Enterprise architecture frameworks with semantic models as a foundation for complex networked operations

TUTORIAL

Semantic Days 2009, May 18th-20th, Stavanger, Norway
Enterprise architecture frameworks with semantic models as a foundation for complex networked operations

- Enterprise architecture frameworks like Zachman, EIF (European Interoperability Framework) DODAF/MODAF/NAF (Defense Architectural Frameworks), TOGAF and others provide an important foundation for the understanding and planning of business models and system models for complex networked operations both in industry, eGovernment and crisis management/defense. This ensures both alignment between business and IT, and also provides a better foundation for system interoperability in networked systems. We will demonstrate the approach using ODM (Ontology Definition Metamodel) with OWL for semantic modelling, BMM (Business Motivation Model) and BPMN (Business Process Modeling Notation) and ARIS/EPC (Event Process Chains) with a transformation so system and service specification in SoaML (Service oriented architecture Modeling Language) with further realization in heterogeneous service oriented architectures (SOA) including web services, Cloud Computing/SaaS (Software as a Service), P2P/Grid and agents. We will show how semantic annotations from existing system specification to an ontology can support semantic interoperability. A basic understanding of business modelling or system specification is an advantage, but experiences in enterprise architectures, semantic models or any of the specific technologies that will be presented is not required.
Agenda

(I) Enterprise Architecture, TOGAF, UPDM (Arne, Ulf, Dima)
- Zachman, TOGAF, MODAF/DODAF/NAF, MDA, UPDM - Arne
- Saarstahl SHAPE - Dima
- European ATM/SESAR - Ulf

(II) INFORMATION and ONTOLOGY MODELING (UML/ER, ODM/OWL with examples/tools) Arne (Ulf, Dima)
- Conceptual Modeling, Information Modeling, Ontologies - Ulf and Arne
- ODM with OWL for semantic modeling (WSMT) - Dima

(III) PROCESS MODELING (EPC/BPMN with examples/tools) (Dima)
- ARIS/EPC (Event-Driven Process Chains) - Dima
- BPMN (Business Process Modeling Notation) - Dima

(IV) SERVICE MODELING and Interoperability (SoaML with examples) (Arne)
- SoaML (Service oriented architecture Modeling Language) - Arne
- Semantic annotations, SAWSDL, from existing system specifications to an ontology can support semantic interoperability - Arne
Relevant OMG and other modeling standards

- EA: Zachman and TOGAF
- UPDM – (MODAF, DODAF, NAF), TOGAF
- UML 2.0 – updated for architecture modeling
- MDA – Model Driven Architecture
- BPMN – Business Process Modeling Notation
- BMM – Business Motivation Model
- SysML – Systems Engineering Modeling Language
- ODM – Ontology Definition Metamodel
- OWL – Ontology Web Language
- SoaML – SOA Modeling Language
- SAWSDL – Semantic Annotation of WSDL/XML (W3C)

See www.omg.org
Representations of Architecture

ARIS

ZACHMAN

GERAM

EN/ISO 19439

Athena OEA

NIST
Selected standards and technologies

- Zachman, TOGAF, DODAF/MODAF/NAF, ARIS, EIF
- OWL, RDF, ODM, (UML, Topic Maps, ISO 15926, …)
- BPMN, EPC
- SysML and SoaML
- WS-*, SWS (OWL-S, WSMO), Agents, P2P, Grid, Cloud, SaaS
- SAWSDL
Zachman Framework – for Enterprise Architecture

