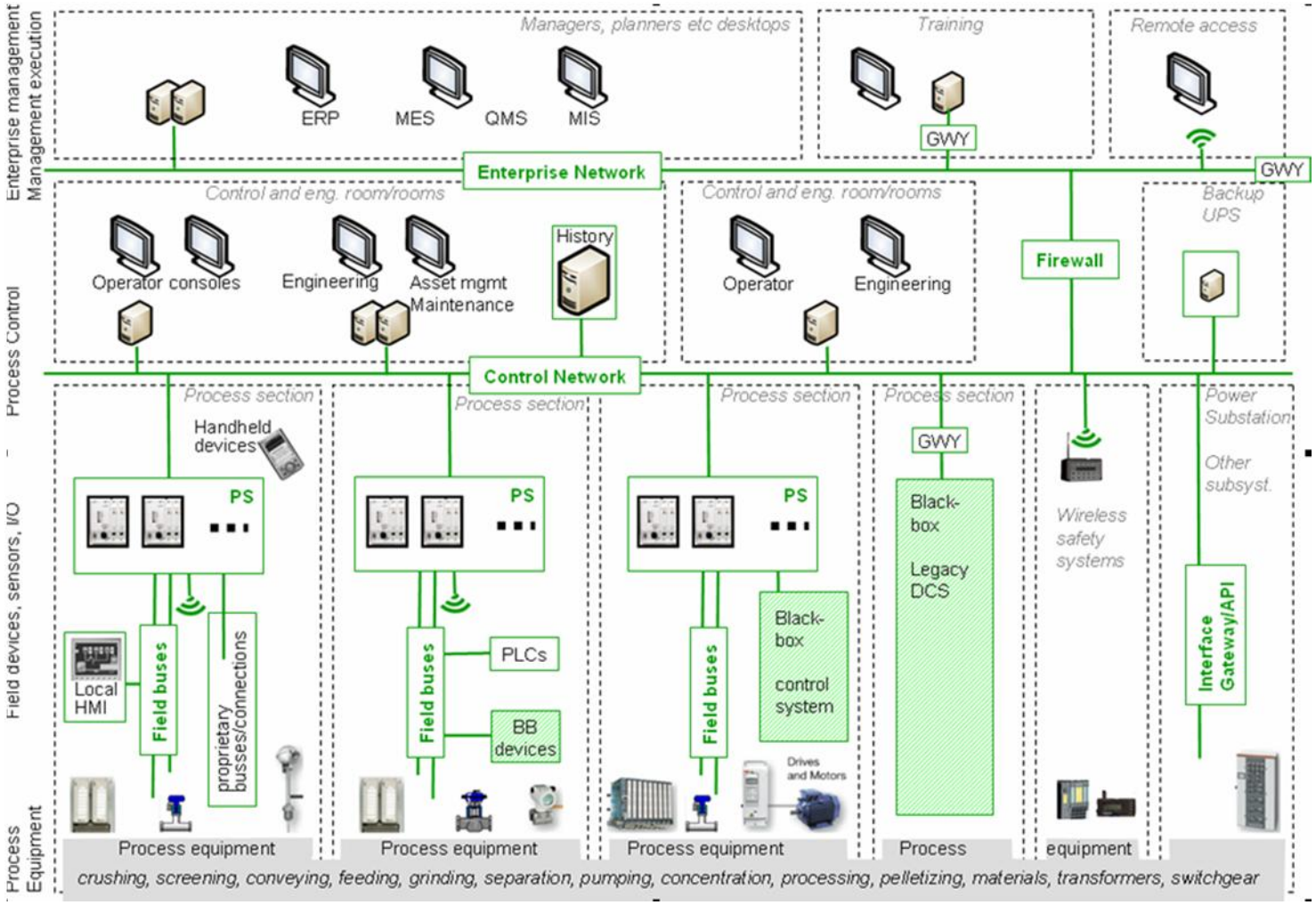
IMC-AESOP Positioning

General Architecture of a Process Control System



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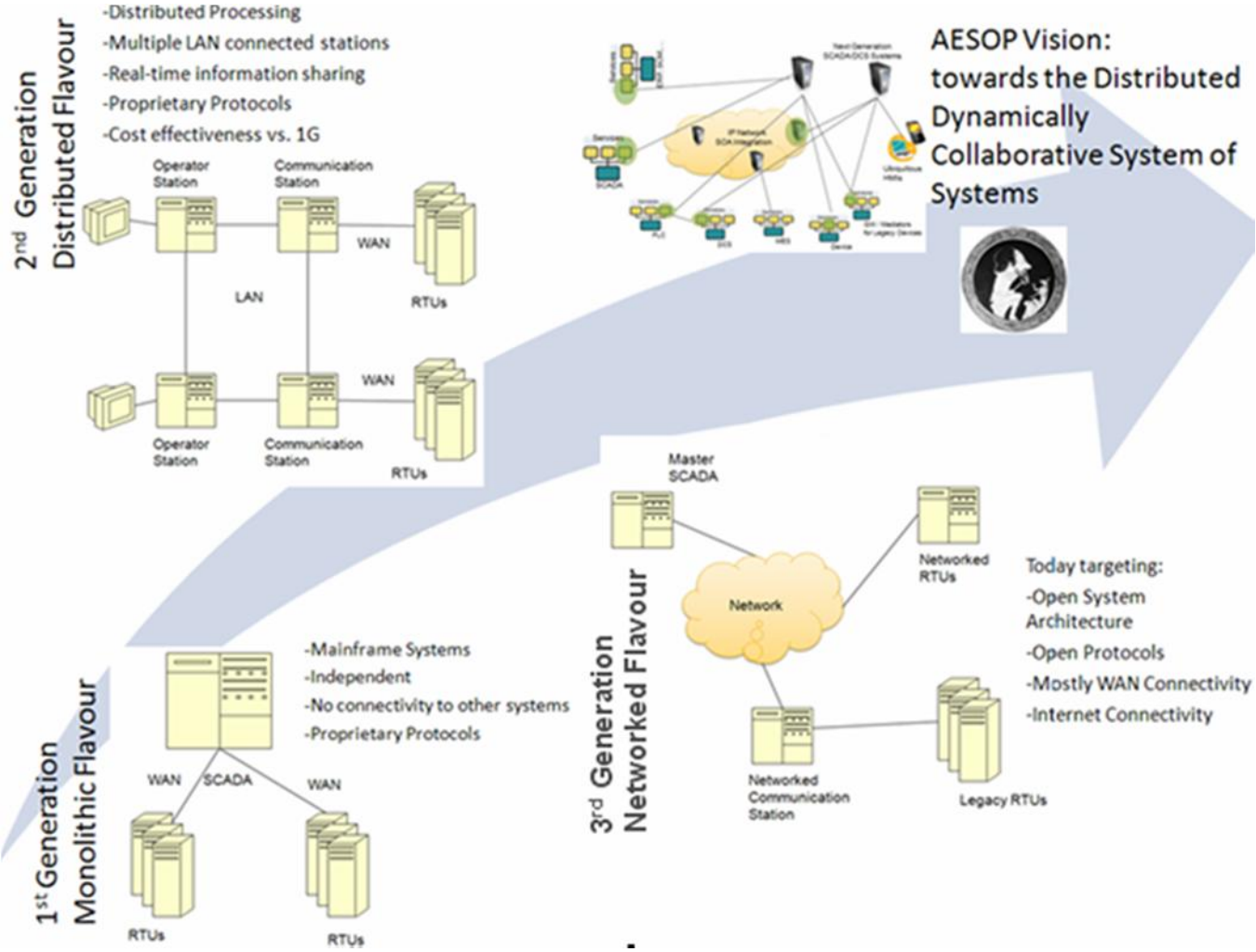
Impact on the Evolution of Supervisory Control Systems (NG-SCADA/DCS)



