

# Enterprise Architectures – Enabling Interoperability Between Organizations

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**Abstract.** Interoperability is central to any form of collaboration between organizations, as it enables information and knowledge sharing by cooperating entities within and across organizational boundaries. Interoperability is particularly important in the public sector where collaboration between public agencies is necessary to realize the notions of seamless services and one-stop government. Enterprise Architectures comprise models and tools to support decision-making and development particularly related to IT applications within an enterprise. This paper presents a survey of Enterprise Architectures focused on the question to what extent they support interoperability among organizations. The work has been carried out as part of a project to build a foundation for the development of an interoperability infrastructure for Electronic Government.

**Key words:** Enterprise Architectures, Interoperability, Electronic Government, Collaborations.

## 1 Introduction

Enterprise Architectures (EAs) are essential for aligning activities and supporting decision making at different levels of an organization. In addition, they support planning and provide the necessary information to support interoperability within and between organizations. In particular, the information captured by EAs may be used to specify, develop and validate interoperability infrastructure solutions.

Currently, there are various EA models and frameworks available for streamlining the development and maintenance of concrete EAs. The resulting EA may be affected by several aspects of these models such as: (i) abstraction level - whether the EA only provides abstract classifications and concepts or concrete models and solutions; (ii)

the type of the organization described, e.g. public versus private; and (iii) the nature of the EA – a framework or a reference model.

This paper provides a comparative analysis of EA models with emphasis on the level of support they provide to technical, semantic and organizational interoperability for both inter- and intra-organizational interactions and collaborations. The outcome comprises two main contributions: a characterization of concrete EA models based on interrogative attributes, allowing organization to use these attributes as criteria for selecting an EA model regarding interoperability concerns, and a guide for developing an ideal EA model from the interoperability point of view.

The rest of this paper is organized as follows. Section 2 presents the core concepts relevant to the survey. Section 3 explains the methodology applied. Sections 4 and 5 describe the results of the survey and a summary of the analysis carried out. The final Section 6 presents some conclusions.

## **2 Background**

The core concepts relevant to the survey are presented in this section, focusing on Interoperability in Section 2.1 and on Enterprise Architectures in Section 2.2.

### **2.1 Interoperability**

In the context of Electronic Government, Interoperability is the ability of ICT systems and business processes in government agencies to share information and knowledge within and across organizational boundaries, in order to better support the provision of public services as well as strengthen support to public policies and processes [1].

Three fundamental Interoperability types - Organizational, Semantic and Technical - can be used to analyze infrastructure solutions. Organizational Interoperability is concerned with defining business goals, modeling business processes and facilitating collaborations between organizations that wish to exchange information, but have different internal structures and processes. Semantic Interoperability ensures that the meaning of exchanged information is understandable in the same way by all applications in collaborating agencies. Technical Interoperability involves linking computer systems and services through the use of open interfaces, interconnection, data integration, middleware, and data presentation and accessibility functions [2].

### **2.2 Enterprise Architectures**

An enterprise is an organization that comprises interdependent resources, with coordinated functions and information-sharing to support the organization's business scope and mission [3, 4]. The mission is never completely fulfilled, as it evolves over time. As this happens, a sequencing plan is required showing at least the current and the target state of the enterprise. EAs can be used to capture these states, describing the components, their structure and interrelationships, and principles and guidelines governing their design and evolution over time [5].

An EA enables a good management practice whereby the resources are aligned to improve business performance and help the organization better execute its mission. The EA describes the current and the desirable future state of the organization, and lays out a plan for transformation from the current to the future state [6].

In order to streamline EA description, development and maintenance, two different EA types - EA frameworks and EA reference models - are employed:

- EA Framework - provides an extensible skeleton for initial development and maintenance of an EA. EA Frameworks are best suited to develop a vertical Enterprise Architecture specific to a concrete business domain.
- EA Reference Model - provides support to consistent development and application of EAs across multiple organizations. EA Reference Models are best suited to guide the horizontal integration of multiple EAs [7, 8, 9].

### 3 Methodology

Six EA models were chosen with the intention to cover the differences in the level of abstraction, the target organization type, and nature of the EA. Despite these differences, a single assessment scheme highlighting strengths and weaknesses of each EA model was applied. The scheme aims to analyze to what extent each model supports the different types of interoperability in intra- and inter-organizational processes.