<table>
<thead>
<tr>
<th>VA Enterprise Architecture</th>
<th>DATA</th>
<th>NETWORK</th>
<th>PEOPLE</th>
<th>TIME</th>
<th>MOTIVATION</th>
<th>Based on work by John A. Zachman</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCOPE (CONTEXTUAL)</strong></td>
<td>What</td>
<td>Where</td>
<td>Who</td>
<td>When</td>
<td>Why</td>
<td>Planner</td>
</tr>
<tr>
<td>Planner</td>
<td>Things Important to the Business</td>
<td>Processes Performed</td>
<td>Business Locations</td>
<td>Events Significant to the Business</td>
<td>Business Goals and Strategy</td>
<td>Scope (CONTEXTUAL)</td>
</tr>
<tr>
<td><strong>ENTERPRISE MODEL (CONCEPTUAL)</strong></td>
<td>Planner</td>
<td>People =  Major Business Organizations</td>
<td>Important Organizations</td>
<td>Time = Major Business Event</td>
<td>End/Means = Major Business Goals</td>
<td>Planner</td>
</tr>
<tr>
<td><strong>SYSTEM MODEL (LOGICAL)</strong></td>
<td>Owner</td>
<td>Work = Work Product</td>
<td>Time = Business Event</td>
<td>Master Schedule</td>
<td>End = Business Objective</td>
<td>System Model (LOGICAL)</td>
</tr>
<tr>
<td><strong>SYSTEM MODEL (LOGICAL)</strong></td>
<td>Owner</td>
<td>Enterprise Unit</td>
<td>Time = Business Cycle</td>
<td>Business Plan</td>
<td>End = Business Objective</td>
<td>System Model (LOGICAL)</td>
</tr>
<tr>
<td><strong>TECHNOLOGY MODEL (PHYSICAL)</strong></td>
<td>Owner</td>
<td>People =  Organization Unit</td>
<td>Time = System Event</td>
<td>Plan</td>
<td>End = Structural Assertion</td>
<td>Technology Model (PHYSICAL)</td>
</tr>
<tr>
<td><strong>TECHNOLOGY MODEL (PHYSICAL)</strong></td>
<td>Owner</td>
<td>Business Processes</td>
<td>Time = Processing Cycle</td>
<td>Design</td>
<td>End = Action Assertion</td>
<td>Technology Model (PHYSICAL)</td>
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<tr>
<td><strong>BUILDER</strong></td>
<td>People =  Identity</td>
<td>People =  Role</td>
<td>People =  Identity</td>
<td>People =  Role</td>
<td>Strategy</td>
<td>BUILDER</td>
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<td>Strategy</td>
<td>BUILDER</td>
</tr>
</tbody>
</table>

Based on work by John A. Zachman.
Open Group
TOGAF ADM

Architecture Development Method
ARIS House
Three Views in C4ISR-AF, DODAF, MODAF, NAF, (UPDM)

 Operational View
- Identifies What Needs to be Accomplished and Who Does It
- Basic Technologies
- New Technical Capabilities
- Basic Technology Supportability
- Operational Requirements
- Systems that Support Information Exchanges
- Information Exchanges Required to Get it Done
- What Needs to Be Done
- Who Does It

 Systems View
- Relates Systems and Characteristics to Operational Needs
- Specific System Capabilities Required to Satisfy Information Exchanges
- Technical Standards Criteria Governing Interoperable Implementation/Procurement of the Selected System Capabilities

 Technical Standards View
- Prescribes Standards and Conventions
Business Motivation Model (BMM) with MeansRealizations
EIF version 2.0 (2009)
Definition: Interoperability

"Interoperability is the ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organizations via the business processes they support, by means of the exchange of data between their respective information and communication technology (ICT) systems."

In fact, interoperability is often confused with other, related concepts. It can be therefore a useful exercise to observe explicitly what interoperability is NOT:

- Interoperability is not **Integration**, which is a means of changing loosely coupled systems to make them into more tightly coupled systems.
- Interoperability is not **Compatibility**, which is more about the interchangeability of tools in a particular context.
- Interoperability is not **Adaptability**, which is a means of changing a tool, adding additional capabilities as needed even on an ad-hoc basis, whereas interoperability refers to inherent capabilities.
EIF - Dimensions of Interoperability
Interoperability levels

Cooperating partners having compatible visions, and focusing on the same things.