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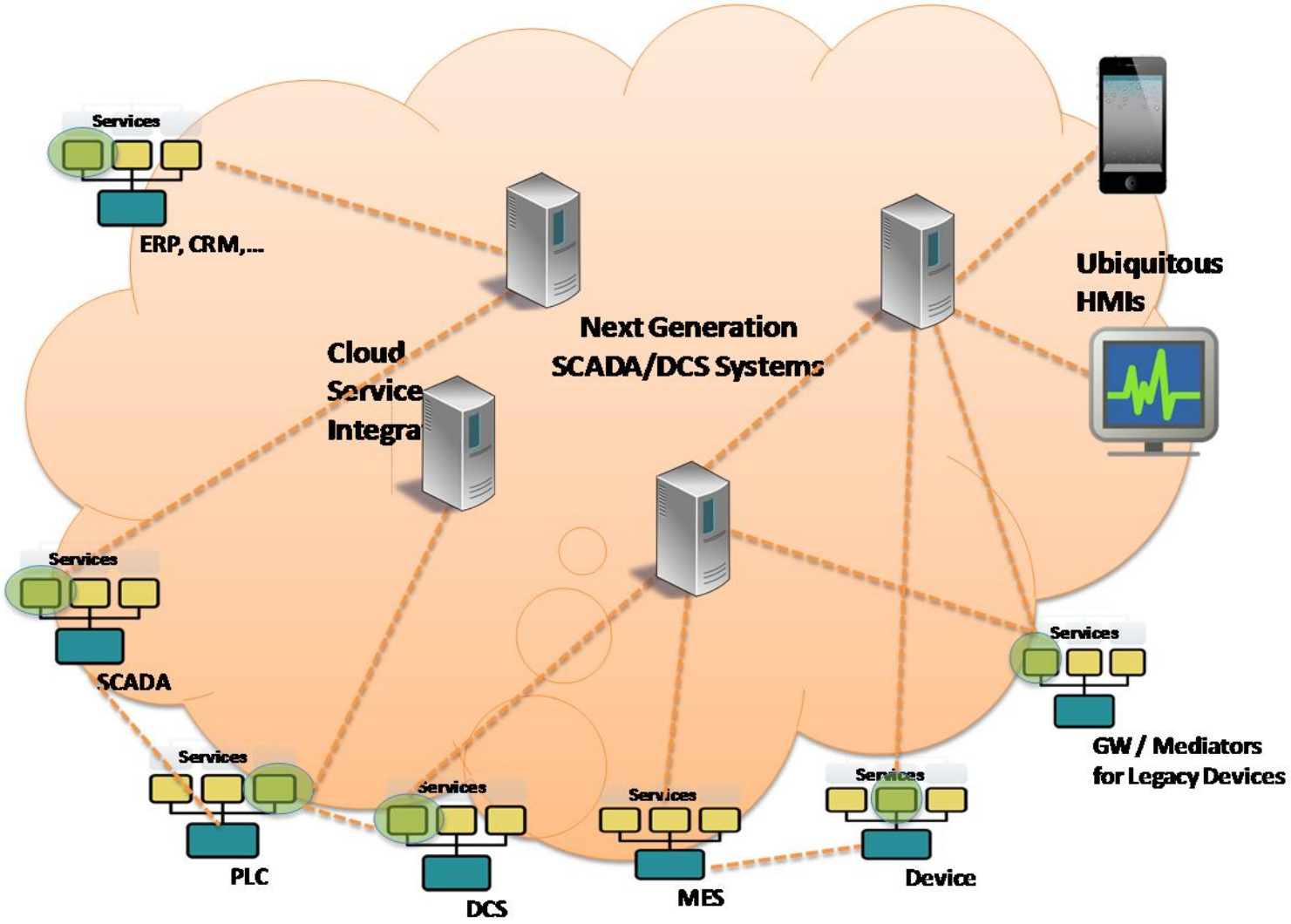
IMC-AESOP Vision