The assessment scheme comprises two sets of attributes: descriptive and interrogative. Descriptive attributes comprise aim, development, structure and process, while interrogative attributes cover Technical, Semantic and Organizational Interoperability, enabling to answer the following questions:

1. Technical – Does the model address Technical Interoperability?
2. Participants – Does the model enable specification of collaborating participants within a single organization as well as between organizations?
3. Business Processes – Does the model enable the description of internal collaborations as well as collaborations involving third-party organizations?
4. Interaction Purpose – Does the model enable the specification of types and the nature of services and functions (e.g. certification or authorization)?
5. Interaction Constraints – Does the model enable the specification of constraints, for instance regulations or rules, to guide interactions?
6. Semantic Assets – Does the model enable the specification of conceptual models and ontologies to describe other enterprise information assets?

### 4 Survey

In this section the body of the survey is presented. Six EA models were surveyed: (1) Zachman's framework; (2) Federal Enterprise Architecture (FEA), (3) Standards and Architectures for eGovernment Applications (SAGA), (4) Governance Enterprise Architecture (GEA), (5) The Open Group Architecture Framework (TOGAF), and (6) A Modeling Framework for Collaborative Networked Organizations (MFCNO).

#### 4.1 Zachman's framework

The Zachman's Framework aims to provide a logical structure to classify and organize descriptive representations of an enterprise. It has been used as a foundation for analysis and development of many EA Frameworks.

**Development:** The Framework was published by J. A. Zachman in 1987 [10, 11], and is currently maintained by the Zachman Institute for Framework Advancement.

**Structure:** The framework structures the representations of an EA into a schema of six columns and five rows. The rows represent the roles (perspectives) involved in the definition of an EA: Planner, Owner, Designer, Builder and Subcontractor. The columns describe the questions each architectural representation should answer: What, How, Where, Who, When and Why.

**Process:** The Framework does not provide a process.

**Table 1.** Zachman's Framework

Criteria	Supports?	Comments
Technical	Yes	It provides place-holders for technical aspects.
Participants (Internal)	Yes	It provides place-holders for identification of the main participants, roles and relationships within the organization.
Participants (External)	Partial	At the scope level, it provides a place-holder for listing of external parties that are related with the organization, but it does not explicitly capture the roles they play within the organization.
Process (Internal)	Yes	The owner's perspective holds models that describe business processes of the organization.
Process (External)	Partial	It does not provide an explicit place-holder for interactions across the borders of the organization.
Interaction Purpose	No	It does not support description of the purpose of interactions with third party organizations.
Interaction Constraints	Partial	The motivation column provides some rules that could be applied to internal business processes. No explicit support for interactions rules across organizational borders. However, the same place-holder for internal business rules can be used for interactions with third parties.
Semantic (Internal)	Yes	It provides a place-holder for semantic models.
Semantic (External)	Partial	It does not provide explicit semantic support to cover interactions with other organizations.

#### 4.2 The Open Group Architecture Framework (TOGAF)

The aim of TOGAF is to assist in the design, evaluation and development of EAs for an organization. TOGAF tries to provide a technology- and tool-neutral industry standard for developing EAs [9], complementary to other recognized EA frameworks.

**Development:** In 1995, the Open Group published TOGAF version 1, which was originally based on the Technical Architecture Framework for Information Management (TAFIM) from the US DOD.

**Structure:** TOGAF consists of a Resource Base and an Enterprise Continuum. The Resource Base is a set of resources - guidelines, templates, background information, etc. to help an enterprise architect in the use of the Architecture Development Method (ADM). The Enterprise Continuum is a repository of all architecture assets that exist both within the enterprise and in the IT industry at large, which the enterprise wishes to make available for the development of EAs.

TOGAF provides a set of architectural views that enable an architect to ensure that a complex set of requirements are addressed adequately: Business Architecture, Data Architecture, Application Architecture and Technology Architecture.

**Process:** TOGAF provides a method for the development and maintenance of EAs called the Architecture Development Method (ADM). ADM includes guidelines on the tools for architecture development and links to practical case studies in the Enterprise Continuum.

**Table 2.** The Open Group Architecture Framework (TOGAF)

Criteria	Supports?	Comments
Technical	Yes	The Technology Architecture View provides a place-holder for technical aspect.
Participants (Internal)	Yes	The business models provided by TOGAF explicitly capture participants, relationships and roles.
Participants (External)	Partial	The Business models provided by TOGAF could be used to capture participants and roles when interacting with other organizations.
Process (Internal)	Yes	TOGAF provides explicit business models to capture internal business processes.
Process (External)	Partial	Some of the business models provided by TOGAF can be used as place-holders to fulfill these purposes.
Interaction Purpose	Partial	
Interaction Constraints	No	Apparently, there is no place-holder for regulations, policies or standards for interactions with third-party organizations.
Semantic (Internal)	Yes	The Information models provide semantic support for business processes within the organization.
Semantic (External)	Partial	TOGAF information models can be used for semantic support of interactions with third parties, but no explicit place-holder is provided.

