

## INFORMATION SYSTEM ARCHITECTURES

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In recent years organizations have been faced with increasingly demanding business environments - pushed by factors like market globalization, need for product and service innovation and product life cycle reduction - and with new information technologies changes and opportunities- such as the Component-off-the-shelf paradigm, the telecommunications improvement or the Enterprise Systems off-the-shelf modules availability - all of which impose a continuous redraw and reorganization of business strategies and processes.

Nowadays, Information Technology makes possible high-speed, efficient and low cost access to the enterprise information, providing the means for business processes automation and improvement. In spite of these important technological progresses, information systems that support business, do not usually answer efficiently enough to the continuous demands that organizations are faced with, causing non-alignment between business and information technologies (IT) and therefore reducing organization competitive abilities.

This article discusses the vital role that the definition of an Information System Architecture (ISA) has in the development of Enterprise Information Systems that are capable of staying fully aligned with organization strategy and business needs. In this article the authors propose a restricted collection of founding and basis operations, which will provide the conceptual paradigm and tools for proper ISA handling. The concepts proposed are discussed presenting a retail company ISA.

### Keywords

Information System Architecture, Information System Modeling, Enterprise Architecture, CEO Framework, UML.

### INTRODUCTION

Market globalization and the transformation of the industrial economy into information and knowledge based economy, among other factors, have been shifting organization competitiveness from its mass production abilities to its capabilities of reorganizing and redrawing continuously its business processes and strategies.

In spite of significant efforts and investments at business and software levels, companies do not currently get the expected returns simply by just using the "best IT" in the market [1].

This paper discusses the vital role that the definition of an Information System Architecture (ISA) – a distinct concept from Software Architecture – has in the development of Enterprise Information Systems that are capable of staying fully aligned with organization strategy and business needs. This is, according to [2], "the issue of the century".

In spite of the potential advantages provided by having an ISA definition - namely better alignment between business and IT, interface and integration cost reductions, coherent data sharing and cheaper IT

maintenance - there is currently no standard organizational praxis to define it. An enterprise ISA definition should be the reference point for any subsequent IS and/or IT developments. Instead, during IS/IT development projects, organizations typically choose to focus on technology and on software development that try to directly match it into business model.

This paper proposes a restricted collection of founding and basis operations, which provide the conceptual paradigm and tools for Information System Architecture representation, and the basis for subsequent ISA planning or ISA quality measure.

The main subjects, concepts and investigations in ISA area, that provide the background for the work presented in this paper, are introduced in next section. In next section 3 a restricted collection of founding and basis operations for ISA representation are defined; in the subsection 3.1, it is describe the major concepts in ISA, in section 3.2, a UML profile for ISA modeling is proposed. In section 4 it is presented a case study that applies the proposed profile, by describing a retail enterprise ISA. The conclusions and future work are presented in the section 5.

## ISA OVERVIEW

Information System Architecture (ISA) is a part of a vaster field of architectures and models relevant for the organization. Considering the architecture level, one can distinguish the following architectures:

- Enterprise Architecture.
- Information System Architecture (ISA).
- Software Architecture (SWA)

Software Architecture (SWA) main study area is on how programs or application components are internally built [3]. At this level it is important to consider the objects and classes needed for implementing the software. SWA is a quite stable and mature field.

Enterprise Architecture is a group of models defined for getting a coherent and comprehensible picture of the enterprise [4]. The models define different “perspectives or viewpoints from which the company is considered, focusing on some aspects and ignoring others in order to reduce complexity” [5]. Thus, a model of the company can contain several activity, processes, organization, information and behavior diagrams of the company.

Finally, Information System Architecture (ISA) addresses the representation of the IS components structure, its relationships, principles and directives [6], with the main purpose of supporting business [7].

In the 80's, software architecture (ASW) and ISA were considered synonymous. Only in last decade the need for manipulation of concepts that overwhelm the description of how a system is internally built emerged. Zachman framework [1], is defined as the first important sign that ASW has not enough.

Quoting IEEE [8], ISA level should be high. Thus, ISA is distinguished from software representation and analysis methods (as E-R diagrams, DFD), presenting an abstraction of internal system details and supporting organization business processes [9].

