Enterprise Architecture (EA)
Service-Oriented Architecture (SOA)
Web Services Architecture (WSA)

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Outline

- What is an architecture?
- Enterprise architecture and enterprise modelling
- Interoperability
- Enterprise architecture and SOA
- Integration, SOA and Web services
- References
What is an architecture?
Different kinds of architectures

- Enterprise architecture
- Business architecture
- Conceptual architecture
- Functional architecture
- Architecture framework
- Service-oriented architecture
- Realisation architecture
- Information architecture
- ICT architecture
- Integration architecture
- Knowledge architecture
- Logical architecture
- Web services architecture
Enterprise architecture (EA) is the practice of applying a method for describing a current and/or future structure and behaviour for an organization's processes, information systems, personnel and organizational sub-units, so that they align with the organization's core goals and strategic direction.

- Holistic view of the enterprise and all its important assets.

Service-oriented architecture (SOA) is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. [OASIS 2006]

- Architectural style for designing (technical) systems.

Web services architecture (WSA) intends to provide a common definition for understanding Web services. A Web services architecture involves many layered and interrelated technologies. [W3C 2004]

- A set of enabling Web technologies for implementing software systems.
IEEE Std 1471-2000

- IEEE Std 1471-2000
  - IEEE Recommended Practice for Architectural Description of Software-Intensive Systems
  - Adopted September 2000

- Architecture definition
  - Structure(s) of a system in terms of
    - components,
    - their externally visible properties,
    - their relations,
    - and the underlying principles

- Common frame of reference for architectural descriptions
  - Common terminology
    - architecture, architectural description, model, view, viewpoint, system, stakeholder, concern, …
The fundamental organisation of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution.

Developed using the methods established by its viewpoint, consisting of views of expressing an architectural description.

The expression of a systems architecture with respect to a particular viewpoint. Addresses one or more of the concerns of the system stakeholder.

Has interest in, or concerns relative to the system.

Those interests which pertain the system’s development, operation and other aspects that are critical or otherwise important to one or more stakeholders.
Architecture of what and for whom?

Virtual enterprise

Business

Software system

Software component

Software object

Decomposition

EA

SOA

WSA

ICT
Enterprise architecture and enterprise modelling
History of enterprise architecture

The major pioneering efforts:
- Zachman Framework - initiated 1978
- ARIS tool set - 1988
- First Metis tool set - 1991
- Troux Knowledge Repository - 2002

Four major approaches:
- Systems development case tools - 1984
- IT process modelling - 1986
- Product and process modelling - 1989
- Business process management - 1995
- Enterprise architecture modelling - 1997
Why enterprise architecture?

How can I involve my people in improving the performance of the business?

How can I use best practices to ensure the success of the business?

How can I ensure that the IS technology helps the work of my people?
Governance with enterprise architecture

- Architecture is a strategic tool
  - not just high-level design
  - Architecture goes beyond ICT
  - Enterprise architecture is a key component of the IT governance process at any organization of significant size.

- Stability and flexibility
  - Seem to be contradictory, but a good architecture facilitates change!

- Communication with stakeholders
  - architects, managers, customers, engineers, …

- Analysis
  - impact-of-change
  - cost and performance

- Enterprise Architecture (EA) is a generic, abstracted and aggregated representation of the core structures and competences of an enterprise.

- EA supports laying out the main characteristics of the enterprise to be analysed and agreed before detailed technical design is started.

- It is shared and discussed enterprise-wide between all stakeholders as a common description forms, functions and features, components, properties and relationships.
Role of enterprise architecture

Describing coherence

Enterprise modelling

Enterprise modelling (EM) is a capability for externalising, making and sharing enterprise knowledge.

EM tools can either be:
- used stand-alone to produce various kinds of model views,
- integrated as front-ends to other systems,
- part of an environment providing a contextual user-environment.
Enterprise modelling languages

- Enterprise modelling languages should allow building the model of an enterprise according to various points of view such as: function, process decision, economic, etc. in an integrated way.
- Languages defined at high level of abstraction as constructs for EM are independent of the technology of implementation.

