ARTEMIS & ITEA2 co-summit

Web of Objects

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Introduction
Main motivation

Many applications
  - Industrial process control
  - Building management (heat, ventilation, air conditioning, lighting control, security, …)
  - Efficient use of multiple energy sources
  - …
require interoperability of multiple devices
  - Sensors
  - Actuators
  - Human-Machine Interfaces
  - …
at low integration cost

➤ “Web of objects”
“Web of Objects”

- Objects of the physical world

- Connected through Web protocols
  - Using “Service oriented Architecture” concepts
  - Implementing “Web Services” technology, embedded into objects
Main customer values

1- Customer Values: Analyst Reports

- “Customers rate solutions and integration capability above all other attributes”
- “Customers want Plug & Play integration and open system architectures”
- “Customers want customized solutions and interoperability, in particular. They also want to work with suppliers that can satisfy global needs”

Source: Morgan Stanley Study
What means SoA?

- It represents a philosophy / conceptual model for software organization
  - It is a set of good principles for designing open & inter-operable software
  - It is not a technology, not a standard, but an architecture philosophy!
  - These concepts are very largely used at IT level since 2000
  - One largely agreed definition: “A service-oriented architecture (SoA) is a set of architectural tenets for building autonomous yet interoperable systems.”
SoA cornerstone: notion of service

- The service is independent of the technology
  - It could be executed locally or remotely
  - It masks the real execution layer & implementation

- The service is described by a contract
  - The contract specify
    - The list of possible operations
    - The detailed format for requests / answers
  - The contract is usually described in XML language

- The service is “autonomous” for execution
  - It owns all resources required for its execution
Expected advantages of SoA

- Better flexibility/modularity of the software
  - Strong interfaces & Versioning patterns for public interfaces
- Ability for re-using existing software
- Ability for stepwise evolution
  - A stronger focus on interoperability
- Openness to third-party tools

- Decrease development & maintenance costs
- Protect investment on legacy software
- Invest gradually in new architecture without “big bang”
Web Services: The SoA implementation

- A full set of standards based on SOAP (Service Oriented Architecture Protocol)
Web Services at the device level
Why SoA and Web Services at the industrial device level?

- Plug and Play
  - Automatic device discovery, identification, configuration, monitoring and first level diagnostic … without any software installation

- Unifying architecture solution
  - From high level applications down to low cost devices

- Interoperability and openness
  - With IT applications (SAP, IBM, …)
  - Between competitors (Schneider, Siemens, ABB, …)

- “Automate the automation”
  - High level interfaces
  - “Russian doll” model
  - Mechatronic devices

- Step wise approach
“Build a system meeting given structural and behavioural requirements, from a given set of components, encompassing Heterogeneity and achieving Constructivity“

Example of Web services addressed customer values: Plug and Play

Intelligent devices

Manufactured pieces of equipment

Business applications
DPWS Open Source stacks available

- DPWS (Device Profile Web Services) is the Web Services implementation at the device level
- DPWS is under OASIS standardization
- As results from ITEA2 SIRENA and SODA projects, several Open Source stacks are available
  - [www.soa4d.org](http://www.soa4d.org)
  - [www.ws4d.org](http://www.ws4d.org)

### Protocol Stack

<table>
<thead>
<tr>
<th>WS-Discovery</th>
<th>WS-Eventing</th>
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<tbody>
<tr>
<td>WS-Addressing</td>
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<tr>
<td>WS-MetadataExchange</td>
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<td>WS-Policy</td>
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<td>WS-Security</td>
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<table>
<thead>
<tr>
<th>SOAP 1.2</th>
<th>WSDL 1.1, XML Schema</th>
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<tbody>
<tr>
<td>UDP</td>
<td></td>
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<tr>
<td>HTTP 1.1</td>
<td>TCP</td>
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<tr>
<td>TCP</td>
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<tr>
<td>IPv4/IPv6</td>
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- Devices Profile for Web Services (DPWS) protocol stack
- Full object implementation in a < 3€ component
Example: Industrial demonstrator
Web Services public industrial fair demonstration

MACH fair – UK – April 24-25, 2008

Fully distributed Web Services demonstration with Schneider devices, linked to SAP system and Loughborough tools
A test rig provided by FORD, now implementing a fully Web Services distributed control

**Before:** Standard (SE Unity) PLC system with remote IO

**Now:** Fully distributed, plug and play, linked to SAP and engineering tools, flexible and easily reconfigurable
The test rig control architecture, linked to SAP and Loughborough applications

Loughborough application design tools

SAP Business application

Loughborough 3D design and simulation tools

Manufacturing order

Manufactured product status

Manufactured product status

Feed

Buffer

Process

Handle

DPWS exchanges
Future steps
DPWS future steps

- DPWS is a strong strategic move from Microsoft
  - All new Microsoft OS are (and will) integrate DPWS (VISTA, Windows 7, Windows CE, .NET microframework)
- DPWS will be standardized by OASIS in spring 2009

- DPWS and OPC-UA merge called “DPUA” for industrial applications
  - Agreement between major European competitors (Schneider, Siemens, ABB)
  - Paving the way towards IEC standardization

- DPWS everywhere in any object
  - Now ready for a full deployment
Integration of SOA in Industrial Automation
Integration of Web-Services and Agent Technology into SoA-based Automation

Overview

- Introduction and Motivation

- Collaborative Automation and SoA
  
  *Main Concepts*

- The EU FP6 STREP InLife Approach
  
  *The SoA Use-case*

- The EU FP6 IP SOCRADES
  
  *Merging SoA and Collaborative Automation Technologies*

- Conclusions and Outlooks
Motivation/ Requirements from Customers
From rigid coupling towards dynamic reconfigurable production

