Technology Roadmap

Survey

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SOCRADES.EU Roadmapping Survey

We would like to invite you to take part in the SOCRADES Roadmapping Survey and contribute with your knowledge and experience to identify the next technological research directions for addressing future industrial challenges.

1 SOCRADES

SOCRADES (Service-Oriented Cross-layer infRAstructure for Distributed smart Embedded devices) is a European research and advanced development project, part of the Information Society Technologies (IST) initiative of the 6th Framework Programme of the European Commission.
Since manufacturing plays a vital role in economy and society, remaining fundamental to creating stable employment, the adoption of manufacturing innovations is needed in order to promote performance improvement of European manufacturing processes.
The primary objective of the SOCRADES project is to develop a design, execution and management platform for next-generation industrial automation systems, exploiting the Service Oriented Architecture paradigm both at the device (i.e. PLC, etc.) and at the business application level (i.e. ERP, etc.).
SOCRADES consortium is made up of 15 partners from 6 European countries. SOCRADES includes the major European players in the industrial automation sector and prestigious Academic institutions.

Within SOCRADES a Technology Roadmap is being developed. Its aim is to provide stakeholders (policy-makers, industry and research) with a vision on future technological research (in SOCRADES domain) needed in order to address the needs and challenges coming from industry.

To do so, we want to attract the largest number of experts and interested stakeholders to participate and help us to identify research priorities within four main technology areas (Service-oriented Architectures, Wireless sensor/actuator networking infrastructure, Enterprise Integration, System engineering & management).

After having completing our survey, you will be the first to receive the results of our roadmapping activity and we will send you the final version of SOCRADES Technology Roadmap.
Please help us shape SOCRADES Technology Roadmap: this survey will take approx. 10 min. All responses will be treated with ABSOLUTE CONFIDENTIALITY. Many thanks for your cooperation!

2 PARTICIPANT INFORMATION

Please, answer the following general questions about You and Your skills.

Name:

Email:

Country:

Organisation type and name:

☐ Industry ☐ Research centre ☐ University

Organisation's core business:

Role within your organisation:

3 SOCRADES Technology areas

A first step in building SOCRADES Technology Roadmap is to identify the research areas (called "Technology Areas") which should be focused in the future for addressing industrial automation needs. Four Technology Areas have been identified: here is a short description of them.

Service-oriented Architectures --- SOA

A service-oriented architecture (SOA) is a set of architectural tenets, i.e. services, for building autonomous yet interoperable systems. In SOCRADES domain, a service can represent, for example, a simple intelligent sensor, a part of a modular machine, or also a complete production system. The adoption of this paradigm, in industrial automation, can improve reconfigurability and flexibility of production systems.

Wireless sensor/actuator networking infrastructure --- WSAN

A WSAN is a distributed system of sensor nodes and actuator nodes that are interconnected over wireless links. For future industrial automation solutions, each individual sensor/actuator will be equipped with a freely programmable processor. This will allow changing paradigm from centralised to decentralised automation. Still, some design issues are not yet completely solved, depending on the actual application.

Enterprise Integration --- EI

In Enterprise Integration the focus is on seamless link between application layer (i.e. ERP, etc.) and device layer (i.e. PLC, etc.) through a common technological approach, based on the service-oriented architecture (SOA) paradigm. In the industrial automation domain, this will help create real-time enterprises, and exploit intelligence distribution to obtain active participation of devices in business process execution.

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System engineering & management --- SE

SE focuses on modelling and logic design of distributed industrial automation systems. SE tools should have the potential to not only automatically generate control logic software but to allow the support of multiple aspects of the production systems engineering life cycle. They may enable higher level design, reconfiguration and visualisation of industrial applications in a virtual environment.

Which is your research area among the following (or the nearest to your field)?

- ☐ Service-oriented Architectures
- ☐ Wireless sensor/actuator networking infrastructure
- ☐ Enterprise Integration
- ☐ System engineering & management

Where research effort should be focused to better support future industrial automation systems? Please compare each of the following pair of the technology areas, and mark the place along the segment indicating which area requires more research effort, looking at industrial automation applications.

