IP for Smart Objects
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Promoting the use of IP in networks of Smart Objects
Sensor/Control Networks are everywhere … with a vast scope of applications

- Energy Saving (I2E)
- Intelligent Building
- Defense
- Improve Productivity
- Enhance Safety & Security
- Smart Home
- Predictive maintenance
- Enable New Knowledge
- Food & H20 Quality
- High-Confidence Transport and assets tracking
- Healthcare
The Current Trend: a poor adoption choice

- In terms of technology there are many ad-hoc alliances and proprietary protocols
- The results: a very fragmented market with NO interoperability
- Push from customers to access these networks using IP
- One PHY will not fit all of the needs and requirements
- Use of protocol translation gateways are unworkable
  - Non-scalable and inefficient
  - Hard to operate and manage
  - Expensive to install and maintain
  - Break end-to-end security and integrity
One solution: IP

- IP is independent of physical layer
- IP works on 8 and 16 bit micro-controllers
  - limited memory, processing, battery operated
- Stack requires only 4k of RAM, less than 32K of Flash
- Leverage existing IP protocols

The solution:

**IP for Smart Objects**
Objectives of IPSO

- Create awareness of available and developing technology with IP for Smart Objects
- Generate tutorials, white papers and highlight use cases
- Complement the IETF which defines standards, but does no marketing
- Link companies that support IP based sensing and control systems
- Coordinate and combine member marketing efforts
- Support and organize interoperability events
Structure of the IPSO Alliance

● Simple 2 tier structure
  ● **Promoter** – voting rights, elect and serve on BoD
  ● **Contributor** – participate in all events and committees

● Fees: $5000 for Promoter; $2500 for Contributor

● Board of Directors – Define Alliance strategy, external communications, direct internal activities

● Technical Advisory Board – Review technical publications, oversee technical committees

● Committees (to date):
  ● MarCom; Interoperability; Membership

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IPSO Alliance use only @2008
Founding members

- Arch Rock
- Atmel
- Cimetrics
- Cisco
- Duke Energy
- Dust Networks
- Électricité de France R&D
- Eka Systems
- Emerson Climate Technologies
- Ericsson
- Freescale
- Gainspan
- IP Infusion
- Jennic
- Kinney Consulting
- Nivis
- PicosNet
- Proto6
- ROAM
- SAP
- Sensinode
- SICS
- Silver Spring Networks
- Sun Microsystems
- Tampere University of Tech.
- Watteco
- Zensys

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Alliance Actions

Support Activities

- 6LoWPAN Working Group
- ROLL Working Group
- ISA100 Industrial Wireless
- IEEE Working Groups

On-going Activities

- Interoperability Testing
- Architecture Design
- Technology Demonstrations
- Use Cases / White Papers
- Tutorials and Educational Materials
● **Internet Protocol**
  - Time tested standard for interoperability
  - Open and Scalable
  - Leverage – No need to reinvent the wheel
  - Efficient for these small devices

● **Purpose of the Alliance**
  - Member companies coming together to realize the benefits of embedded IP solutions
  - Spread the word and demonstrate the technology
The IPSO Alliance will extend the reach of IP into “Internet of Things”
The EU FP6 IP SOCRADES
Service-Oriented Cross-Layer Infrastructure for Distributed Smart Embedded Devices

Unprecedented constellation of all major European ICT players of the industrial value chain
(Coordinated by SE)

3-years Project (01.09.2006-31.08.2009)
15 Partners from 6 European Countries
Effort: 1100 PM
Total Budget: 13.746.808 €
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Services and Web Services

- **Service** is a software interface that encapsulates the functionality of a device or process.

