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Frameworks for Building Enterprise Information Architectures

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ABSTRACT

Large enterprises are complex entities operating in a fast-moving environment facing increasing demands for even higher values. To ensure that a firm's IT structure and knowledge base is effectively managed, it has already been recognised that enterprises need to develop and maintain appropriate Enterprise Information Architectures. With this in mind, this paper provides a review of a number of enterprise architecture frameworks and other initiatives including Zachman Framework, RM-ODP, TOGAF and C4ISR/DoDAF. Their merits are discussed and relevant comparisons are made. The aim is to produce a comparison and provide some useful background information for large enterprises, who are in the process of assessing the feasibility of developing enterprise-wide IT and information architectures.

1. INTRODUCTION

Recognition already exists that appropriate exploitation of Information Technology (IT) and effective management of a firm's knowledge base is the key to its success. With the increasing complexity of the way the large enterprises operate, it is imperative that the functions of the various units of an enterprise are properly aligned and the firm's data/information organised using an appropriate Enterprise Information Architecture (EIA). A survey of Information Systems (IS) executives, conducted in 1995 (Brancheau, 2002), provides a clear evidence of the growing need for the development of such architectures for the modern enterprise. In 2001/2, Giga Information Group interviewed 200 leading companies in the USA and Europe and established top ten priorities for the Information Officers for 2002. '*Developing & maintaining Enterprise Architecture*' appears as number 7 on the list (Adaptive, 2002). As John Zachman also suggests*' in the 21st century it [architecture] will be the determining factor, the factor that separates the winners from the losers'* (Fowler, 1997).

Thus, organisations need to build enterprise environments conducive to accommodating high rates of change. Fortunately, the readily available technology does have the required tools for the enterprises to guide their planning efforts and to manage their information and knowledge base.

In this paper, we discuss the concept of EIA and its implications and investigate a number of existing IE frameworks. A brief discussion and conclusion is also presented towards the end of the paper.

2. ENTERPRISE INFORMATION ARCHITECTURE (EIA)

A well-established enterprise has a *Strategic Vision* that sets a future direction. This helps the enterprise to move from current position (where it is) to its future state (where it wants to be) and provides a guidance to develop the enterprise's *Business Strategy*, which drives the *Information System (*or *IT) Strategy*. The IT Strategy, considered in terms of enterprise's vision guides the development of what is called *Enterprise Architecture (EA)* which is intended to address enterprise-wide concerns such as:

- Strategic goals, objectives and strategies
- Meeting stakeholders needs
- Aligning IT with the business
- Derivation of accurate and timely information from operational data
- Improving operating procedures and decision-making
- Migration strategy for future development
- Information and Application requirements
- Seamless integration of business systems and processes and data sharing
- Technology infrastructure and appropriate information systems
- Data integrity, quality, consistency, security and dependability
- Reducing duplication and complexity of business functions

Harrison (1995) defines EA as '*the capture of all behaviour that goes on in an organisation i.e. the who, what, why, when, where and how of the business at every level from high-level corporate goals to the code of low-level programs that implement business processes used to achieve those goals'*. According to the Reference Model for Open Distributed Processing (ODP, 1995), architecture of a system is '*a set of rules to define the structure of the system and the interrelationships between its parts'* (Fowler, 1997). Zachman (1987) defines architecture more fully as '*the set of principles, guidelines, policies, models, standards and processes that, aligned to business strategy and information requirements, guides the selection, creation and implementation of solutions that are aligned with future business directions'*. Thus, EIA is a high level view of an organisation's information-related components that conveys an overall understanding of each component and an understanding of the relationship and the interaction between these components.

In general, EIA maps the information needs of a firm's business requirements and encompasses the application level aspects. It is a multi-tier model employing several tightly coupled architectures (Malhotra, 1996) including:

- **Business Architecture** – which refers to the enterprise vision and future targets i.e. the business strategy, governance and related processes
- **Data Architecture** – which describes the physical and logical information assets i.e. the acquisition, usage, storage, maintenance and exchange of data, with respect to enterprise's business needs
- **System (or Application) Architecture** – which refers to application systems and data requirements with respect to the provision of the business processes
- **Computer (or Information or Technology) Architecture** – which describes the hardware/software and technological base for the System Architecture.

