Service-Oriented Architectures for Smart Manufacturing Project

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Agenda

• SOA for Smart Manufacturing Project: An Overview
• Message Standards Development and Use: Problems and Needs
• A Model-Driven Approach: Core Components Standard Approach
• Traditional vs. Model-Driven Approach to Message Standards Use
• NIST Tools in Support of Model-Driven Message Standards
• Summary
Cloud-Enabled Service-Oriented Manufacturing

How best to transition?

ERP – Enterprise Resource Planning
MOM – Manufacturing Operations Management
SCADA – Supervisory Control and Data Acquisition

Integrability, Interoperability, and Composability

• Integrability
  • Enables correct information exchange by using correct protocols.

• Interoperability
  • Enables correct understanding of meaning by using correct conceptual models.

• Composability
  • Enables correct consequences of interaction by using correct behavior models.
Integrability, Interoperability, and Composability

- **Integrability**
  - Enables correct information exchange by using correct protocols.

- **Interoperability**
  - Enables correct understanding of meaning by using correct conceptual models.

- **Composability**
  - Enables correct consequences of interaction by using correct behavior models.

Message standards are key to achieving services interoperability.
Why is This Significant?

• The number of manufacturing services is growing substantially.
• Soon, all manufacturers will need to be using those services.
Need: Increased Efficiency of Services Integration

• Manufacturers will need to assure their business processes are supported and improved by services
• They will be looking for optimal services out there
  • Ease of integration, configuration, and re-configuration
• The services will need to be interoperable and composable, based on standards.
A Leading Message Standards Development Organization: Open Applications Group Inc.

Who Uses Open Applications Group Integration Specification (OAGIS)?
Overview of the OAG Integration Specification (OAGIS)

• Specifies message definitions (BODs) for integrations of business and engineering applications (*manufacturing services*)

• Supports many industries
  • Automotive, Aerospace, Defense, Process Manufacturing, Electronic Manufacturing, Construction, etc.

• Supports nearly all operational areas of a manufacturing enterprise
  • Sales, manufacturing, supply, and financials

• Contains 1000+ BODs
Problems

• BOD complexity
• Single syntax support
Problem: A Complex Standard

A BOD can contain between 58 and 300k+ data fields!!!
Need: Profiling Capability

The ability to create from a standard BOD
• Simpler
• More specific, and
• More precise

BOD specification, for
• Each specific industry
• Each specific process
• Other specific aspects
Problem: A Syntax Specific Standard

Front Office Applications
- CRM
- Custom
- Hosted
- eStore
- Portals
- Self Service
- Other

XML / XML Schema

Back Office Applications
- ERP
- Supply Chain
- B2B
- Legacy
- Analytics
- Service Providers
- Custom
Need: Multiple Syntax Support

Model Driven Approach

Syntax Independent OAG Standard

Production Rule for JSON Schema
- Cloud and Mobile Platform
  - OAG JSON Schema Standard

Production Rule for XML Schema
- Enterprise Integration Platform
  - OAG XML Schema Standard

Production Rule for OWL/RDF Schema
- Business Intelligent Platform
  - OAG RDF Schema Standard
Overview of CCS Modeling Methodology

Core Component

Business Information Entity

Business Context

Profile BOD Information Entity

Context Category Values

- Electronics
- Retail
- Manufacturing
- Category

Make-to-Stock

Assemble-to-Order
Functional Requirements to CCS Mapping

Core Component
- Syntax Independent BOD

Semantic Restriction

Business Context
- Usage Situation

Business Information Entity
- Syntax Independent, Context Specific Profile BOD

Syntax Specific Generation

Profile BOD in XML Schema

Profile BOD in JSON Schema
Example

- **Core Component** + **Business Context** = **Business Information Entity**
  - **Bill of Materials** + **Sales, Assemble-to-Order, Electronic Mfg** = **Super BOM**
  - **Bill of Materials** + **Fulfillment, Assemble-to-Order, Electronic Mfg** = **Instance BOM**
  - **Bill of Materials** + **Manufacturing, Assemble-to-Order, Electronic Mfg** = **Manufacturing BOM**
  - **Bill of Materials** + **Sales, Retail** = **Bundle**
Traditional Message Standards Use (1)
Traditional Message Standards Use (2)
Traditional Message Standards Use (3)

- Core OAGi Standard Message Definitions in Language L1
- Application Schemas
- Document Editor: Human Developer-based Message Profiling
- Profile Message in Implementation Language L1
- SW Developer
- Integration Requirements
- Business Process Analyst

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Phase Overview:
- Design Phase
- Implementation Phase
Traditional Message Standards Use (4)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Business Process Analyst
Integration Requirements
Application Schemas

Core OAGi Standard Message Definitions in Language L1

Document Editor
Profile Message in Implementation Language L1

SW Developer

Hard to Reuse

Hard to Reuse

Design Phase
Implementation Phase
Traditional Message Standards Use (5)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Integration

Application Schemas

Core OAGi Standard Message Definitions in Language L1

Document Editor

Profile Message in Implementation Language L2

Profile Message in Implementation Language L1

Hard to Reuse

Business Process Analyst

Integration Requirements

Business Process Analyst

Integration Requirements

Design Phase

Implementation Phase
Model-Driven Message Standards Use (1)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Design Phase
- Business Process Analyst
- Business Process Catalog
- Business Process Context Model
- Business Process Classification Tool