The appropriate synchronization of the legislation in the cooperating MS so that electronic data originating in any given MS is accorded to proper legal weight and recognition wherever it needs to be used in other MS.

The processes by which different organisations such as different public administrations collaborate to achieve their mutually beneficial, mutually agreed eGovernment service-related goals.

Ensuring that the precise meaning of exchanged information (concept, organisation, services, etc) is preserved and well-understood.

The technical issues involved in linking computer systems and services (open interfaces, interconnection services, data integration, middleware, data presentation and exchange, accessibility and security services, ...)

Political Context

Legal Interoperability

Legislative Alignment

Organisational Interoperability

Organisation and Process Alignment

Semantic Interoperability

Semantic Alignment

Technical Interoperability

Syntax, Interaction & Transport
OMG Model-Driven Architecture (MDA)

www.omg.org/mda
MDA
CIM, PIM and PSM/Code

**Computational Independent Model**
- **CIM**
  - ATL
  - BPMN, POP*, ARIS, ArchiMate, GERAM, GRAI, Zachman, UEML, B.Rules

**Platform Independent Model**
- **PIM**
  - BPDM, SBVR, EDOC, UPMS, PIM4SOA, ODM
  - MOFScript, ADM

**Platform Specific Model/Code**
- **PSM**
  - BPEL, WSDL, XML, XPDL, OWL-S, WSML, WSDL-S
  - ADM

**Code, Java JEE, ....**
SHAPE project partners and roles

See www.shape-project.eu
# SHAPE Reference Matrix

<table>
<thead>
<tr>
<th>Aspect / Level</th>
<th>Information</th>
<th>Service</th>
<th>Process</th>
<th>Rules</th>
<th>Events</th>
<th>Organization</th>
<th>Goals</th>
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<tbody>
<tr>
<td><strong>CIM</strong></td>
<td>MM</td>
<td>Ontologies - ODM (SPM/ESM taken into account)</td>
<td>BPMN/EMF</td>
<td>SBVR</td>
<td>EPC (BPMN/EMF)</td>
<td>OSM</td>
<td>BPM</td>
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<td></td>
<td>Tool</td>
<td>Objecting, WSMT</td>
<td>Objecting</td>
<td>CIMFlex</td>
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<td>COMET-S, OASIS, ESIM, SCM, SM, SMART, Soma, ISE, ESAO</td>
<td>UML Class diagram, ODM, EMM</td>
<td>UML Behaviour (BPMN)</td>
<td>(BPR)</td>
<td>(BPR)</td>
<td>(BPR)</td>
<td>OGSMA, Participant, UML Deplom, Element, (Agent Goals), (WSAO Goals)</td>
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<td>XJTA</td>
<td>RIF</td>
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<td>Jack, Plane, Jade, Behaviors</td>
<td>Jack, Events, Jade, Messages</td>
<td>Jack, Team, Jade, Agent, Organ</td>
<td>Jack, Goals, Jade</td>
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<td>OWL, WSML</td>
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<td>WSMD NFP</td>
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<td>P2P</td>
<td>-</td>
<td>JXTA</td>
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<td>Grid</td>
<td>Grid Resource Ontologies</td>
<td>OGSOA (Open Grid Service Architect)</td>
<td>OGSOA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Grid Security Infrastructure (GSI)</td>
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</tbody>
</table>
CIM-PIM-PSM

Adopted to SoaML

SoaML-SHA

SoaML

Service Variability

PIM4
- WS-A
- SWS
- Agents
- P2P/Grid/Components

WSDL, WSMO, OWL-S, JACK, JADE, JXTA, OGSA, J2EE, CORBA

J2EE, NetWeaver, .Net, ...

BPMN
BPDM
BMM
EPC
...