Sassoon, discusses the concept of “IS urbanization”, emphasizing, like in city planning, the need for models that guide the evolution and growth of IS robust and independent of technological trends [10].

ISA usually distinguishes three aspects, defining three “sub architectures” [11]:

- **Informational Architecture**, or Data Architecture. This level represents main data types that support business.
- **Application Architecture**. Application architecture defines applications needed for data management and business support.

- **Technological Architecture**. This architecture represents the main technologies used in application implementation and the infrastructures that provide an environment for IS deployment.

Organizational Engineering Center (*Centro de Engenharia Organizacional* (CEO), in Portuguese), supported on other authors' research ([12], [13], [14]), in [15], proposes a framework for enterprise modeling. The CEO framework provides a restricted set of business objects, defined in an UML profile [14], used for Enterprise modeling. In spite CEO framework presents some extensions in order to represent business/system dependences, it does not allow to define ISA.

The business objects defined in the framework are: goals, for strategy modeling; processes, for business process modeling; resources, for business resource modeling; and blocks, for IS modeling.

CEO, supporting its framework in an Object Oriented approach, namely UML, ensures consistence, easy of use and provides mechanisms for maintain modeling integrity, reducing the gap between business and IT architectures.

Figure 1 presents the UML profile for enterprise modeling defined by CEO framework.

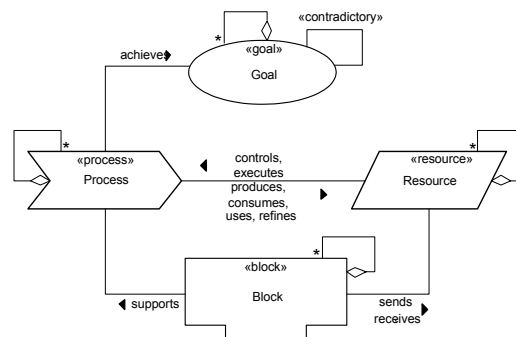


Figure 1. CEO framework meta-model profile

In spite CEO framework provides the means for jointly IS and business modeling through formal mechanisms (supported in UML), it presents several insufficiencies, namely at ISA level, like the proposed taxonomy used to represent the concepts at IS level is not sufficient, it does not identify stakeholders, perspectives or views, it does not define objects or attributes for application or technological architecture, it also does not define a methodology for ISA definition or evaluation, among others.

As discussed previously in this section, the ISA definition has a vital role in development IS that actively contribute for business and IT aligning, defining an adequate IT strategic, ensuring IS robust,

more IT independent, flexible and adaptable to business needs.

Formerly, the software development process was focused on coding – minimizing the internal application architecture – nowadays, the vast majority of organizations, in order to respond to business demands, opt to acquire or implement applications that answer instantly to its needs, without firstly define a global solution for the IS.

The related work research confirmed that, nowadays, it is not possible to represent an ISA, at informational, application and technological levels, and its dependences with business level, in a standard, normalized and simple way – in order to develop subsequent inspection and/or simulation of different business and technological scenarios.

## INFORMATION SYSTEM REPRESENTATION

The related work discussion presented in previous section emphasized the inexistence of any praxis, mechanism or language for ISA modeling.

In this article, the authors argue that it is crucial to have formal, comprehensible and useful mechanisms that assist the ISA representation, namely at information, application and technology levels, as well as in its relationship with the business model.

The authors argue that the ISA representation, at information, application and technology levels, presents a vital stage in subsequent IS research.

The next subsections present a collection of operations and founding and root concepts, as well as graphical representations that allow the semantic ISA manipulation. From the authors' viewpoint, the definition of such founding concepts provides the conceptual tools for addressing subsequent research issues in ISA area.

### A Taxonomy

In this subsection a set of the concepts considered crucial to ISA specification are presented.

The scope of the taxonomy proposed in this section is the description of an ISA at informational, application and technological levels, relationship between these and relationship with the business model. Moreover this taxonomy provides the foundations for the definition of a graphic representation of the concepts introduced, supported in a formal and standard modeling language (UML) [14], described in the following sub-section.