	More research-needed ← Equal → More research-needed	
SOA	|————|————|————|————|————|————|————|————|	WSAN
EI	|————|————|————|————|————|————|————|————|	SOA
WSAN	|————|————|————|————|————|————|————|————|	EI
SOA	|————|————|————|————|————|————|————|————|	SE
SE	|————|————|————|————|————|————|————|————|	WSAN
EI	|————|————|————|————|————|————|————|————|	SE

4 Technology features

Within each Technology Area, we identified many relevant technology features that are expected (and needed) to become available in the future. After the identification phase, a selection of the most important features identified has been carried out.
Now, we ask you to compare these selected features, in order to find out which ones need more research effort in order to be implemented in the future industrial automation domain. Here we propose a brief description of each feature; they are divided following the four technology areas classification.

4.1 Service-Oriented Architectures (SOA)

- **Orchestration:** practice of sequencing and synchronizing the execution of services, which encapsulate business or manufacturing processes. The nature of orchestration makes it to be self-evolving: i.e. the orchestration can adapt itself to the requirements of the system in terms of number of services to be orchestrated and ways of orchestrating them. In the future, optimization of the orchestration process may increase its complexity, due to the increasing number of dimensions of systems. Finally the increase of features to today orchestration is expected in the next future.
- **Decision Support System:** since Orchestration by itself can not solve every problem arising during the operation of the system, a DSS is expected to increase its importance in the system. Some issues can be handled locally at the lower levels (through orchestration), but by implementing all functions in same level could neutralise the flexibility of the system, so external DSS (implemented with Expert Systems, MAS, etc.) are expected to become necessary to address complexity and reconfigurability.
- **Context-aware services:** this is the capacity of services being aware of devices, of factors such as service location or service state and in general of their environment and reacting, by adapting their functionality. Semantic description of services and ontology should be the proper tools in order to describe context, however the present state of the art does not fully address how the implementation should be carried out. Main limits are: no language to describe context and no ability to make context composition.
- **Standardization of basic functionalities (provided by services):** in the future standardization of basic functionalities should be developed. A further step is the evolution of standardization in different domains and cross-domain. A separation between the standardization of the communication technologies and the standardization of basic functionalities provided by services is needed. From the latter group of standardization many improvements and supplements are expected in the future.
- **Run-time behaviour of a SOA:** model of concurrency is core of a real-time program. Whilst concurrency model of high-integrity systems is well understood and has found representation in subsets of languages, the model is conservative. There is a need for more expressive subsets. Further solutions for handling concurrency, embodying multiple levels of abstraction have to be researched. Moreover, further study of Quality of Service models suitable for SOA (e.g.: Service Level Agreement, etc.) is required.

Please compare each of the following pair of features, and mark the place along the segment indicating which feature needs more research effort in order to be implemented in the future industrial automation domain.

	More research-needed ← Equal → more research-needed	
Orchestration	|——|——|——|——|——|——|——|——|	Context-aware services
Decision Support System	|——|——|——|——|——|——|——|——|	Standardization of basic functionalities
Context-aware services	|——|——|——|——|——|——|——|——|	Run-time behaviour of a SOA
Standardization of basic functionalities	|——|——|——|——|——|——|——|——|	Orchestration
Run-time behaviour of a SOA	|——|——|——|——|——|——|——|——|	Standardization of basic functionalities
Decision Support System	|——|——|——|——|——|——|——|——|	Context-aware services
Orchestration	|——|——|——|——|——|——|——|——|	Run-time behaviour of a SOA
Standardization of basic functionalities	|——|——|——|——|——|——|——|——|	Context-aware services
Run-time behaviour of a SOA	|——|——|——|——|——|——|——|——|	Decision Support System
Decision Support System	|——|——|——|——|——|——|——|——|	Orchestration

Moreover, do you think that a relevant feature of this Technology Area is missing and should be developed in the future? If yes, please describe it shortly.

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4.2 Wireless sensor/actuator networking infrastructure (WSAN)

- **Energy autarky (self-sufficient devices):** as a WSAN is thought to be communicating wirelessly, it makes no sense to have wires left for power supply. Another way of powering devices in a decentralized manner has to be found (e.g.: very powerful batteries, ways of energy harvesting, or a hybrid systems of both approaches). Still a very demanding research topic with only very limited solutions. Another way to reach energy autarky is optimization of energy usage (e.g., activating sensors only when useful).
- **Interoperability (heterogeneity):** today's WSAN technologies are mainly proprietary and do not provide product and/or vendor interoperability. This incurs higher costs and slows down market adoption. The emergence of WSAN standards (ZigBee, ISA SP100, WirelessHART) should facilitate the deployment of increasingly large industrial wireless networks at both plant and field levels. A key issue is the development of new models to deal with the complexity involved in such large and scalable systems.

