Service-Oriented Cross-layer InfRAstructure
for Distributed smart Embedded Devices
SOCRADES

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Agenda

- Manufacturing Needs
- Socrades Answer
- Wireless Technology
- Maintenance Improvement
- Conclusions
Manufacturing Needs (1/5): Customization and time to market

- Trends in production:
  - Mass production
  - Mass customization

- Reduction of control and automation systems' time-to-market:
  - From 3-5 years to 6-9 months
Manufacturing Needs (2/5): Fill the Integration Gap

**ERP**
- Enterprise
- Resource
- Planning

**MES**
- Manufacturing
- Execution
- System

**DCS**
- Distributed
- Control
- System

**Business Level**
- DISCONNECT
- Production Control Level
- Process Control Level

**Orders**

**Invoice**

**Raw Mat.**

**Goods**
Manufacturing Needs (3/5): Concurrent and Modular Engineering

- Traditional build is largely sequential with a major bottleneck during commissioning
  - Late application verification
- Pre-designed Modules can be rapidly built with minimum engineering effort and risk
  - LOWER COSTS
  - EASIER PROJECT MANAGEMENT

Source: Loughborough University
Manufacturing Needs (4/5): Wireless technology

- **Wireless technology in industrial automation is here!**
  - Long range applications (SCADA) been around for some time
  - Emerging standards like ISA-SP100 and WirelessHART
  - Products and solutions

- **Growth in medium and short range applications**
  - WLAN on the shop floor
  - RFID
  - Process industry instrumentation
  - Discrete manufacturing control applications
  - Wireless Sensor Networks

Manufacturing Needs (5/5): Real time enterprise
Manufacturing needs: business requirements

- **Business Domains**
  - Business Activity Monitoring
  - Mobile Equipment Assistance
  - Maintenance Optimization
  - Overall Equipment Effectiveness (OEE)
  - Customized manufacturing with late order freeze
  - Automotive Domain / Remote Systems

- **Requirements for networked embedded device infrastructure**
  - Web Service Support
  - Support an Event Driven Architecture (EDA)
  - Service Lifecycle Management
  - Business Process Modeling
  - Occasionally Connected Assets
  - Occasionally Disconnected Assets
  - Business Process Monitoring
  - Alerting
  - Risk Management
  - Standardized communication and information exchange
  - Maintenance Control
  - Predictive Maintenance
  - Access to Device Status
Socrades: overview

Socrades: an unprecedented constellation of all major European ICT players of the industrial value-chain.

Main Facts
- 3-years Project (01.09.2006 - 31.08.2009)
- 15 Partners from 6 European Countries
- Total Efforts: 1100 [PM]
- Efforts 1st 18-Months: 556 [PM]
- Total Budget: 13.746.808 [Euro]
- Total EU Funding: 8.599.274 [Euro]
- Budget 1st 18-Months: 7.001.815 [Euro]
- EU Funding 1st 18-Months: 4.458.671 [Euro]
- Web site: www.socrades.eu
Socrates: an Integrated Project

Socrates goals:

- Methodologies, technologies and tools for modelling, design, implementation and operation of networked systems made of smart embedded devices.
- Co-operation of heterogeneous smart embedded devices to achieve enhanced system intelligence.
- Middleware technologies based on Service-Oriented Architecture (SOA) paradigm.
- Socrates SOA as software component encapsulating device-specific functionality.
Socrades: Partners Tasks

WP1
Trend screening, requirements, state-of-the-art, technology assessment

WP2
Framework specification for ad-hoc networking service platform

WP3
Wireless sensor/actuator networking infrastructure

WP4
Device-centric infrastructure

WP5
Service-centric infrastructure

WP6
Enterprise integration

WP7
System management & engineering

WP8
Application Pilots Demonstrators

WP9
Dissemination

WP10
Exploitation, standards & roadmapping

Other partners covering R&D activities: KTH & Lulea University
Other partner covering Research + Technology Developments: ARM

Three Industrial Application Areas for the SOCRADES Technology:

- Manufacturing (Jaguar)
- Electronic Assembly (FlexLink)
- Continuous Processes (Boliden)
Socrates: SOA

Why Service oriented Architectures in the industrial domain?