The key concepts for the Information System Architecture are:

### Business process

Based on [16] definition, a business process is collection of activities that produces value to a customer.

In spite business process is not part of ISA scope, it is a key concept in the relationship between ISA and the business model. Thus, from the ISA perspective, the business process attributes are not important, but the awareness of its existence and its relationships with the IS architectural components is fundamental.

### Information Entity

Information entity stands for any person, place, physical thing or concept that is relevant in the business context and on which is possible and relevant (for the organization) to keep information. Information entities are mainly concepts commonly accepted through out the organization. Information entity data exists in different formats in different systems.

### IS Block

Application architecture main aim is on the architecture functional components characterization. The major applications needed for data management and business support are defined at application architecture [11].

Also notice the technological independence that this architecture should present [11].

At application level, the IS Block (or Application Block) concept is the founding concept. IS Block is defined as the collection of mechanisms and operations organized in order to manipulate organization data [11].

### IT Block

As presented in section 2, the technological architecture defines the major technologies implementing the applications and describes the IT environment provided to applications.

Technological architecture addresses a large variety of notions, caused, on the one hand, by the continuous technological evolutions and, on the other hand, for different specialized IT architectural views needed – as security, hardware and software development architectures.

In order to encapsulate this diversity, it is propose the "IT Block" concept. IT Block is the infrastructure, application platform and technological/software component that realizes (or implement) an (or several) IS Block(s).

IT Block defines three major sub-concepts:

- **IT Infrastructure Block.** This block represents the physical and infra-structural concepts existing in an ISA: the computational nodes (as servers, personal computers or mobile devices) and the non-computational nodes (as printers, network, etc.) that support application platforms.
- **Application Platform Block** stands for the collection of services needed for implementing and IT application deployment.
- **IT Application Block.** The IT application block is defined as the technological implementation of an IS Block. At this level is relevant to consider the kind of IT Application Block (namely presentation, logic, data and coordination block), and its “technological principles” (like if it is implemented using components, modules, OO principles, etc..), among other characteristics.

Two other concepts are also important in ISA description. These concepts are:

**Service**

Service is an aggregation of a set of operations provided by an architectural block. Notice that the primitive concept is a generalization of the web service notion [17]. In this paper service includes the notion of web service and business and system services provided by blocks.

We consider three distinct services in an ISA:

- **Business Service.** A business service is a collection of operations provided by IS Blocks that support one (or several) business(es) process(es).
- **IS Service.** The set of operations provided by an IS Block to others IS Blocks defines the IS service.
- **IT Service.** The technological services provided by application platforms are the IT services [15].

**Operation**

Inherent to the service definition described before is the notion of operation. Operation is the abstract description of an action supported by a service [17].

Thus, operations are the minor level concept relevant in an ISA.

**An UML profile for ISA**

The representation and graphical manipulation of a model on some thing or concept is a critical tool for discussion and abstraction.

In this paper, aligned with other researches [15], it is proposed a set of extensions to the UML modeling (standard) language [14], defining a new ISA profile.

The profile proposed in this section, supported in the concepts introduced in previous section, provides the means for ISA representation, at informational, application and technological levels.

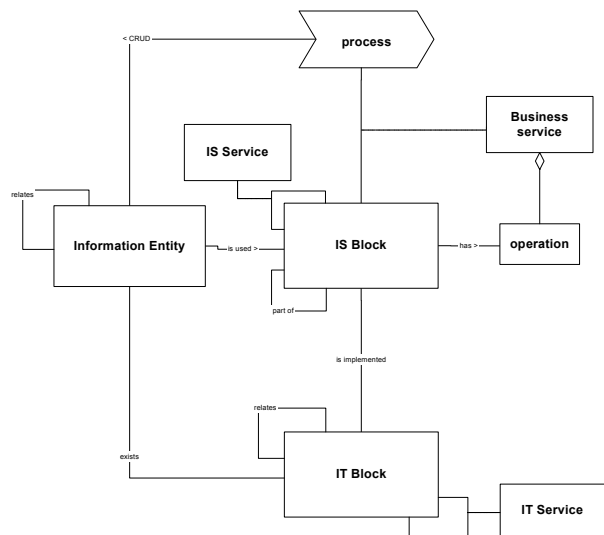
As previously stated, the base blocks in an ISA are: the information entity, IS block and IT Block.