CIM
- Business Models

PIM
- System Models

PIMs for different Architectural Styles

PSM
- Implementation Models

Realization Technologies
UPDM History
(UML Profile for DODAF and MODAF)

DoDAF v 1.0
(2004)

OMG Kickoff

MODAF v 1.0

Three Initial Submissions
Raytheon + Team Telelogic
IBM + Team

RFP issued

MODAF v 1.0

Two Revised Submissions

Feb 2005
Sept 2005
June 2006
Nov 2006
Dec 2006
March 2007
June 2007
March 2008
June 2008
Sep 2008
Dec 2008
March 2009

DoDAF v 1.5
Draft Inputs

Unified Submission

OMG Adopts UPDM

UPDM FTF Voted Down

UPDM RFC Interim

UPDM RFC Submission

OMG Vote to Adopt

UPDM FTF2

DoDAF v 2.0
Draft for review
Nov 2008 ?

Team 1 (IBM) & Alpha Merge

UST (Raytheon +) and Telelogic Merge As Team Alpha

UPDM RFC Formed

UPDM History
(UML Profile for DODAF and MODAF)

Models replace documents as the primary product or artifact of SE processes.

Document-centric

Model-centric
UPDM: Context – Introduction

Context

- Stakeholders
  - US DoD
  - UK MOD
  - NATO
  - Canada/Australia
  - OMG, INCOSE

- OMG
  - XMI, UML, SysML
  - BPMN
  - UPMS, BMM

- End Users
  - Aerospace
  - Commercial

- Tool Vendors
  - Software
  - Systems
  - Enterprise

UPDM Domain Meta Model

UPDM Profile Meta Model

UML4SysML

SysML Extensions

UPMS, BMM, SBVr Extensions

Products -- Reports -- Simulations
Context – DoD AFD 1.0 / 1.5 ….2.0 Ontology

Figure 2-1: Fundamental Linkages Among the Products and Architecture Data Elements

Figure 2-2: Architecture Products by Use

Figure 2-4: Example Object-Oriented
How: UPDM Compliance Levels
SysML diagrams
How: Information Flow into SysML and UML

UPDM System Development

Acquisition View (AcV) → All View (AV)
Strategic View (StV)
Operational View (OV)
Service Oriented View (SOV)
Systems View (SV)
Technical View (TV)

Systems Development with SysML and UML

Hardware System
Software System
Procedural System
Mechanical System
Chemical System

Reuse
UPDM RFC - Domain Meta Model

- Package structure organizes stereotypes by viewpoint
- Multiple viewpoints manage model complexity
EA Tool support

- EPC – ARIS
- UPDM – MagicDraw, Enterprise Architect
- Troux
- BPMN: 50+ tools
- SHAPE project: CIMFlex, Objecteering
Enterprise architecture frameworks with semantic models as a foundation for complex networked operations

Enterprise Architecture:
Problem areas
Saarstahl, Statoil, Eurocontrol Use Cases
Example – StatoilHydro

- Ongoing activity in the SHAPE project
- Ref. Presentation by Einar Landre on Wednesday
Agenda

- Saarstahl Example
  - Problem Domain
  - Use Case “Coordination between rolling mills and steel works”
  - Modeling Example
Problem Domain

- Saarstahl – German steel manufacturing company with global presence on the steel production market.

- Saarstahl – recognized for a high level of competence in the field of steel production and further processing.

- Saarstahl – one of the most important manufacturers of long products (i.e. bars or rods) in the world.