- **Service-Oriented Architecture (SOA)**
  - Service provider
  - Service requestor
  - Service broker

- **Web Services**
  - Specific technology for SOA, XML-based
  - SOAP for invocation (XML/HTTP)
  - WSDL for Service Advertisements (publish/locate)
Semantic Web Services

- **Web** – Distributed repository of data
  - Processed and interpreted by humans
- **Semantic Web** – Distributed repository of machine-interpretable knowledge, using ontology
  - Processed and interpreted by software entities

- Use ontology to describe Web Services
  - **Semantic Web Services**

- Software Agents can process service ontologies:
  - Discover machines/devices
  - Select machines/devices
  - Invoke machines/devices
  - *Using inference – without previous knowledge on the services*
The Target: Cross-Layer Infrastructure based on Semantic Web Services (SOCRADES)
Industrial State of the Art in Middleware

Own experiences in the Electronics manufacturing Domain
IPC/CAMX MOM

- CAMX MOM is based on SOAP
- Provided communication models:
  - publish/subscribe messaging channels: messages associated to topics, for one-to-many communication
  - point-to-point messaging channels: for one-to-one communication
- Guaranteed Message Delivery
- Messaging channels have a MOM server as an intermediary
  - Asynchronous communication
  - Processes don’t need to wait on other processes
CAMX Protocol Stack

- Computer Aided Manufacturing using XML
- Simple Object Access Protocol
- eXtensive Markup Language
- Hyper Text Transfer Protocol

[Diagram showing the protocol stack with layers:
- Presentation: XML: IPC-25xx Messages
- Session: SOAP: CAMX/IPC-2501
- Transport: HTTP
- Network: TCP
- Data Link: IP
- Physical: IP Enabled Networks (Ethernet, ATM, ModBus, etc)
- Copper, Optical, Wireless, etc]
• Missing mechanisms/standards for:
  • Discovery (of new CAMX “clients”)
  • Security (by mistake different CAMX clients were addressed equally in the domain configuration)
  • The abstract models are a great starting point, but the UML Class diagrams are not enough descriptive and they do not capture formally the existing knowledge -> need for ontologies
  • No QoS provisions
  • Scalability
  • ...

• **HOWEVER**: today CAMX provides still an advantage for industries and industries are in their way to adopt it
We moved to Semantic Web Services combined with decision support systems using multiagents
DPWS and 6LoWPAN Stacks

**DPWS API**
- WS-Discovery
- WS-Eventing
- WS-Security
- WS-Policy
- WS-MetadataExchange
- WS-Addressing
- SOAP 1.2
- WSDL 1.1, XML Schema
- IP v4/v6

**Socket API**
- UDP/ICMP
- IPv6 6LoWPAN
- IEEE 802.15.4
Embedded Web services are described using ontology in order to enable automatic discovery, selection, composition and invocation. Agents discover and select embedded Web services through reasoning processes. They invoke the Web services in order to execute the device-oriented devices underlying physical processes. Embedded Web services can be orchestrated in order to create composite services.
Synthesis of component PN-models done by PN "Compiler" tool.

Typical factory layout done by PN "Compiler" tool.

Component linkage information.

Simulation, Validation, Analysis of the complete production system model.

Component's PN-model Library.

Enterprise Integration MES/ERP.

Daily Production List (DPL) Active Production List (APL) Bill of Materials (BOM)…

Orchestration Engine interprets Service providers Service consumers Interpreters DPWS stack Generic services SOCRADES container Service providers Service consumers Interpreters DPWS stack Generic services SOCRADES container...
Understanding Semantic Web Services

- **Semantic** Web Services are Web Services that are *augmented* by a machine-interpretable *description*

- The software implementation of the service is exactly the same

- The service is described by an *ontology* that serves as user guide for autonomous software agents

- Any Web Service can be a Semantic Web Service
Our pragmatic Approach

- Web Ontology Language (OWL) is used to create the proposed Product, Equipment and Services ontologies and for the Process Taxonomy.
- These ontologies will become our knowledge base at run time.
- The WSDL standard is used to describe services,
- … and by using SAWSDL (SemanticAnnotations for WSDL) it is possible to include semantic information in the WSDL files.
- This semantic information is nothing more than attributes based on the XML Schemas which contain pointers to the previously created knowledge base.
Future Directions
Collaborative Automation and Service Oriented Architectures in the Industry
Web Services: Schneider Prototype Implementations (R&D Agenda)