- Easy system integration
- Reliability and robustness
- Flexibility "Plug and Play"
- Interoperability (open standards)
- Real-time performance and low cost

Industrial automation complexity
Socrades: SOA

**Developing the building blocks**
Intelligent functions embedded into smart devices (profiles, HMI, tools, web, agents)

**Making the blocks work together**
Design of networked autonomous and fault adaptive systems (protocols, robust, security)

**Assuring a common objective**
Concepts, methods and tools for building robust, reconfigurable intelligent systems and guarantee expected overall system behavior
Socrades: Integration Architecture

**Socrades Middleware**
- Service Integration
- Eventing
- Service Invocation

**Smart Devices**
- SCADA/HMI Services
- DCS Systems
- MES Systems
- Custom Database
- Plant Historians
- SPC/SPC Systems
- Laboratory Systems
- Maintenance Systems

**Business Applications**
- Event Resolution Dashboards
- Manufacturing Intelligence Dashboards

**Web Services Communication**

**Enterprise Software System**

Real-time messaging, Events, Alerts…

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Socrades: System Architecture

**Application layer**
- Control Supervision
- Maintenance Management
- Manufacturing Business

**Composition layer**
- Controller
- Composite device
- Industrial PC

**Device layer**
- Device
- Gateway

**Gateway**
- Peer-to-peer Real-time messaging
- Field bus

**Alarm**
- Alarms
- Data access

**Configuration**
- Work orders

**Real-time control**
- Data access

**SOCRADES infrastructure**
- Reliable messaging
- Security
- Resource management
- Orchestration
- Semantic Web services
- Discovery & Metadata
- Agent-based control
- Dynamic deployment
- Real-time extensions
- Eventing
- Web services

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Socrades: Target Architecture
Components, Levels and Functions (Overview)

ERP/MES
WS

Device
WS

Distr. IO
WS

PLC, RC
WS

Workpieces
WS

Service mediator
WS

Gateway
WS

Engineering System
WS

IP network (wireline or wireless)

WS: Web Service capability provided by DPWS and OPC-UA

Device: Motor, valve, conveyor, drive, HMI, …
RC: Robotic Control
Service mediator or Gateway: Industrial PC, PLC, dedicated device

Wireless Sensor / Actuator Network

Legacy & Low Resource Devices

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Intelligent Web Service
Wireless technology – Why?

- **Increase productivity – productive time and utilization**
  - Flexibility
  - Availability
  - Mobility

- **Decrease cost**
  - Planning and engineering
  - Installation and commissioning
  - Maintenance

- **New applications**
  - Moving
  - Rotating
Wireless Technology & future Automation

- **ERP**
  - Enterprise Resource Planning
- **MES**
  - Manufacturing Execution System
- **Control Level**
- **Field Level**

Wireless Sensor / Actuator Networks will alter the Automation Structures beneath ERP Layer

Sensor Actuator Networks control several processes

Additional Functions
Additional Business

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Wireless Technology: Complexity of Sensor Actuator Networks

European IP
SOCRADES

Micro-electronics
MEMS

Sensors

RF

Wireless

Energy Autarky

Software

Sensor Networks

New Functionality

Sensor Actuator Networks
Maintenance Improvement vision STEP 1

- Smart embedded devices will measure and manage maintenance data for prognostics and proactive maintenance.
- The enhanced system intelligence will organise and manage maintenance activities.
Smart embedded devices will be able to carry out maintenance activities, evolving to protect, heal and correct.

Active decision taking by intelligent devices and widespread wireless communication.
Conclusions

- Distributed smart embedded components / devices with communication, information processing and embedded intelligence, showing capabilities like
  - self-discovery
  - automatic dynamic re-/configuration
  - real-time plug and play
  - structural and behavioural, horizontal and vertical collaboration (from shop floor to higher level of Inter- and Intra-enterprise levels)
  - ....and direct knowledge/interaction with manufactured pieces of equipment.

- Cross-Layer collaborative infrastructures that are
  - open for extensions to unknown devices and/or aggregation of devices
  - able to use uniform protocols for vertical and horizontal, peer-to-peer asynchronous communication
  - able to use wired and wireless media

- Manufacturing system intelligence by a large population of smart and networked embedded devices at a high level of granularity.