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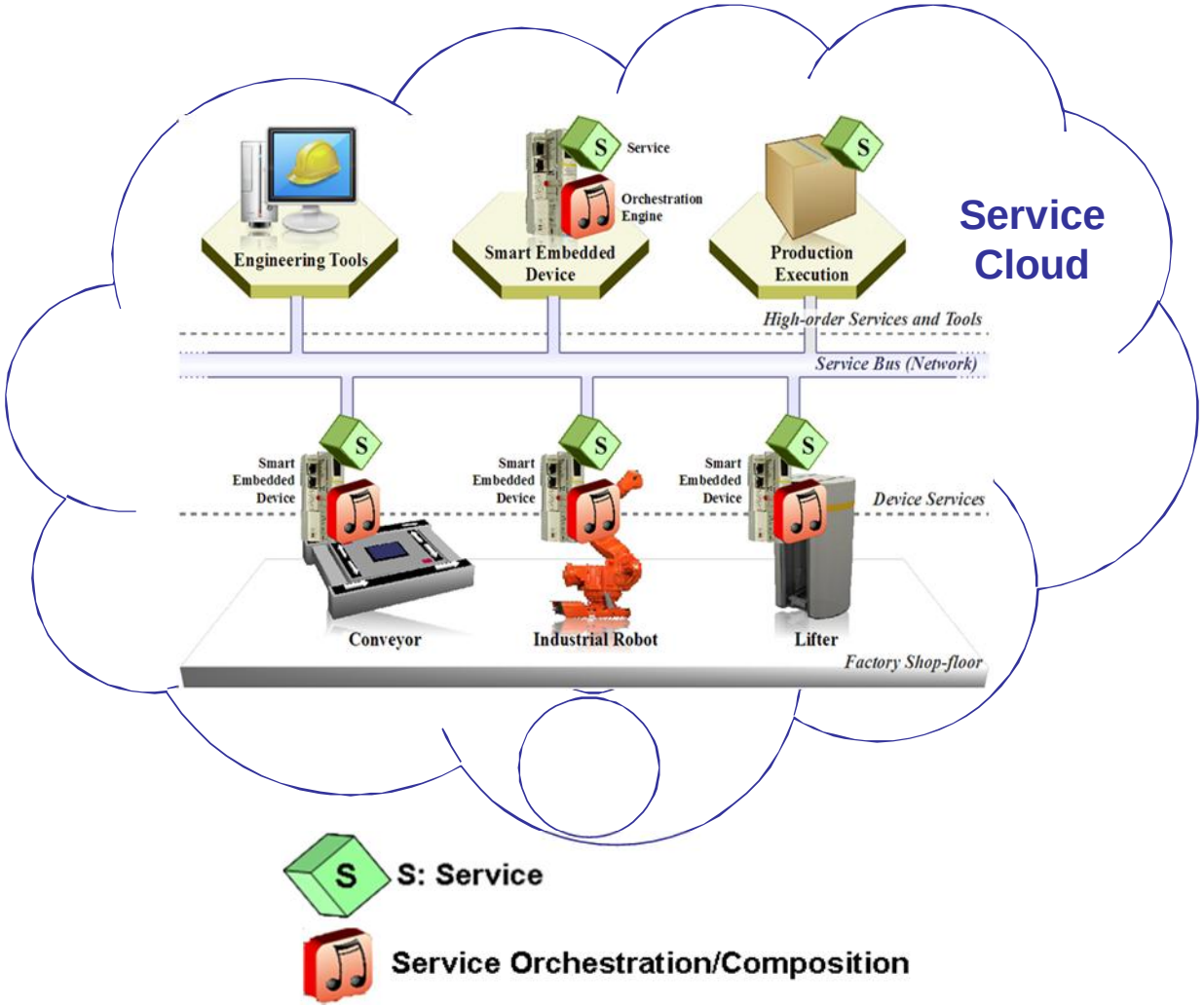

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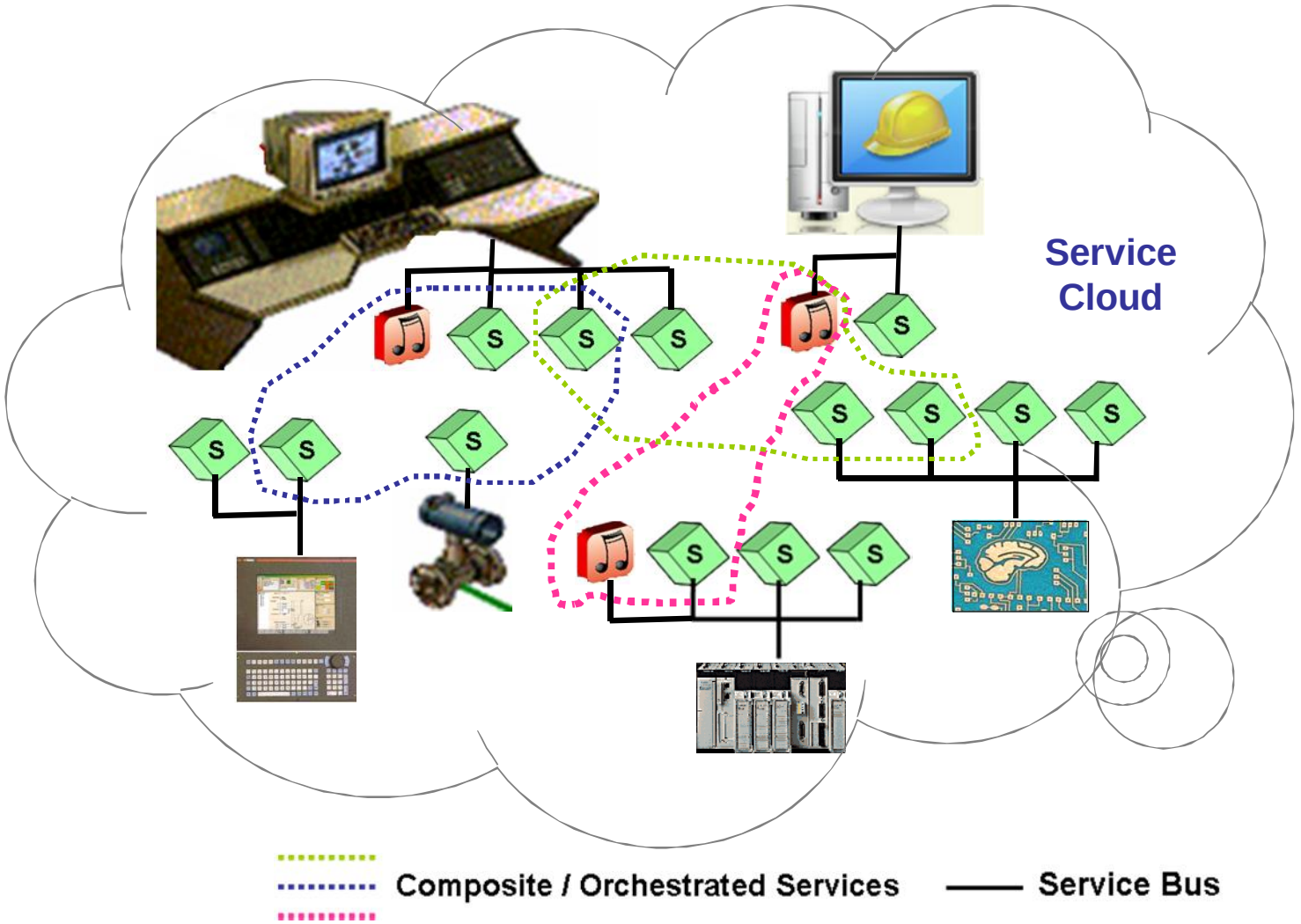