- **Quality of Service:** this feature includes several aspects. Real-time service: wireless links by nature are less stable than wired ones and real-time requirements imply a higher degree of energy consumption. Determinism: reliable delivery of data packets with a guaranteed delay. Reliability of sensors: in particular concerning the integration of support for dependability and real-time. Efficient communication: energy use is linked to frequency of communication and to duration for each communication.
- **De-centralization:** this describes the trend in the shifting of intelligence and processing tasks towards the field level devices. Of course, this is not a dogma for all devices; some might still be communicating directly to the central unit. Generally decentralization can add robustness, flexibility and scalability to the system by reducing the number of centralized critical points. For Factory Automation de-centralization at the moment is impossible due to the requirements for real-time and determinism.
- **Self-X Features:** for reasons of easier engineering, easier maintenance, etc. features like self-organization, self-optimization, self-healing, self-describing etc. are important. Even if simple self-x features already exist (e.g. self-description), higher levels of self-x (e.g. self-optimization) are only in their infancy. R&D is needed to understand how an autonomic system can be controlled/configured, considering different needs for degree of autonomicity in different automation scenarios.

Please compare each of the following pair of features, and mark the place along the segment indicating which feature needs more research effort in order to be implemented in the future industrial automation domain.

	More research-needed ← Equal → more research-needed	
Energy autarky	|———|———|———|———|———|———|———|———|	Quality of Service
Interoperability	|———|———|———|———|———|———|———|———|	De-centralization
Quality of Service	|———|———|———|———|———|———|———|———|	Self-X Features
De-centralization	|———|———|———|———|———|———|———|———|	Energy autarky
Self-X Features	|———|———|———|———|———|———|———|———|	De-centralization
Interoperability	|———|———|———|———|———|———|———|———|	Quality of Service
Energy autarky	|———|———|———|———|———|———|———|———|	Self-X Features
De-centralization	|———|———|———|———|———|———|———|———|	Quality of Service
Self-X Features	|———|———|———|———|———|———|———|———|	Interoperability
Interoperability	|———|———|———|———|———|———|———|———|	Energy autarky

Moreover, do you think that a relevant feature of this Technology Area is missing and should be developed in the future? If yes, please describe it shortly.

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4.3 Enterprise Integration (EI)

- **Flexible Production with Enterprise Support:** future manufacturing plant will be connected to all its vital components: workers, machines, and products. To have automatic integration of manufacturing data, widening the view of manufacturing both vertically and horizontally is needed. This implies also concepts/techniques for autonomous production (i.e.: production orders automatically followed by self-preparation of machines, supply chain activation, production and self-qualification of produced parts).
- **Device to Business Integration (D2B Integration):** device manufacturers are increasing the amount of embedded software in their products. Hence, devices can handle several computing/communication tasks, but they can also provide their functionalities as services. Therefore, devices can participate in business applications by providing information from their domains and consuming services at enterprise level (e.g.: devices can directly trigger an event in the business process and affect its execution).
- **Cross-layer Adaptive Modelling:** as software development is becoming more complex, model-driven engineering technologies can help alleviate the complexity of platforms and express concepts effectively. Approaches that effectively handle service modelling and management of intelligent distributed business processes in highly populated web-service-enabled device infrastructures are needed. Business logic traditionally resided at high-level systems but in the future it will be distributed in several layers.
- **Security / Service Policy Compliance:** the future foresees an open infrastructure where rapidly changing business processes and collaboration among companies at several layers are occurring. The openness and heterogeneity of such systems is requiring a different security approach from that of traditional systems and architectures. These security architectures must be tailored to application-specific security requirements, comply/adapt to laws, and be seamlessly integrated with security environments.
- **Industrialization of software development:** software built for automation domain is often developed from scratch. However as the heterogeneity and applicable domains increase, it will be impossible to keep up tackling all needs at high quality. What is needed is to “industrialize” at a fine grained level the process of creating software in order to be able to rapidly configure, adapt and assemble independently developed, self describing components to produce families of similar but distinct systems.

Please compare each of the following pair of features, and mark the place along the segment indicating which feature needs more research effort in order to be implemented in the future industrial automation domain.