- Saarstahl – important preliminary products for the automotive, construction, the aerospace industry, general mechanical and power industry engineering, and other steel processing branches.
Steel Production

- Steel production – first phase of most Supply Chains in different areas

- Steel manufacturing companies are strongly affected by bull whip effect:
  - Irregular nature of incoming orders
  - Frequently changing customer requirements on accepted orders

- Therefore → it is important to improve operational efficiency

- Needed: flexible planning and scheduling systems handling considerable amounts of data
Planning Efforts

- **Existing systems:**
  - Commonly centralized decision making approaches
  - Mostly data driven
  - Often not modeling the business processes conveniently

- **Saarstahl made great efforts to deal with the planning and scheduling problems along its production chain:**
  - Steel production is a disassembling, continuous process and resulting in a vast number of different products
  - Time restrictions are more important than in other production chains, since certain processes cannot be interrupted
  - For instance, hot metal leaving the blast furnace factory must be transformed and casted into steel billets within a certain time
Supply Chain of Saarstahl

- Blast Furnace Dillingen
- Steel works Völklingen
- Rolling mills Nauweiler
- Rolling mills Burbach
- Rolling mills Neunkirchen

Processing Stages:
- Arrangement
- Pickling
- Annealing
- Saw Cutting

Customers:
Agenda

- Saarstahl Example
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  - Modeling Example
Use Cases Overview

- Coordination between Rolling Mills and Steelworks
- Capacity planning of Annealing Furnaces
- Creation and Optimization of Heats and Sequences
- Cross-plant order coordination from steel works’ point of view
Coordination Use Case

Sales Department → Planing Department → Steel works Völklingen → Semi-finished product inventory → Rolling mills Nauweiler, Rolling mills Burbach, Rolling mills Neunkirchen
Saarstahl Pilot Case

- Specification of business models and requirements:
  - Formalize business models (CIM-level) using EPCs (event-driven process chains) or BPMN (business process modeling notation).
  - Ensure the business models will contain information wrt. involved organizational units, provided functionalities, and exchanged data and resources.

- Model transformations from CIM to the SoaML/ShaML.

- Model transformations from the SoaML/ShaML to Semantic Web Services, agents, P2P and Grid systems.
Use Case Challenges

- How to simplify the choreography of the 4 rolling mills and the steelmaking plant?

- Which kind of service interaction patterns should be used (e.g. multiagent systems)?

- How to formulate business requirements on the CIM-level that can then be easily translated into a running system?
Agenda

- Saarstahl Example
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Modeling Example
European Air Traffic Management

Ulf Larsson
LFV
Semantic Days Norway 18-20 May
Single European Sky ATM Research, SESAR

- Why started European Commission SESAR?
  Reduction of Cost, automation and rationalisation of ATM!
- Budget 22 billion Euros (2 billion used within the DP-phase –2006 to 2008)
- A new approach SESAR addresses the entire ATM? airports, ANSPs, Air Space Users (airlines), MIL, others
- A common joint development - SESAR Joint Undertaking (SJU)
  - 2009 till 2013 IP1
  - 2013 till 2017 IP2
  - 2017 till 2020 IP3

50% % - 50%
Participants in SESAR?
SESAR Definition Phase (start 2006 end March 2008)

The Market
- Analyse air transport value and role of ATM

Its Requirements
- Performance Requirement COMPLETED

The Top Product
- ATM Target Concept selection COMPLETED

How to Build it
- Deploymen COMPLETED
- Analysis sequence

Action Plan
- Build the ATM COMPLETED Master Plan

Go!
- Define organisation & work-programme 2008-2013

24 months including CONOPS
Information Management addresses both Air-Ground and Ground-Ground Data and ATM Service Exchange. Information Management is supported by a set of architectural elements (the SWIM infrastructure) underpinned by a communication Network – opposed to closely coupled interfaces.
Objectives and activities

Capacity: 3 fold increase (represents 73% on 2004 traffic for 2020)
Safety: Increase by a factor of 10 (ensure no negative safety impact on 2020 traffic)
Environment: 10% reduction by flights (applicable 2020)

Cost: 50% reduction (applicable to 2020)
Main Gaps!

- Missing the Enterprise level of Architecture
- Formal Business Process models
- Formal Information Models
- Formal Operational Goals
- Formal Service Model Framework
- The Development is not driven from Business Perspective
- Missing Service Oriented mindset, too much focus on Systems
The future ATM architecture – its focus!