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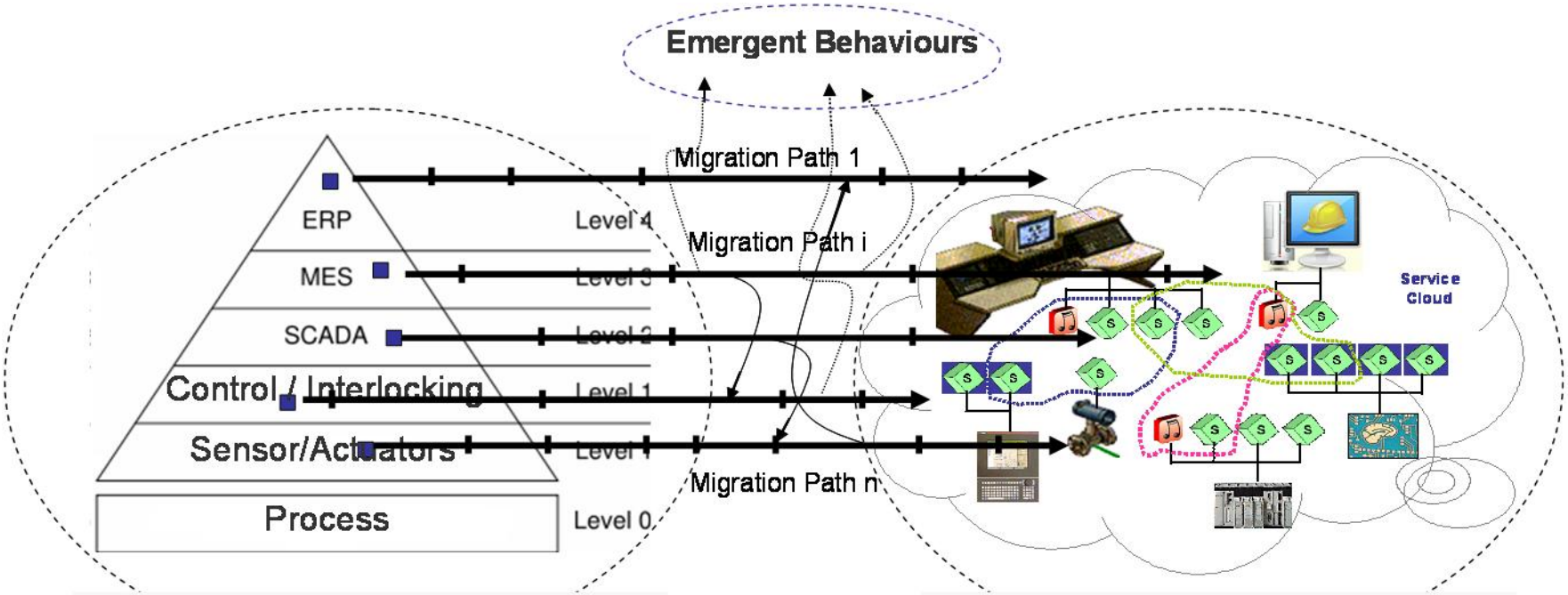

- System´s property/characteristic to be migrated to SoA
- Inter-dependencies among migration paths due to architectural and functional relationships between system´s characteristics.

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Use Cases – Listening to "Customers" and Potential Users of Project Results

1. *Isolation aspect with long time view*

A part of the plant has to be time resistant in order to be architecturally and functionally connectable (this feature is called "future compatible" with new coming "emerging technology / components").

This can be realized through:

- Description of a plant / plant-section as Web Services-compliant (Architecture). Functions exposed as Web Services.
- SW implementation of a gateway or mediator.

2. *Building a "New Generation" plant (prototype or simulation)*

A full plant or plant-section may be built with AESOP-compliant technology.

3. *SCADA-DCS functions (aspects) as Services*

Aspects will be specified and deployed into a pilot plant built as described above. This might be applicable to, e.g. Asset Management.

	Use case	1	2	3
Application		Plant lubrication	Oil lubrication	Plant energy optimization
Evolution addressed	Migration of legacy systems	X	X	X
	Building completely new systems		X	X
Tasks dedicated	Engineering	X	X	
	Control	X		X
	Monitoring	X	X	X
	Maintenance	X		
Use case raised by:	LKAB	X		
	FluidHouse		X	
	Customers of Honeywell			X

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State-of-the-Art Perspectives

Progress beyond the State-of-the-Art End-User Dimension

Based on the SOA approach supported by standard-based and formal-based software design methods, the AESOP project will define architectures, technologies and migration strategies and tools suitable for addressing seamless and timely integration of data and information from subsystems and devices.