Examples are:
- IEM
- Metis Enterprise Architecture Framework (MEAF)
- CIMOSA
- GRAI
- IDEF
- PSL
- WPDL
- XPDL
- BPML
- EDOC
- BPDM
- BPDM
- EPC
- Archimate
Enterprise architecture frameworks

- Enterprises architecture frameworks are fundamental structures which allows defining the main sets of concepts to model and to build an enterprise.
- Architectural frameworks are designed to define views of specific enterprise domains.
- Frameworks lack capabilities for
  - meta-data management
  - role-driven viewing
  - integration with platforms
  - model-driven design
  - generation of interoperable solutions

- Examples are:
  - ZACHMAN
  - GERAM
  - GRAI
  - ARIS
  - CIMOSA
  - DoDAF
  - TOGAF
  - TEAF
  - Troux/Metis/AKM
  - ISO 15745
  - MISSION
Representations of architecture
<table>
<thead>
<tr>
<th>VA Enterprise Architecture</th>
<th>DATA</th>
<th>FUNCTION</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>SCOPE (CONTEXTUAL) Planner</td>
<td>Things Important to the Business</td>
<td>Processes Performed</td>
<td>Business Locations</td>
<td>Important Organizations</td>
<td>Events Significant to the Business</td>
<td>Business Goals and Strategy</td>
<td>SCOPE (CONTEXTUAL) Planner</td>
</tr>
<tr>
<td>TECHNOLOGY MODEL (PHYSICAL) Builder</td>
<td>Physical Data Model</td>
<td>System Design</td>
<td>Technology Architecture</td>
<td>Presentation Architecture</td>
<td>Control Structure</td>
<td>Rule Design</td>
<td>TECHNOLOGY MODEL (PHYSICAL) Builder</td>
</tr>
<tr>
<td>DETAILED REPRESENTATIONS (OUT-OF-CONTEXT) Sub-Contractor</td>
<td>Data Definition</td>
<td>Program</td>
<td>Network Architecture</td>
<td>Security Architecture</td>
<td>Timing Definition</td>
<td>Rule Design</td>
<td>DETAILED REPRESENTATIONS (OUT-OF-CONTEXT) Sub-Contractor</td>
</tr>
<tr>
<td>FUNCTIONING ENTERPRISE</td>
<td>Data</td>
<td>Function</td>
<td>Network</td>
<td>Organization</td>
<td>Schedule</td>
<td>Strategy</td>
<td>FUNCTIONING ENTERPRISE</td>
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**Zachman Framework**

**ICT**

**SINTEF**
Enterprise Unified Process (EUP)

**Development Disciplines**
- Business Modeling
- Requirements
- Analysis & Design
- Implementation
- Test
- Deployment

**Support Disciplines**
- Configuration and Change Mgmt.
- Project Management
- Environment
- Operations & Support

**Enterprise Disciplines**
- Enterprise Business Modeling
- Portfolio Management
- Enterprise Architecture
- Strategic Reuse
- People Management
- Enterprise Administration
- Software Process Improvement
Interoperability
Interoperability research

- **Project type:** Network of Excellence (NoE)
- **Full title:** Interoperability Research for Networked Enterprises Applications and Software
- **Project duration:** 3 years
- **Project budget:** 12.0 M€
- **EU IST funding:** 6.5 M€
- **Partners/contractors:** 50
- **Start date:** Nov 1, 2003
- **Web page:** [www.interop-noe.org](http://www.interop-noe.org)

- **Project type:** Integrated Project (IP)
- **Full title:** Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications
- **Project duration:** 3 years
- **Project budget:** 26.5 M€
- **EU IST funding:** 14.4 M€
- **Partners/contractors:** 19
- **Start date:** Febr. 1, 2004
- **Web page:** [www.athena-ip.org](http://www.athena-ip.org)
Rationale for interoperability

- Interoperability is the key to increase competitiveness of enterprises.
- “Enterprise systems and applications need to be interoperable to achieve seamless operational and business interaction, and create networked organizations” – European Group for Research on Interoperability, 2002

**Application integration license revenue**

(Source: the Yankee Group 2001)