### 4.3 Federal Enterprise Architecture (FEA)

FEA aims to assist in the development and maintenance of cross-agency, consistent EAs [17]. It emphasizes the evaluation of the performance of IT investments.

**Development:** The US Office of Management and Budget (OMB) developed and maintains FEA.

**Structure:** FEA allows the OMB and its agencies to identify business functions, relate performance measures and service components to these functions, and relate standards and specifications to the service components needed to support the business functions. It is composed of five interrelated models, as follows [8]: Business Refer-

ence Model (BRM), Performance Reference Model (PRM), Service Component Reference Model (SRM), Data Reference Model (DRM) and Technical Reference Model (TRM).

**Process:** FEA provides a guide to develop and maintain EAs. It particularly supports the planning of transition from the baseline to the target architecture [6].

**Table 3.** Federal Enterprise Architecture (FEA)

Criteria	Supports?	Comments
Technical	Yes	It addresses this issue through the TRM.
Participants (Internal)/ (External)	No	It does not provide any place-holder describing participants, roles and relationships between business processes
Process (Internal)/ (External)	No	It does not prescribe business process modeling.
Interaction Purpose	Partial	The BRM can be used to characterize the purpose of interactions with third-party organizations.
Interaction Constraints	No	There are no components addressing this issue. There are some compliance guidelines but they do not apply to third-party organizations.
Semantic (Internal)	Yes	The Data Reference Model (DRM) provides semantic support.
Semantic (External)	Partial	The DRM can be used to provide semantic support to the interactions with third-party organizations.

#### 4.4 Standards and Architectures for e-Government Applications (SAGA)

SAGA provides a set of standards to enable e-Government development in Germany. Its purpose is to achieve interoperability, reusability, openness, cost and risk reduction, and scalability.

**Development:** The Federal Government's Coordination and Advisory Board for IT in the Administration (KBSSt) developed and maintains SAGA.

**Structure:** SAGA approaches the description of distributed e-Government applications using the Reference Model of Open Distributed Processing (RM-ODP). The analysis of an application is broken down into five different viewpoints as follows: Enterprise Viewpoint, Information Viewpoint, Computational Viewpoint, Engineering Viewpoint and Technology Viewpoint.

**Process:** SAGA classifies standards and defines a clear evaluation process.

**Table 4.** Standards and Architecture for e-Government Applications (SAGA)

Criteria	Supports?	Comments
Technology	Yes	The Technology Viewpoint and the Engineering Viewpoint both address this issue.
Participants (Internal)	Yes	The Enterprise Viewpoint identifies the major participants and their roles.

Participants (External)	Partial	SAGA does not explicitly identify the external participants and their roles in the interactions, but it addresses how they (the private sector mainly) will be assessed for conformance with the standards.
Process (Internal)	Yes	The Enterprise Viewpoint considers business process modeling.
Process (External)	Partial	Interactions with third-party organizations are not explicitly addressed or enforced, but SAGA provides the means to specify and agree on the interactions (mainly the private sector).
Interaction Purpose	No	Apparently, this issue is not addressed.
Interaction Constraints	Yes	The level of conformance to the standards should be explicitly addressed through contracts.
Semantic (Internal)	Yes	The Information Viewpoint provides semantic support.
Semantic (External)	Partial	Conformance to the shared data models could be enforced through contracts (private sector). Cross-country data model standardization is mentioned but not addressed.

#### 4.5 Governance Enterprise Architecture (GEA)

The purpose of GEA is to supply generic domain descriptions of Public Administrations to be applicable to any country [18, 19, 20].

**Development:** GEA was developed by Vassilios Peristeras and Konstantinos Tarabanis.

**Structure:** The five high-level models that comprise GEA are described as follows: Mega-Process Model - a top-level process model for the overall governance domain; Interaction Model - depicting the transformation of the inputs to the governance system (society needs) to outputs (services), with detailed descriptions of participating actors (society, administrative system and political system); Public Policy Formulation Model - integrating and customizing six strategic concepts to aid the formulation of public policies - Culture, Environment, Knowledge, Organization, Resources and Functions; Service Provision Object Model – describing the public service interaction phase; and the Object Model for the Overall Governance System – depicting the main objects and relationships that constitute the overall governance system, covering the path that leads from the conceptualization of administrative actions to the realization and process execution in the real world.