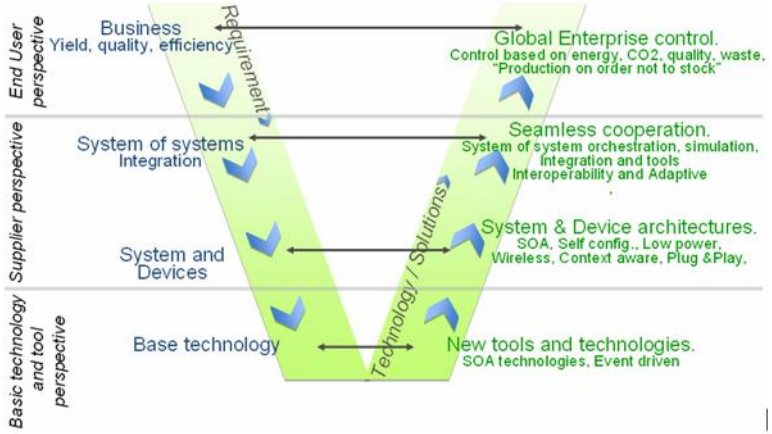
Altogether, this will open for large improvements in the flexibility of monitoring and control of very large systems. Thus making it economically and man power-wisely possible to address knowledge improvement possibilities regarding product and production quality as well as e.g. energy usage optimization.

Progress beyond the State-of-the-Art Supplier Dimension

The AESOP project will define SOA architecture for monitoring and control of very large systems. With support from formal-based and standard technology tools the technology limits for SOA on subsystems and devices will be investigated regarding real-time, event aggregation and filtering, event-driven mechanisms etc. It will be possible to demonstrate and, subsequently, provide business concepts which costs will effectively address end-users desires.

Progress beyond the State-of-the-Art. Tools and Technology Dimension

The AESOP project will investigate and introduce formal-based technologies, thus open for automated verification of code functionality and guaranteed real-time performance, making code generation, debugging and verification more economical.



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IMC-AESOP Impact and Synergies (i)

Expected impact listed in Work Programme	How IMC-AESOP will contribute
Strengthened competitiveness of the industry supplying monitoring and control systems through next generation process automation products that are superior in terms of functionality, accuracy, dynamic range, autonomy, reliability and resilience.	**SOA process automation systems, services and devices resulting from the project will provide more distributed intelligence both at the device level and at the system (DCS / SCADA) level of the monitoring and control systems. It will result in more system functionality and more device autonomy. Better resilience and reliability will be provided by dynamic characteristics of Web Services (plug & play), and by automatic service replacement by a similar service, when a service becomes unavailable.**
Higher energy efficiency and reduction of waste and of resource use in manufacturing and processing plants.	**Higher energy efficiency and reduction of resource use in manufacturing and processing plants is one of the dedicated objectives that will be investigated through the use case 3.** **SOA paradigm is a very good candidate for efficient use of resource, by its adaptability to process conditions, as for example the use of event-driven communications providing an exact communication image of the monitored process (no communication if nothing happens in the process).**

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IMC-AESOP Impact and Synergies (ii)

Expected impact listed in Work Programme	How IMC-AESOP will contribute
Improved ease-of-use and simplified operation and maintenance of monitoring and control systems, also for non-experts.	**Ease of use for non-experts, at all steps of the process control application life cycle, will be provided thanks to implemented Web services with plug-and-play mechanisms. The provided tools will automatically detect devices and their embedded services. They will also propose several filtered and aggregated views of them, helping the user to monitor and/or manage the selected sub-group of devices or services, without needing to have a deep knowledge of underlying protocols and application implementations, while keeping the possibility to access any low level information.**
Reinforced European inter-disciplinary excellence in control and systems engineering and associated modelling and simulation tools as well as in real-time computing, communications, wireless sensor (and actuator) networks and cooperating objects.	**Several WP will reinforce the collaboration among partners regarding:** ➢ **control and systems engineering, modelling and simulation tools, mainly through WP4, 5 and 6 addressing the migration, tools and application parts of the project** ➢ **real-time implementations and communication networks (including large scale systems over IPv6 networks), through WP2 and 3 addressing the architecture and core technology parts of the project** **This cooperation will provide real applicable solutions to the "Web of Objects" concept.** **Moreover, the international cooperation will be re-enforced through the IIAB.**