It is about BPM and Service and less about systems and functions!

Systems will be system-objects in a larger ATM architecture, and within LFV an architecture office is required!
Transition ..a cooperative effort forward!

Previous vision
Platform-centric, service embedded, large conflict, well established C2

New vision
Network-centric, interoperable, joint, integrated, flexible

Future structure

Revolution

Evolution
What is the goal/objectives more than reducing the costs?

- It is about building seamless and interoperable distributed information systems within ATM;
  - Reuse of information and components (soft-ware components),
  - Share on-line operational information e.g. concerning flights and information that may affect a flight etcetera
- In a flexible way make new demand/requirements possible (opposed to system flexibility)
- The development requires new methods, tools, architecture (description) frameworks and formal description languages
Concept Description
Enterprise Architecture Framework

Fragmentation
• Existing systems
• Development projects
• Interoperability
• Operational usage

Alignment
• Commonality
• Consistency
• Coherence
• Interchange
• Standardisation
• Increased cost/benefit
Concept Description
Enterprise Architecture Framework

MoDAF 1.2 and NAF (NATO Architectural Framework)

- Each View represents a specific Perspective of the Architecture
- Each View contains subviews

STRATEGIC Views
Articulate high-level requirements for enterprise change over time – capabilities, goals, ensuring tasks

OPERATIONAL Views
Articulate operational scenarios, activities, and information flows

SERVICE Views
Articulate services, their interfaces, behaviour and policy

SYSTEM Views
Articulate the solution specification – resources, functions & interactions

ACQUISITION Views
Articulate programme, dependencies, milestones and statuses

TECHNICAL STANDARDS Views
Articulate policy, standards, guidance, constraints & forecasts
Concept Description
Enterprise Architecture Framework

A framework Meta-model describes the content and relationships between views.
The expected relationship and content can be used to check completeness.
Enterprise Architecture

Figure 22: Boundary between operational requirements and implementation
What is on-going concerning architecture frameworks?

A global standardisation activity UPDM!
The outcome of SESAR DP!

- SESAR DP documented;
- Performance Based Approach, 11 KPAs are described to guide decision makers in order to reach the Vision (Cost / Effectiveness, Capacity, Interoperability etc.)
  - EAEA perspectives
  - SOA vs Service-Oriented Architecture (SoS, FoS)
  - Enterprise Architectural Framework
  - MDA (Modelling Driven Architecture)
  - NetCentric ("Intranet of ATM")
  - The development should follow a "top-down approach"

ATM Europe has started changing the suit and it is a comprehensive paradigm shift which affect all levels within ATM ("requires a change in mind set").
Logical Architecture 2020

Figure 11: High level European ATM System 2020 logical architecture
Key Performance Areas (ICAO, SESAR)

- Safety
  - uniform_safety_standards_risk_assessments_and_management
  - environmental_atm_system_performance
- Environmental_sustainability
  - risk_prevention_occurrence_of_unlawful_interferences
- Security
  - control_monitor
- "ATM Business Concept" Governance
  - fundamentals_for_the_governance
- Performance
  - business_trajectory_planning_stage
  - atm_changes_identification
- Societal_outcome
  - societal_and_political
- Operational_performance
  - assessing_operational_performance
  - business_concept-performance_measurement
  - air_space_users_ability_to_modify_requirements_dynamically
- Standard
  - global_standards_uniform_principles_to_ensure_technical_and_operational_interoperability
- Performance_enablers
- Participation
  - global_standards_uniform_principles_to_ensure_technical_and_operational_interoperability
  - airspace_users_access_to_atm_resources
- Interoperability
- Access_and_Equity
  - price_of_the_air_traffic_services
  - assessing_operational_performance
  - business_concept-performance_measurement
- Efficiency
- Predictability
- Cost_effectiveness
- Flexibility
- Capacity