3. EIA FRAMEWORKS AND RELATED PROCESS MODELS

A framework provides a generic problem space and a common vocabulary within which individuals can operate to solve specific problems. Frameworks are not necessarily comprehensive, but they can be leveraged to provide at least a starter set of the issues and concerns to be addressed in architecture development. The various frameworks gener-

ally share similar objectives but they vary in focus, scope and intent. Each business sector (e.g. manufacturing, service, financial) operates differently and has its own aims and goals. Thus, there are many *architecture models*. In general, these frameworks consist of a number of *views*, each addressing one particular aspect of the architecture or the *viewpoint* - each *view* conforms to a *viewpoint*. According to IEEE 1471:

- A **view** *'is a representation of one or more structural aspects of an architecture that illustrates how the architecture addresses … concerns held by … its stakeholders'.*
- A **viewpoint** *'is a collection of patterns, templates and conventions for constructing one type of view. It defines the stakeholders whose concerns are reflected in the viewpoint'***.**
- A **stakeholder** *'is a person, group, or entity with an interest in … the architecture'.*
- A **concern** *'is a requirement, an objective, … or an aspiration a stakeholder has for that architecture'.*

4. FRAMEWORKS CONSIDERED IN THE PRESENT STUDY

Numerous frameworks for the management and architecture of enterprise information have been developed, compared and reviewed by other researchers (e.g. Allen, B. and Boynton, 1991; Ross and Rockart, 1999; Rowley 1998). In the current study, we review only the following:

- **Zachman's Framework** (Zachman, 1987 and 1999) as this is a widely used approach for developing enterprise-wise IS architectures and considered as a reference model against which other frameworks can map themselves
- **RM-ODP** (ODP, 1995 and Putman, 2001) as this uses a well understood object modelling technique (OMT) and developed by highly reputable agencies such as ISO and International Telecommunications Unit
- **TOGAF** (WWW document 4) as this is an industry standard generic framework which is freely available
- **C4ISR/DoDAF** (WWW documents 1,4 and 5) as these are huge frameworks developed for the US Department of Defence.

Majority of other models are variations on these and not discussed in this paper mainly for the reason of lack of space.

4.1 Zachmann EA Framework

Introduced by John Zachman in 1987 (Zachman, 1987, 1999), this framework provides structure and definition of a complete set of views, which describe an enterprise. It is a widely used approach for documenting enterprise-wide information architecture providing a framework to support the acquisition, access, integration, interpretation, development and management of the organisation's information resources. It describes a holistic model for the classification of all the elements an EA should contain – by organising business processes around the points of view, known as *perspectives*, taken by various *players*, known as *aspects*. There are 30 views arranged as a matrix of five rows providing *representations* and six columns providing *aspects*. Refer to Figure 1.

The *representations* (or *perspectives* of the enterprise for different roles) refer to:

- **Scope and objectives** – represented by *The Strategic Planner* – correspond to an executive summary referring to estimates of size, cost and functionality
- **Business model** – represented by *The Business Owner* – shows business entities and processes and their interaction
- **IS or System model** – represented by *The Designer* – corresponds to software functions and data that represent the Business model
- **Technology model** – represented by *The Builder (analysis/ developer)* – considers tools and technologies
- **Detailed representation** – by *The Sub-contractors (coder)* – represents individual modules and the operational system.

The six aspects, providing appropriate abstractions, relate to the following:

- **What** – refers to business data – describes entities involved in each perspective e.g. business objects, system data, relational tables
- **How** – refers to control flow – shows the functions within each perspective e.g. business processes, software functions, hardware functions
- **Where** – refers to locations and interconnections – e.g. location of network nodes
- **Who** – refers to staff, departments, people relationships, responsibilities
- **When** – refers to durations of business processes and time-event relationships
- **Why** – refers to motivation of the enterprise with respect to objectives, business plans and knowledge architecture.

The complete matrix provides the highest-level view of a generalized IA. Each cell is filled with a particular view with respect to an associated representation. The vertical axis refers to potential viewpoints for the architect and the horizontal axis provides a generic taxonomy of concerns. The top two rows are business-oriented while the last three are in the technical domain. There is no guidance on process or implementation and the framework does not prescribe any methods for developing viewpoints or the order in which they should be developed. There are no explicit 'rules' or 'product standards'. The focus is on ensuring that all aspects of an enterprise are well organised and exhibit clear relationships to ensure a complete system, regardless of the order in which they are established. The framework is concerned with content rather than process.

If a framework of choice has most of the things that an organisation needs but lacks something, then Zachman Framework can be applied to identify the gaps, which can then be filled by following/adopting methodologies given in another framework.

The main contribution of the framework is explicit decomposition of EIA into distinctly defined points of view from different perspectives. The main weakness is a lack of scientific basis and a lack of means to ensure absence of conflicts among different views. Zachman Framework is not a standard so there are no compliance rules.