Implementation Phase
- Profile Message in Implementation Language L1
- Business Process Analyst
- Business Process Catalog
- Business Process Context Model
- Business Process Classification Tool

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource
Model-Driven Message Standards Use (2)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource
Model-Driven Message Standards Use (3)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Business Process Analyst

Integration Engineer

Core Component Model
- Syntax Independent OAGi Standard Message Definitions

OAGi Standard Repository

Semantic Restriction

Business Information Entity
- Syntax Independent, Context Specific Profile Message

Context
- Usage Situation

Business Process Context Model

Business Process Catalog

Business Process Classification Tool

Profile Message in Implementation Language L1

Design Phase

Implementation Phase

Legend:
Model-Driven Message Standards Use (4)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Design Phase
- Integration Engineer
- OAGi Standard Repository
- Core Component Model
  - Syntax Independent OAGi Standard Message Definitions
- Semantic Restriction
- Context
  - Usage Situation
- Business Information Entity
  - Syntax Independent, Context Specific Profile Message
- Business Process Context Model
- Business Process Catalog
- Business Process Classification Tool

Implementation Phase
- Business Process Analyst
- Language L1 Specification
- Syntax Specific Generation
- Profile Message in Implementation Language L1
- Business Process Analyst
Model-Driven Message Standards Use (5)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Core Component Model
- Syntax Independent OAGi Standard Message Definitions

OAGi Standard Repository

Semantic Restriction

Context
- Usage Situation

Business Information Entity
- Syntax Independent, Context Specific Profile Message

Integration Engineer

Language L2 Specification
- Specification

Profile Message in Implementation Language L2

Low-cost re-implementation

Syntax Specific Generation

Profile Message in Implementation Language L1

Profile Message in Implementation Language L1

Business Process Context Model

Business Process Catalog

Business Process Classification Tool

Design Phase

Implementation Phase

Integration Engineer

Business Process Analyst
Model-Driven Message Standards Use (6)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Integration Engineer

Core Component Model
Syntax Independent OAGi Standard Message Definitions

OAGi Standard Repository

Semantic Restriction

Business Information Entity
Syntax Independent, Context Specific Profile Message

Context
Usage Situation

Business Process Context Model
Business Process Context & Semantic Constraints Specification

Business Process Catalog

High Potential for reuse

Business Process Analyst

Profile Message in Implementation Language L1

Profile Message in Implementation Language L2

Language L2 Specification

Syntax Specific Generation

Language L1 Specification

High Potential for reuse

Design Phase

Implementation Phase
Model-Driven Message Standards Use (7)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Integration Engineer

Core Component Model
Syntax Independent OAGi Standard Message Definitions

Semantic Refinement Tool (SRT)

Low-cost re-implementation
Profile Message in Implementation Language L2

High Potential for reuse

High Potential for reuse

Syntax Specific Generation

Profile Message in Implementation Language L1

OAGi Standard Repository

Business Process Catalog

Business Process Context Model
Business Process Context & Semantic Constraints Specification

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

High Potential for reuse

Business Process Analyst

Implementation Phase

Design Phase

Syntax Specific Generation

Profile Message in Implementation Language L1

Syntax Independent, Context Specific Profile Message

Business Information Entity

Context
Usage Situation

High Potential for reuse

Business Process Classification Tool
Model-Driven Message Standards Use (8)

Legend:
- Manual Effort or Human Readable Document
- Automated Process or Computer Processable Resource

Integration Engineer

Core Component Model
- Syntax Independent OAGi Standard Message Definitions

Semantic Refinement Tool (SRT)
- Profile Message in Implementation Language L2
- Profile Message in Implementation Language L1
- Low-cost re-implementation

Business Process Context Model

Business Process Cataloging & Classification System (BPCCS)
- Business Process Catalog

Business Process Analyst

Context
- Usage Situation

High Potential for reuse

High Potential for reuse

Business Information Entity
- Syntax Independent, Context Specific Profile Message

Syntax Specific Generation

Implementation Phase

Design Phase
Why These Two Tools?

• Semantic Refinement Tool & Business Process Cataloging and Classification System have been selected to
  • Boot-strap Model-Driven approach to message standards
  • Enable low-hanging fruit and engage industry early in the R&D process
Semantic Refinement Tool: Quick Overview

• Developed a new syntax-independent data model and structure for OAGIS standard - based on CCS (ISO 15000-5) standard

• Designed a cloud-based architecture for collaborative message specification management

• NIST developed and verified a prototype Semantic Refinement Tool (SRT) with feedback from OAGi members.

• NIST transitioned the prototype to develop a cloud-based multi-tenant implementation
Business Process Cataloging and Classification System: A Quick Overview

• Created the BPCCS meta-model based on ebRIM (ISO/TS 15000-3) standard
• Developed and verified a BPCCS prototype with feedback from OAGi industry members.
• Validating prototype for message profiling and business process search
Summary

• The project helps industry address interoperability challenges for Service-Oriented Manufacturing (SOM)

• Industry requires improved message standards and their development processes

• The project team worked with industry and responded with
  • New model-driven approach to development and use of message standards
  • Software tools in support of the new approach
    • Semantic Refinement Tool (SRT)
    • Business Process Cataloging and Classification System (BPCCS)