**System implementation budget**

- Integration 40%
- Imp. Services 20%
- Software 10%
- Hardware 10%
- Misc. 20%

The cost of non-interoperability are estimated to 40% of enterprises IT budget.
Knowledge integration

- The originality of the projects are to take a multidisciplinary approach by merging three research areas supporting the development of Interoperability of Enterprise Applications and Software:
  - **Architecture & Platforms**: to provide implementation frameworks,
  - **Enterprise Modelling**: to define Interoperability requirements and to support solution implementation,
  - **Ontology**: to identify Interoperability semantics in the enterprise.
## 4-layered view of an enterprise

<table>
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<tr>
<th>Business Operational Architecture</th>
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<tr>
<td>Operations</td>
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<tr>
<td>Laws, rules, principles</td>
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<tr>
<th>Enterprise Knowledge Architecture (EKA)</th>
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<tr>
<td>Enterprise methodology</td>
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<td>Metamodels and languages</td>
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<th>Information and Communication Technology (ICT) Architecture</th>
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<td>Business and user services</td>
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<td>Software platforms</td>
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### Semantics
- Dictionaries
- Ontologies
- Nomenclatures
- Classifications

### Nomenclatures and Classifications
- Business terms
- Laws, rules, principles
- Agreed norms and practices
- Procedures and routines

### Operations
- Strategy
- Governance
- Metamodels and languages
- Product models
- Reference architectures

### Software platforms
- Modeling tools
- Management tools

### Infrastructure services
- EKA services

### Business and user services
- Operations
- Strategy
- Governance
Holistic approach to interoperability

To achieve meaningful interoperability between enterprises, interoperability must be achieved on all layers:

- **Business layer**: business environment and business processes
- **Knowledge layer**: organisational roles, skills and competencies of employees and knowledge assets
- **ICT layer**: applications, data and communication components
- **Semantics**: support mutual understanding on all layers

**Interoperability (def.)** is “the ability of two or more systems or components to exchange information and to use the information that has been exchanged” – IEEE Standard Computer Dictionary
Enterprise architecture and SOA
Motivation for SOA

Enterprise
- Challenges
  - Business agility
  - Flexibility and adaptability
- Enterprise architecture frameworks
  + Holistic approach
  + Different views of an enterprise as related (visual) knowledge models
  - Current enterprise architectures are only blueprints

ICT
- Challenges
  - Inflexible and difficult to adapt
  - Enterprise application integration (EAI)
- Service-oriented architecture (SOA)
  + Architectural style
  + Loosely coupled systems
  + Horizontal integration between different business domains
  + Use case oriented service composition
  +/- Web services (enabling technology)

Requirements
- Enterprises require operational enterprise architectures
- ICT solutions must be designed to be inherently interoperable
Business and technology alignment

**Business**
- Services can be seen as business capabilities that support the enterprise.
- Services usually represent a business function or domain.
- Services provide the ‘units of business’ that represent value propositions within a value chain or within business processes.
- Traceability between the service as a business capability and its technical implementation.
- Services will improve delivery methods that are an integral part of the business product.

**Technology**
- Modular design
- Compositions and granularity
- Services are loosely coupled
- From compile-time and deployment-time dependencies to run-time dependencies
- Dynamic discovery and binding
- Services are standardized (“platform independent”)
- Standard Internet and Web protocols as the common “glue” to provide “syntactical interoperability”
Problems with current EA frameworks

- User's problems
  - A lot of enterprise architecture proposals on the "market"
  - However, it is usually difficult to understand, compare and choose
- Researcher's problems
  - There is no justification, nor evaluation of existing enterprise architectures
  - No adequate architecture representation language, too many different views and levels of detail
  - Confusing notions between Enterprise Architecture, Enterprise Model, Enterprise Infrastructure
  - Lack of standardized terminology and collaboration between different EA communities (system engineers, software engineering,…)
- Engineer's problems
  - There is no "architecture continuity", it is difficult to transform an architecture from conceptual to implementation levels, and vice versa
  - There is no "architecture interoperability", enterprise applications built on different architectures are not interoperable
  - There is no scientific "architecture principles" like we have in the construction or shipbuilding domains, enterprise architecting is still a matter of experience
ATHENA's approach to operational EA