4.2 TOGAF (The Open Group Architecture Framework)

This TOGAF development was started by the Open Group in the mid 1990s (WWW document 4). Initially based on the Technical Architecture Framework for Information Management (TAFIM) developed by the US-DOD (TAFIM, 1994), its latest version TOGAF 8.1 (WWW documents 2,3) was released in December 2003.

Figure 1. Zachman Framework

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)
Objectives / Scope	Essentials for the enterprise	Business processes	Locations where enterprise operates	Organizational units	Business events / cycles	Business goals / strategies
Model of the Business	Entity relationships	Business process models	Logistics network	Organization chart, roles, skills	Business schedule	Business plan
Information System Model	Data models	Applications architecture	Systems architecture	Interface architecture	Dependency diagrams	Business rule model
Technology Model	Data architecture	System design: pseudo-code	System architecture	User interface	Control flow diagram s	Business rule design
Detailed Representation	Data design	Program design	Network architecture	Screens,/security architecture	Timing definitions	Rule specification

It is an industry-standard framework with a detailed method and tools for developing, implementing and maintaining an EA. It focuses mainly on mission-critical business applications and embodies the concept of *Enterprise Architecture Continuum* (providing a context for the use of multiple frameworks and models) in conjunction with the *ADM* (Architecture Development Method), which is a core component of TOGAF. Refer to figures 2 and 3. The *ADM* explains how to derive an architecture that addresses business requirements whereas the *Continuum* reflects different levels of abstraction in the development process and provides communication and understanding within and across enterprises and with vendor organisations.

Another important component - the TOGAF *Foundation Architecture* - provides for the development of a generalised architecture consisting of four types of architectures (refer to figure 2):

- **Business Architecture** – to define business strategy, governance, organisation and core business processes
- **Data (or Information) Architecture** – to describe logical and physical data assets
- **Application (or System) Architecture** – to establish the application systems, their interactions and relationships to the core business processes
- **Technology (or IT) Architecture** – to describe the software infrastructure to support the business applications.

Another major component - the *Resource Base* - provides resources available for applying the *ADM*. These resources are entities such as architecture compliance reviews, architecture principles, architecture views, business scenarios, case studies, governance strategies, etc.

Unlike the Zachman Framework's regular grid of cells organised in rows and columns, the TOGAF graphic is dynamic: a set of circles representing phases of the *ADM* and the architecture models used/created during the phases of the EA development. Refer to Figure 3. TOGAF also suggests additional viewpoints (e.g. security and manageability viewpoints) that are not provided in the Zachman Framework.

Since, TOGAF is a generic framework to be used in a variety of environments, it does not prescribe any specific deliverables, rather it refers to the types of deliverables that need to be produced and focuses on the development methods. TOGAF can be used in conjunction with other frameworks.

4.3 RM-ODP (Reference Model for Open Distributed Processing)

The RM-ODP (ODP, 1995 and Putman, 2001) is a joint effort by International Standards Organisation and International Telecommunications Unit. The purpose is to provide a common well-defined architecture for the specification of a distributed information system and its environment. The model provides a means to define and specify different types of transparencies (e.g. access, failure, location, migration, replication and transaction) and sets out to achieve the following:

- Portability of applications across heterogeneous platforms
- Meaningful exchange of information across the distributed system
- Distribution transparency.

The RM-ODP is based upon four architectures: *Applications*, *Software*, *Technical* and *Operations*. It defines five *viewpoints* to provide different ways of describing the system and eight *transparencies* which identify problems unique to distributed systems. The five basic viewpoints of a system and its environment are (Kudras, 1999):

- **Enterprise view:** refers to the purpose, scope and policies
- **Information view:** focuses on the structure and exchange of information
- **Computational view:** focuses on the system as a set of interacting objects
- **Engineering view:** refers to mechanisms and functions of system objects to support the Computational View
- **Technology view:** deals with the hardware and software components.

The RM-ODP is influenced by the Zachman's Framework and formal methods. It uses Object Modelling Technique (OMT) for defining viewpoints. RM-ODP is tightly focused on problems relating to interactions between object of the distributed Information Systems, while TOGAF embraces the full spectrum of systems: distributed or not.

4.4 C4ISR (Command/Control/Communication/Computers, Intelligence, Surveillance and Reconnaissance) Architecture Framework

C4ISR version 2 was published in 1997 (WWW document 4). Its current reincarnation known as DoDAF (US DoD Architecture Framework) was released in 2003 (WWW documents 1,5). The framework provides rules, guidance and procedures for the various Commands, Services, Agencies and C4 related domains within the US-DoD. The aim is to ensure that architecture descriptions developed by the agencies are:

- Inter-relatable between and among the C4 related domains' operational systems
- Comparable and integral across joint and combined organisational boundaries.