Reconfigurability in real-time production conditions

- Plug-out / plug-in
- Plug and Produce/work
- Etc.
Motivation/ Requirements from Customers
Modular interoperable / interconnectable production components

Modularity of HW reflected into Modularity of Control and Automation Systems

- Plug-out / plug-in with different degrees of granularity
- Exchange/Integration of Mechatronics Modules (including Intelligent Control and Communication)
- The Embedded Component (TEC) into The Embedded Machine (TEM) into The Embedded Production System (TES)
Motivation/ Requirements from Customers
Flexible behaviour under real-time production conditions

Flexible material flow

- Chaotic flow of pallets
- Dynamic Re-scheduling to meet extrem customized production
- Short-term (local) decision-making capabilities
- Recover from un-expected situations in real-time production conditions
Collaborative Automation and Service Oriented Architectures
Towards complete decentralized and flat SoA- and Agent-based automation

Addressing customer values: Applications with SoA and WS
- Decentralized, non-hierarchical, flat application
- No gateway to specific interface
- Uniform communication protocols
- Vertical and horizontal communication
- Peer-to-peer asynchronous communication
- High level self describing real time protocols

Addressing customer values: Reconfigurability / Flexibility
- Dynamically add new devices, functions, machines.
- Duplicate machines or manufacturing lines by “icon and paste” in Intelligent Devices
- Automatically build the application by assembling mechatronics devices (e.g. conveyors)
- Full Plug and Play (Run at the application level)
- Detect and manage manufactured pieces of equipment
### Collaborative Automation and Service Oriented Architectures

**InLife: Componentization Concept / Building Blocks**

- **Each device is provided an IT frontend**
  - Harmonizes the devices with the infrastructure
  - Improves Flexibility and Scalability
  - Enables (re)composition of the system using building blocks
  - Encapsulates complexity

- **Coalition Leader Service (CLS)**
  - Orchestration
  - Aggregation

- **Manufacturing Device Service (MDS)**
  - IT Frontend for Manufacturing Devices

- **Service to Machine Interface (SMI)**
  - Legacy Integration
  - Interoperability

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**Implementation**

- Each type of service (CLS, MDS and SMI) is generic for a given family of hardware.
- Each service provides generic processing and information flow
- Each service has a typical interaction pattern

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*Integrated Ambient Intelligence and Knowledge-Based Services for Optimal Life-Cycle Impact of Complex Manufacturing and Assembly Lines*

**NMP2-CT-2005-517018**

Collaborative Automation and Service Oriented Architectures
InLife: Componentization of a Flexible Assembly Cell (NOVAFLEX)

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Hardware</th>
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<tbody>
<tr>
<td>CLS</td>
<td>Pallets, Station “Orchestrators”, Node “Orchestrators”</td>
</tr>
<tr>
<td>MDS</td>
<td>Robots, Grippers, Tool warehouses, Conveyors, Conveyors, Routing Devices, Fixing Devices</td>
</tr>
<tr>
<td>SMI</td>
<td>Bosch Controller SMI</td>
</tr>
</tbody>
</table>
The pallet is the main Coalition Leader and orchestrates its way around the system.

Each station has its own orchestrator (CLS) that according to the devices under the coalition offers different complex skills. For instance Station 2 provides pick and place and switch gripper operations under the presence of the following MDS: robot, gripper and toolwarehouse.
The full demonstration comprises 35 DPWS services
The EU FP6 IP SOCRADES
Service-Oriented Cross-Layer Infrastructures for Distributed Smart Embedded Devices

SOCRADES presents an unprecedented constellation of major European ICT players / stakeholders of the industrial value-chain (Co-ordinated by SE)

- 3-years Integrated Project (01.09.2006-31.08.2009)
- 15 Partners from 6 European Countries
- Efforts: 1100 PM
- Total Budget: 13.746.808 [Euro]

Web Page: www.socrades.eu
The EU FP6 IP SOCRADES
An Approach towards a Cross-Layer Reconfigurable Factory
The EU FP6 IP SOCRADES
A Cross-Layer Architecture

Integration of Web-Services and Agent Technology into SoA-based Automation

ERP/MES
Orchestr. j
Orchestr. j
Engineering System

WS
WS
WS
WS

Device
Distr. IO
PLC, RC
Workpieces

WS
WS
WS
WS

Service mediator
Gateway

WS
WS
WS
WS

Wireless Sensor / Actuator Network
Legacy & Low Resource Devices

IP network (wireline or wireless)

E.g., Electronics Assembly Scenario

Schneider Electric – C. Le-Pape – F. Jammes
– A. W. Colombo
SOCRADES
A SoA-based Production System: Behaviour

Embedded Web services are described using ontology in order to enable automatic discovery, selection, composition and invocation.

Embedded Web services can be orchestrated in order to create composite services.

Agents discover and select embedded Web services dynamically deployed, through reasoning processes. Then, the agents invoke the Web services in order to execute the underlying physical processes. The SOCRADES infrastructure: service-oriented devices.

Building block of the WS Stack is the WS Orchestration and WS Invocation.

Described by
Semantic WS Description

WS Management
WS Orchestration
WS Invocation

Building block of the SOCRADES infrastructure: service-oriented devices.
The 3 main messages


2. From the operational point of view, the services are offered and/or requested by self-reliant production automation units, which are stable and able to survive disturbances. The subordination to higher level components ensures the effective operation of the larger whole within an enterprise architecture.

3. The results of the first SoA-based pilot installations at industrial level are very good and promising.

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