EA is the holistic expression of the enterprise’s key business knowledge, information, application and technology strategies and their impact on business functions and processes, that:

- Guides investment strategies and decisions
- Provides the framework needed to innovate the business
- Consists of the current targeted Enterprise Knowledge Models (EKMs):
  - EBA: Enterprise Business Architecture
  - EKA: Enterprise Knowledge Architecture
  - EIA: Enterprise Information Architecture
  - EAA: Enterprise Application Architecture
  - ETA: Enterprise Technology Architecture
- Oversees integration across the core architectures that provides a synchronized set of EA artefacts that needs to be created, collected, organized and communicated to enable adaptation to change business and technology
- Is defined and deployed through the company-wide process councils
Enterprise architecture viewpoints

 Integrates Across EBA, EKA, EIA, EAA

**Business Processes**
- Information Flows (between processes)
- People, Teams, RAA
- Business Policy & Strategy

**Business Information**
- Information Policy & Strategy

**Applications**
- Application Data
- Data Flows (between Apps)
- Application Policy & Strategy

**IT Platform and Infrastructure**
- Hardware & OS
- SW Services & Middleware
- Productivity Apps.
- Technical Policy & Strategy
From EM to Enterprise Visual Scenes (EVS)

- Utilizing the powers of visual enterprise knowledge scenes
- Redefining Enterprise Knowledge Modelling
- EM is externalizing and sharing enterprise knowledge, developing the enterprise knowledge architecture and enabling EVS.
- EKM is extending EM by Intelligent Infrastructure and knowledge architectures to support continuous enterprise architecting, business management and more.

![Diagram](image)

- Different kinds of views to support process roles.
- Four types of views: meta-data, content, functional and context.
- Many kinds of diagrams
- Views can also be turned into and be models
- Views have their specific view styles, and dependencies.
Enterprise architecture layers – Integrated by intelligent infrastructures

*Inter-related reflective views of key roles – replacing frameworks as mosaics of static kinds and types of views (the knowledge legacy from paper carriers)*

**Layers, aspects:**

**Business layer:**
Methods, models, operations, strategy, governance, …

**Enterprise Knowledge Architecture (EKA) layer:**
POPS methods, EIS templates, UEML +++

**ICT architecture layer:**
Services as reusable tasks, servers and EKM repositories

**Logic and content:**

Law, rules, principles, agreed practices and norms, day to day routines

User views (types and kinds), Enterprise-models and sub-models, Meta-models:
Languages, Structures and Type-hierarchies

Access services, capabilities to integrate legacy systems, extract data, handle parameterised sub-models
The **Process Dimension** includes constructs related to activities, tasks and processes going on in the enterprise or between enterprises.

The **Organisation Dimension** focuses on organisational structures, as well as members and positions thereof. Also, focus is set on interaction between structures, both as a whole and between members.

The **Product Dimension** is used to model product architectures or product structures, for the purpose of design, development and engineering or product data management.

The **Decision Dimension** is concerned with the collection of concepts and constructs that allow describing the decision-making structure in terms of decision centres and decision activities.

The purpose of the **Infrastructure Dimension** is to support modelling of infrastructures and the services they provide.
Mutually reflective views

- An object in one view will have reflections in other dimensions
  - No orthogonal, layered meta-hierarchy
  - No difference between modelling and metamodelling
- View connections and dependencies are designed or automatically created
- Types and kinds of views for each design role
- A content view for role A may be a definition view or functional view for role B
Enterprise Knowledge Spaces (EKSs) are externalised knowledge spaces of four or more knowledge dimensions that contain mutual and complex dependencies of domains and elements in the four dimensions.
Modelling Platform for Collaborative Enterprises (MPCE)

The integrator of all systems and provider of new solutions

Model-designed and generated working environments supporting concurrent design, planning and execution.

Model-generated workplaces with business and user services

The ICT infrastructure is a platform of software component services.