C4ISR/DoDAF defines 26 architecture products organised within three sets of views:

- **Operational:** describes/interrelates the operational elements, tasks and activities to accomplish mission operations
- **Systems:** describes systems and interconnections to support the Operational View

Figure 2. The TOGAF Overall Structure and Components

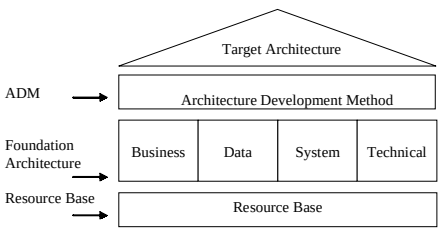
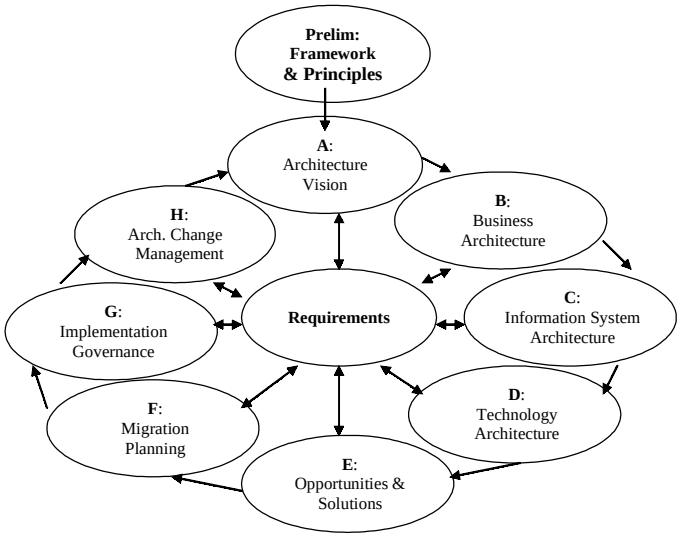


Figure 3. The TOGAF ADM Structure [Source: WWW document 6]



- **Technical Standards:** describes rules governing the arrangement, interaction and interdependence of system components to augment the Systems View.

The DoDAF, applies to all functional areas of the US-DoD, defines architecture products as *those graphical, textual, and tabular items that are developed in the course of gathering architecture data, identifying their composition into related architecture components or composites, and modeling the relationships among those composites to describe characteristics pertinent to the architecture's purpose.*

The framework provides direction on how to *describe* architecture (i.e. *what* should be included in an architecture description) rather then *how* to construct or implement a particular architecture. Note that the use of the term *view* in the C4ISR framework is somewhat different from what it means in TOGAF.

C4ISR is a successor to the Technical Architecture Framework for Information Management (TAFIM, 1994) - developed in 1995 and withdrawn in 2000.

5. DISCUSSION

Organisations in the US are rising to the challenge more readily than those in the UK or Europe. One reason is the IT Management Reform Act of 1996 (WWW documents 7,8), which requires the US Federal Agencies to develop and maintain enterprise IT architectures to meet their strategic aims. Development of C4ISR and DoDAF are a direct result of this. However, the process started in 1987 when John Zachman published his EA Framework (Zachman, 1987).

Zachman Framework may be considered as a reference model. It is a widely used approach for developing enterprise-wise IS architectures. It does not prescribe to any particular method or process; instead it describes a holistic model where a set of views is represented in a two-dimensional matrix of five *perspectives* and six *aspects.*

On the other hand, TOGAF, developed by the Open Group, which is freely available and based on a well-defined ADM, focuses on the methods for the development of the required deliverables. TOGAF also recommends additional viewpoints not available in the Zachman Framework.

Whereas, TOGAF is a generic framework to be used in a variety of environments embracing the full spectrum of systems, RM-ODP is focused on the distributed Information Systems. Nevertheless, it provides a common and well-defined architecture for such systems.

6. CONCLUSION

This paper discusses the importance of enterprise-wide information architectures and examines a number of architectural frameworks that have been developed in recent years. Frameworks present general guidelines and they vary in focus and scope depending on the application domain. Thus, an enterprise wishing to embark on the process of developing an EA needs to be aware of the difficulties inherent and the costs involved as well as a general knowledge and understanding of the various frameworks and the available toolkits. Zachman Framework, TOGAF and RM-ODP form the basis of many other frameworks. A number of adaptable frameworks e.g. C4ISR and DoDAF initially developed for the US DoD, US Treasury and other US federal agencies can be usefully exploited by other similar agencies across the world.

In this paper, we have presented a review and comparison of some existing architectural frameworks. We hope that large enterprises, wishing to embark on the development and implementation of IS architectures, will find the information useful.

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