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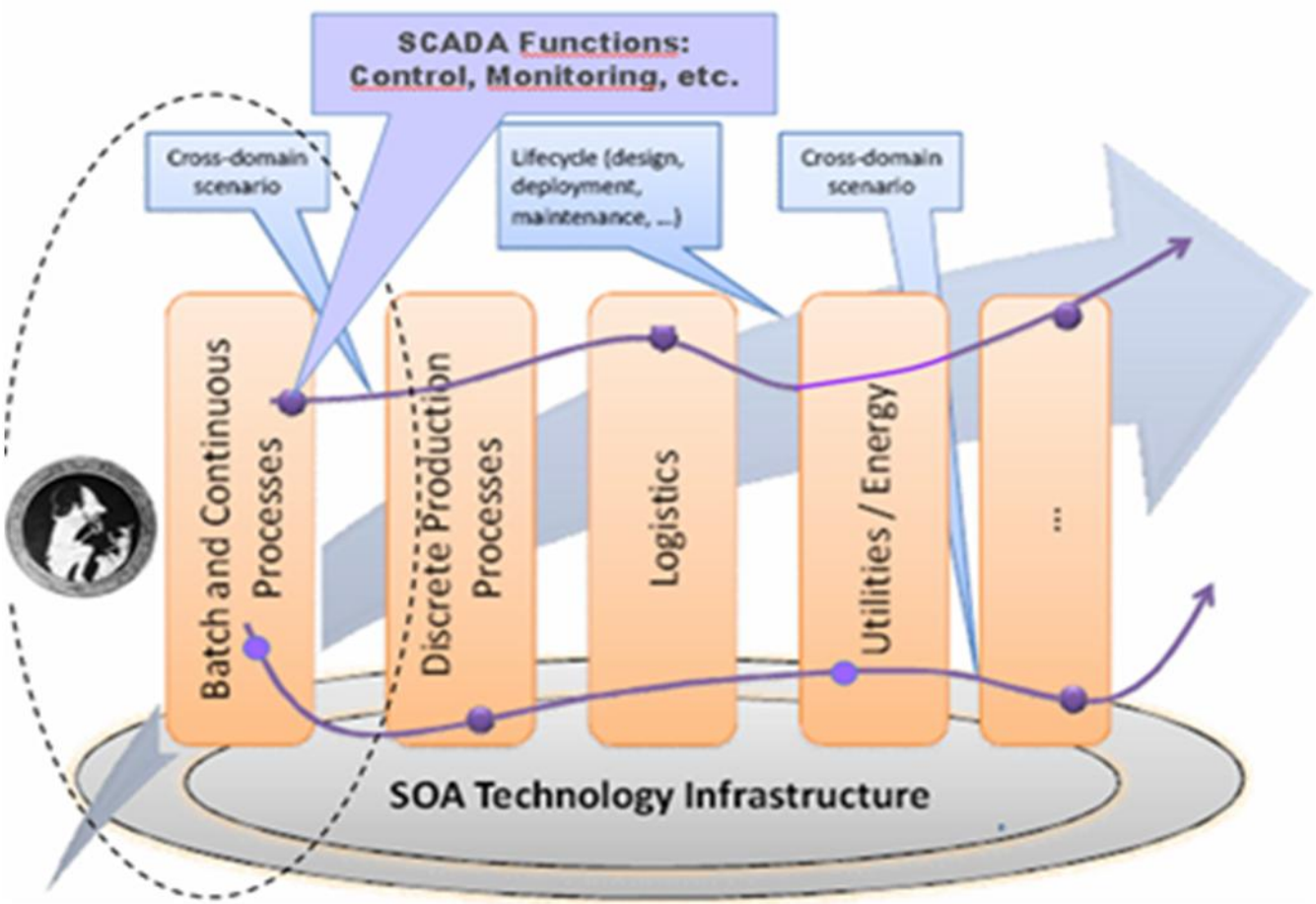
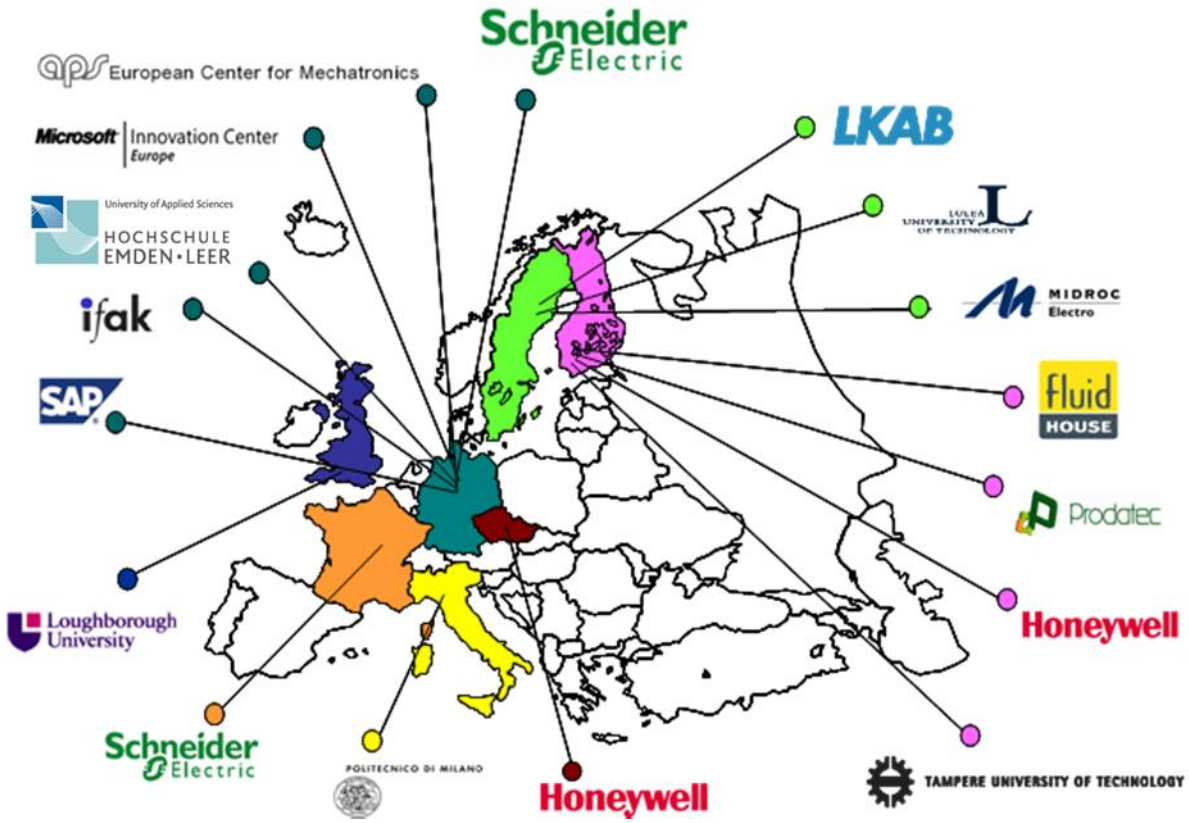
IMC-AESOP Impact and Synergies (iii)



IMC-AESOP Consortium (i)



Participant organisation name
Schneider Electric Automation GmbH
APS Europäisches Center für Mechatronik
Europäisches Microsoft Innovation Center GmbH
FluidHouse Oy
Honeywell, spol. s r.o.
Institut für Automation und Kommunikation e.V.
Loughborough University
Luleå University of Technology
Luossavaara-Kiirunavaara Aktiebolag
Midroc Automation
Politecnico di Milano
Prodatec Oy
SAP AG
Schneider Electric Industries SAS
TTI-SÄÄTIÖ (TUT)
Honeywell Oy
Univ. of Applied Sciences Emden-Leer