	More research-needed ← Equal → more research-needed	
Flexible Prod. with Enterprise Support	|———|———|———|———|———|———|———|———|	Cross-layer Adaptive Modelling
D2B Integration	|———|———|———|———|———|———|———|———|	Security / Service Policy Compliance
Cross-layer Adaptive Modelling	|———|———|———|———|———|———|———|———|	Industrialization of software developm.
Security / Service Policy Compliance	|———|———|———|———|———|———|———|———|	Flexible Prod. with Enterprise Support
Industrialization of software developm.	|———|———|———|———|———|———|———|———|	Security / Service Policy Compliance
D2B Integration	|———|———|———|———|———|———|———|———|	Cross-layer Adaptive Modelling
Flexible Prod. with Enterprise Support	|———|———|———|———|———|———|———|———|	Industrialization of software developm.
Security / Service Policy Compliance	|———|———|———|———|———|———|———|———|	Cross-layer Adaptive Modelling
Industrialization of software developm.	|———|———|———|———|———|———|———|———|	D2B Integration
D2B Integration	|———|———|———|———|———|———|———|———|	Flexible Prod. with Enterprise Support

Moreover, do you think that a relevant feature of this Technology Area is missing and should be developed in the future? If yes, please describe it shortly.

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4.4 System engineering & management (SE)

- **Efficient/effective (re-)configuration:** ability to configure systems built from SOA-enabled modules both statically and dynamically in a standardized manner, e.g., with predictable system performance. Flexible use of systems components coupled with a high-level system configuration capability (e.g. ERPs). Whilst individual system components may be of relatively low complexity, effective overall system configuration and change management are of key importance to the end-user.
- **High level process definition:** the ability to describe the overall behavior of systems composed of many distributed devices in a high level process description language, which directly relates to the specific process the user is concerned with. The mapping of desired process behaviour to control systems is very

time consuming and error-prone. In the future standardization of process definition and standardization of definition tools are expected in order to make the process more open and standards based.

- **Collaborative, integrated, distributed business-driven engineering:** systems capable of being configured and managed in a global business context. Support for globally distributed engineering teams. In future Web-services offer the promise of better, more open enterprise integration. This includes SOA-enabled Cooperative Lifecycle Management Design to improve the design phase in a global scenario, and maintenance, live run monitoring tools and also tools to improve the design phase of maintenance.
- **Service-oriented engineering:** engineering support provided primarily through the provision of services rather than on-site engineering activities, e.g., diagnostics, expert assistance, and process optimization will be remotely provided. Nowadays, it is provided on a single vendor/product basis. In a competitive globalised market the effective utilization of remote services will offer a key competitive advantage. SOA will help this type of remote support by linking various systems both physically and in conceptual terms.
- **SOA-enabled Digital Factory:** this includes seamless integrated digital engineering, i.e. seamlessly mix the engineering of digital, and real system components. Moreover, fully digital mock-up of machines, i.e. overall digital representation of machines, including mechanical structure simulation, process simulation, and prediction/validation of production results in design-time. Finally, Product Lifecycle Management, i.e. tools to design, analyze and manage machine tool products through all their lifecycle.

Please compare each of the following pair of features, and mark the place along the segment indicating which feature needs more research effort in order to be implemented in the future industrial automation domain.

	More research-needed ← Equal → more research-needed	
Efficient/effective (re-)configuration	|———|———|———|———|———|———|———|———|	Collaborative engineering
High level process definition	|———|———|———|———|———|———|———|———|	Service-oriented engineering
Collaborative engineering	|———|———|———|———|———|———|———|———|	SOA-enabled Digital Factory
Service-oriented engineering	|———|———|———|———|———|———|———|———|	Efficient/effective (re-)configuration
SOA-enabled Digital Factory	|———|———|———|———|———|———|———|———|	Service-oriented engineering
High level process definition	|———|———|———|———|———|———|———|———|	Collaborative engineering
Efficient/effective (re-)configuration	|———|———|———|———|———|———|———|———|	SOA-enabled Digital Factory
Service-oriented engineering	|———|———|———|———|———|———|———|———|	Collaborative engineering
SOA-enabled Digital Factory	|———|———|———|———|———|———|———|———|	High level process definition
High level process definition	|———|———|———|———|———|———|———|———|	Efficient/effective (re-)configuration

Moreover, do you think that a relevant feature of this Technology Area is missing and should be developed in the future? If yes, please describe it shortly.

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