**Process:** GEA does not provide a process for developing and maintaining EAs.

**Table 5.** Governance Enterprise Architecture (GEA)

Criteria	Supports?	Comments
Technical	No	GEA does not provide support for Technical Interoperability.
Participants (Internal)	Yes	GEA provides high level models that describe generic interactions and identify key participants and roles. The participants include agents that are not part of the organization
Participants (External)	Yes	

Process (Internal)/ (External)	Yes	Business processes including those that cross organizational boundaries are captured and characterized: mega-process model, interaction model and object model for the overall governance system.
Interaction Purpose	Yes	
Interaction Constraints	No	Apparently, there are no generic codes of behavior captured in GEA that regulate interactions with third party organizations.
Semantic (Internal)	Yes	GEA describes the semantics of business processes and interactions with the parties outside the government.
Semantic (External)	Yes	

#### 4.6 Modeling Framework for Collaborative Networked Organizations (MFCNO)

The purpose of the MFCNO is to provide a comprehensive modeling framework that captures enough information to understand, manage, simulate, predict and develop software for Collaborative Networked Organizations (CNO) [21].

**Development:** This framework was developed by Luis M. Camarinha-Matos and Hamideh Afsarmanesh.

**Structure:** The framework provides three different perspectives: the IN-CNO Perspective – modeling the CNO as seen from the inside, comprising Structural Dimension, Compositional Dimension, Functional Dimension and Behavioral Dimension; the About-CNO Perspective – modeling the CNO as seen from the outside, characterizing different interactions between the CNO and external entities, comprising Market Dimension, Support Dimension, Societal Dimension and Constituency Dimension; and the CNO-Life-Cycle Perspective – modeling the main stages of the CNO life cycle, namely creation, operation, evolution and metamorphosis/dissolution.

**Process:** The framework does not provide a process for developing and maintaining the models.

**Table 6.** Modeling Framework for Collaborative Networked Organization (MFCNO)

Criteria	Supports?	Comments
Technical	Yes	The Compositional Dimension of the In-CNO perspective provides a place-holder for this issue.
Participants (Internal)	Yes	Both the structural and componential dimensions of the In-CNO perspective address this issue.
Participants (External)	Yes	The About-CNO perspective provides place-holders for this issue.
Process (Internal)	Yes	The functional dimension of the In-CNO perspective provides place-holders to address this issue.
Process (External)	Yes	The About-CNO perspective provides a place-holder for interactions with third party organizations.
Interaction Purpose	Yes	There is no specific place-holder for describing or characterizing the purpose of all possible interactions with third party organizations, but the About-CNO perspective provides place-holders to support interactions with the society and the market, as well as interactions with organizational member candidates.



Interaction Constraints	Yes	One of the issues that the About-CNO perspective describes is how the organizational behavior is regulated during interactions with third party organizations. This is also addressed explicitly for business processes that involve only the members of the organization through the behavioral dimension of the In-CNO perspective.
Semantic (Internal)	Yes	The compositional dimension of the In-CNO perspective addresses this issue.
Semantic (External)	Partial	It provides no specific place-holder for semantic support to interactions with third-party organizations, but both In-CNO and About-CNO can be used to fulfill this requirement.

## 5 Analysis

This section summarizes the analysis of the presented EA models, compared against each other. The analysis concludes that:

- Most EA models support the specification of business processes, data models and interactions, and process participants.
- Most EA models support all three types of interoperability between members of the same organization, with the exception of FEA and GEA. FEA deliberately omits business processes, focusing more on performance assessment of IT investments, and GEA does not address technical interoperability.
- Most EA models do not deal with third-party interactions. Consequently, core interoperability-related information is not captured.
- Generic and abstract models, such as GEA or CNO focus on collaborations between agencies, and thus are particularly suitable for specifying semantic and organizational interoperability solutions.
- Most EA models were applied to concrete organizations, with the exception of CNO and GEA which are products of the research community. GEA is currently applied in the SemanticGov project that aims at building the infrastructure for enabling the offering of semantic web services by public administrations at the Pan-European level.

## 6 Conclusions

The survey compared the features of existing EA models in view of their suitability to support intra- and inter-organizational interoperability.

In conclusion, none of the EA models currently applied to organizations provides a complete support for interoperability. GEA and MFCNO - relatively abstract models originating from the research community and explicitly supporting collaborations between agencies stand out from all other models which essentially describe the interactions within an organization.

An ideal EA model would combine the structure of SAGA, with the characteristic consistency of FEA, and support for collaboration showed by MFCNO or GEA.

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