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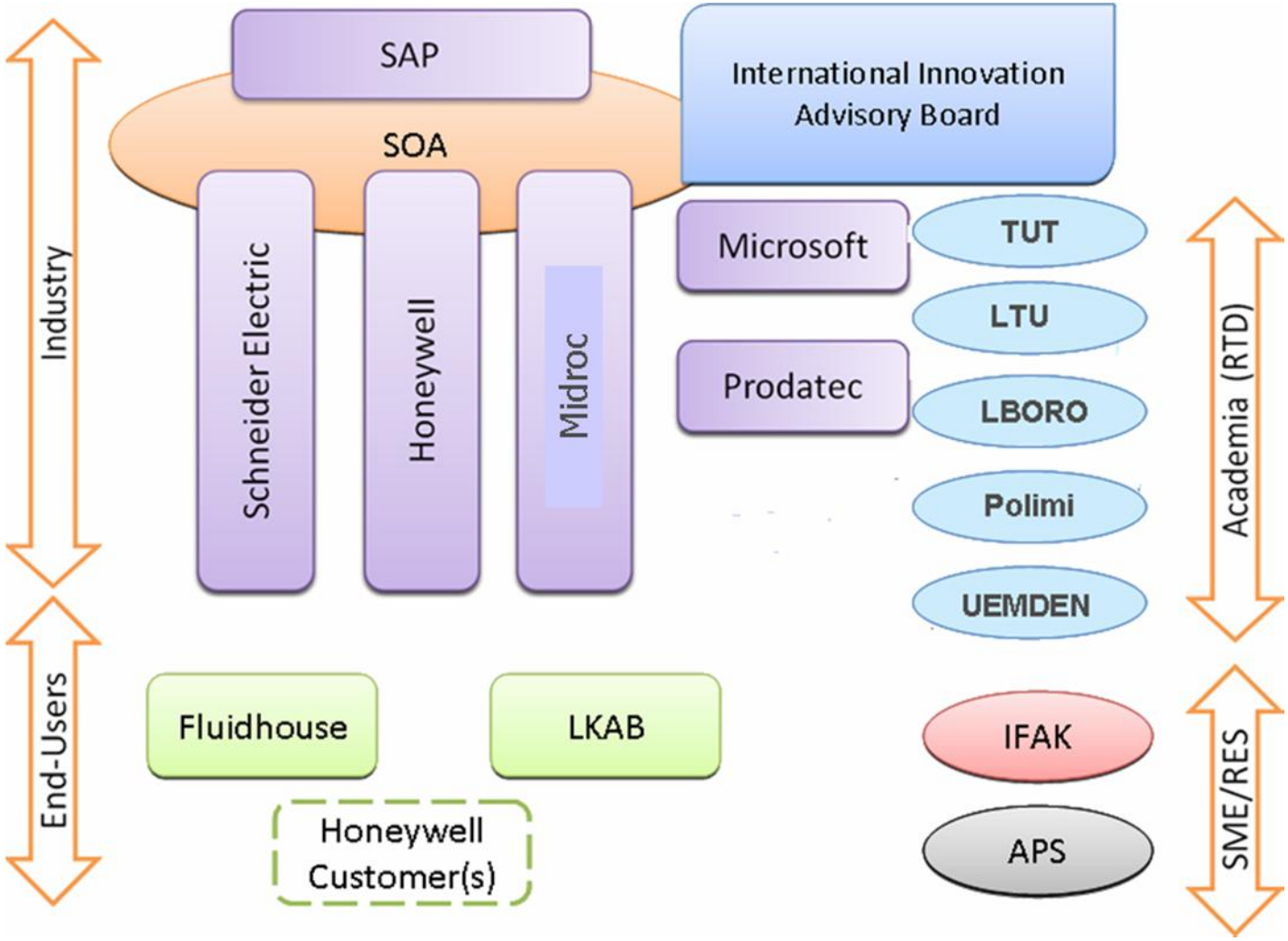
IMC-AESOP Consortium (ii)



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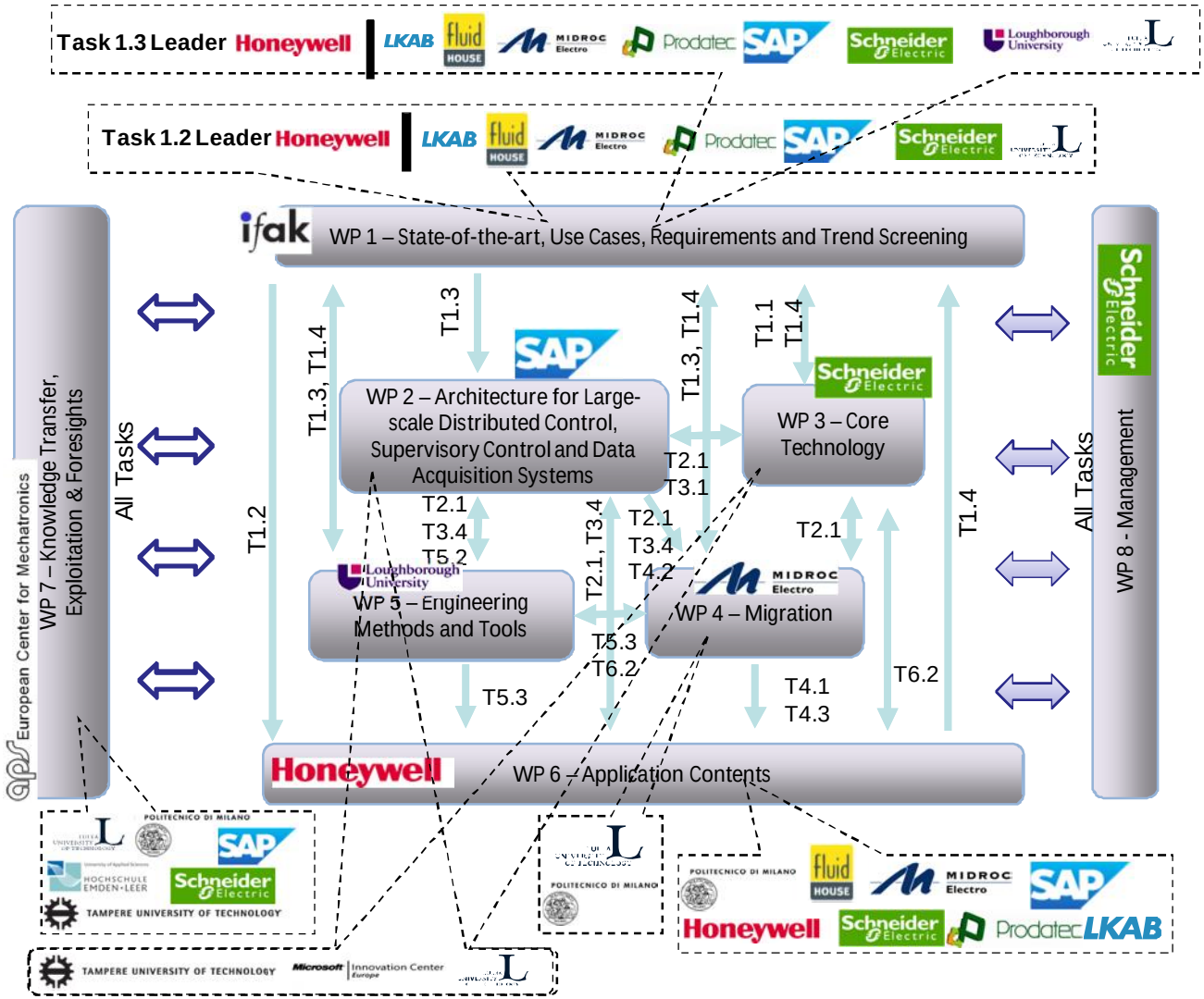
IMC-AESOP Project Structure and Work Plan (i)