The ICT infrastructure is a platform of software component services.
Integration, SOA and Web services
The waves of client/server technology

Base Source: Client/Server Survival Guide, 1994
Robert Orfali, Dan Harkey
OS/2 Edition, VNR Computer library + AJB update 2004
Web service

- Web service
  - “Applications identified by a URI, whose interfaces and bindings are capable of being defined, described and discovered as XML artefacts. A Web service supports direct interactions with other software agents using XML-based messages exchanged via Internet-based protocols.” (W3C)
  - [http://www.w3.org/](http://www.w3.org/)

- SOA ~ architectural style
- Web services stack ~ technology/protocol standards
- SOA =/= Web services
Web services architecture

- Web services can be used to implement service-oriented solutions.
- They adhere to the set of roles and operations specified by the service oriented model.
- They have also managed to establish a standardized protocol stack.
WS-* stack to-be

- Simplified version of the to-be WS-* stack
  - Families of related specs not expanded
  - Competing spec families not shown
  - “Historical” or abandoned specs not shown
WS-* stack as-is

- Complete version of the as-is WS-* stack
  - The 3 widely-accepted specs today are the same as 5 years ago
  - BPEL and WS-Security is gaining momentum
  - Orchestration, discovery and brokering do not exist in today’s world
Application architecture vs. SOA
SOA and integration

- Fundamental change for integration: X <-> Y
  - Pre-SOA: outside, after development
  - Post-SOA: inside, integral part of development / computational model

- Consequences
  - How should integration be done?
  - Innovation and experience
  - Competition, expansion, consolidation

- Not understood:
  - IDC Directions 2006 (3/2/06): SOA important but not understood or deployed as claimed
  - Gartner (2/15/06): “Globally, organizations placing minor emphasis on understanding the role of data integration in SOA and creation of data services at the foundation of their architectures”
History of integration

1950 – 2006: Integration = develop then integrate
- 1950s-1970s: Simple, manual integration
- 1970s-1980s: Distributed Computing
  - Applications (interoperation)
  - Databases (integrate)

1990s: Business Driven Integration – concepts, technologies, and tools – increased automation, internet-based computing
- Concepts: Workflows, Processes, Web,
- Integration solutions blossom (diverge): ETL, EAI, BPM, …

2000: SOA Emerges
- 2000: Web services
- 2003: Integration solution evolution accelerates, vendor chaos ensues
- 2005: Growth in all integration categories
Integration in SOA

- 2006 – 2012: Integration = dominant programming model
  - 2001-2010: Wrapping
  - 2005-2010: Re-Engineering
  - 2006-2008: Consolidation
  - 2006-2008: Research on Semantic SOA
  - 2007-2012: Emergence of SOA Platforms and Solutions
  - 2006-2012: Problem Solving Era: IT/integration relegated to low level function
SOA platform consolidation

- Data and information integration ➔ Information Fabric
  - EII: Enterprise information integration
  - ETL: Extract, transform and load
- Application integration ➔ Integration Suite
  - EAI: Enterprise application integration
  - B2Bg: Business-to-business gateway
  - ESB: Enterprise service bus
- Applications and Processes ➔ Business Process Management Suite
  - BPM: Business process management
  - B2Bi: Business-to-business integration
- Enterprise workplace ➔ Interaction Platform
SOA Framework: Process + Applications + Data

Business Process Management Suite

Information Fabric

Virtualized Data
Goal: Composite applications


Extensions: Adapter, collaboration, analysis, reporting, development, monitoring, contracts, SOA standards, …
Business process management suite & interaction services

- Goal: Continuous process improvement
- Components: BPM
  - human-centric: people-intensive processes
  - Integration-centric: system-intensive processes
Information fabric services

- Goal: Holistic view of data (information virtualisation)
- Components: DBMS, EII + ETL + replication
- Extensions: Distributed meta-data repository, distributed data access, integrated data management
Trends

- Consolidation ↔ comprehensive platforms
- Merging of Human Workflow and System Orchestration/Process services
- Integration of Business Rules Engines
- Support for Event Notification services (publish and subscribe)
- Integration of Model-generated workplaces and role/task-oriented user interfaces, user interaction services, portals, and multi-device interfaces
- Explicit use of models (Enterprise and System)
- Enterprise architecture + SOA
References
References