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IMC-AESOP Project Structure and Work Plan (ii)

01.September.2010 **PPR 1st Release (28.02.2011)** **PPR 2nd Release (31.08.2011)** **31.August.2013**

IMC-AESOP PLAN		1. YEAR												2. YEAR												3.YEAR					
	Yearly Periods	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Total Duration	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
WP1	**Requirements**																														
T1.1	State of the art																														
T1.2	Use case																														
T1.3	Requirements																														
T1.4	Trend screening																														
WP2	**Architecture**																														
T2.1	Global																														
T2.2	Information retrieval																														
T2.3	Event based																														
WP3	**Core technology**																														
T3.1	Real time																														
T3.2	Large scale																														
T3.3	Event based																														
T3.4	Services																														
WP4	**Migration**																														
T4.1	Strategy and scenario																														
T4.2	Architectural aspects																														
T4.3	Functional aspect																														
WP5	**Tools**																														
T5.1	Cartography																														
T5.2	Modelling																														
T5.3	Prototyping																														
WP6	**Application**																														
T6.1	Metrics																														
T6.2	Prototype and validation																														
WP7	**Diss. Expl. Std.**																														
T7.1	Dissemination																														
T7.2	Exploitation																														
T7.3	Standardisation																														
WP8	**Management**																														
T8.1	Organizational																														
T8.2	Financial																														
T8.3	Quality																														
T8.4	Collaboration																														
									M1								M2												M3		

Requirements are defined **Architecture / Technology alligned** **Components are available**

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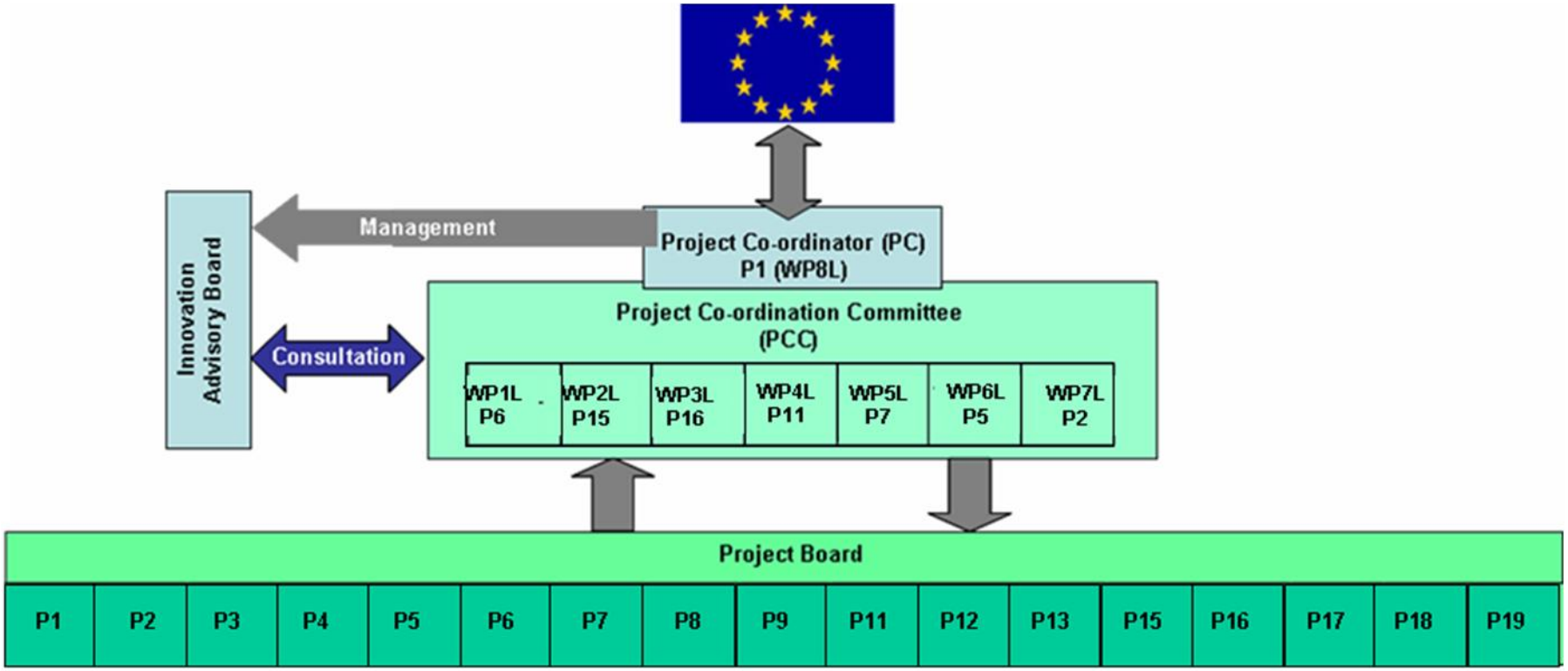
IMC-AESOP Management Structure



Note: P_i *[i=1:19]* is the partner *P* number *i*, as addressed in the List of Beneficiaries (Pages 1-2)