The information entity data can be Created, Read, Updated or Deleted (CRUD) by business processes. The information entity is also used by the IS block and it exists (physically) in an IT block - e.g., the data regarding an information entity exist in a given machine, in a given database. An information entity can still be associated with other entities (through associations) or can be hierarchy specialized.

An IS Block is characterized by the functions or operations provided that support business processes (using business Services). IS blocks relate with other IS blocks, through IS Service, and are implemented in IT blocks.

Finally, IT Blocks are responsible for IS Block implementation and for the physical information entity data manipulation.

Figure 2 illustrates the proposed meta-model profile for ISA.



**Figure 2. Proposed meta-model profile (level 0)**

Each of proposed enterprise modelling objects in Figure 2, could be detailed and specialized. In this paper, however (for page number limitations) the ISA metamodel proposed is not more detailed.

**THE X COMPANY CASE STUDY**

In order to validate the UML profile for ISA, proposed in section 3, in this section it is described an

ISA (at application and informational level) of a fictitious retail company, the X Company.

At information level, Figure 3 presents the major information entities and its interactions.

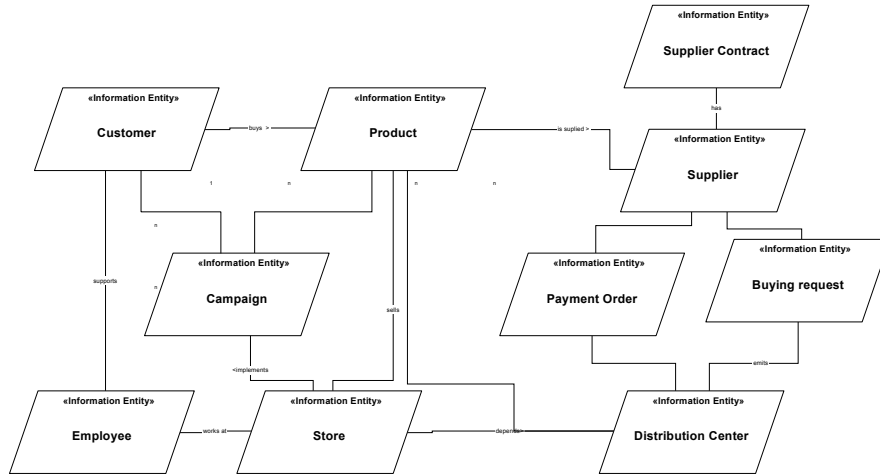


Figure 3. X Company Informational Architecture (partial view)

An Information Entity, when needed, may be specialized. In this case study, X Company provides different retail channels, presenting three different clients types – Figure 4.

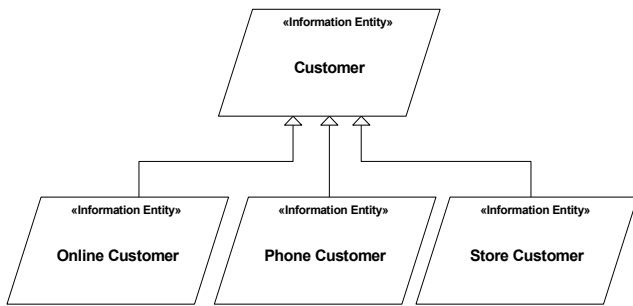


Figure 4. Customer Information Entity

Information entities attributes should also be defined – see Figure 5.

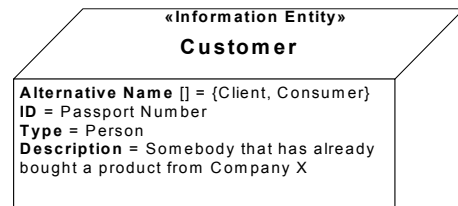


Figure 5. Customer information entity detailed description

In Figure 6 is presented application architecture, presenting the dependences between IS blocks (using «IS Service»(s)).

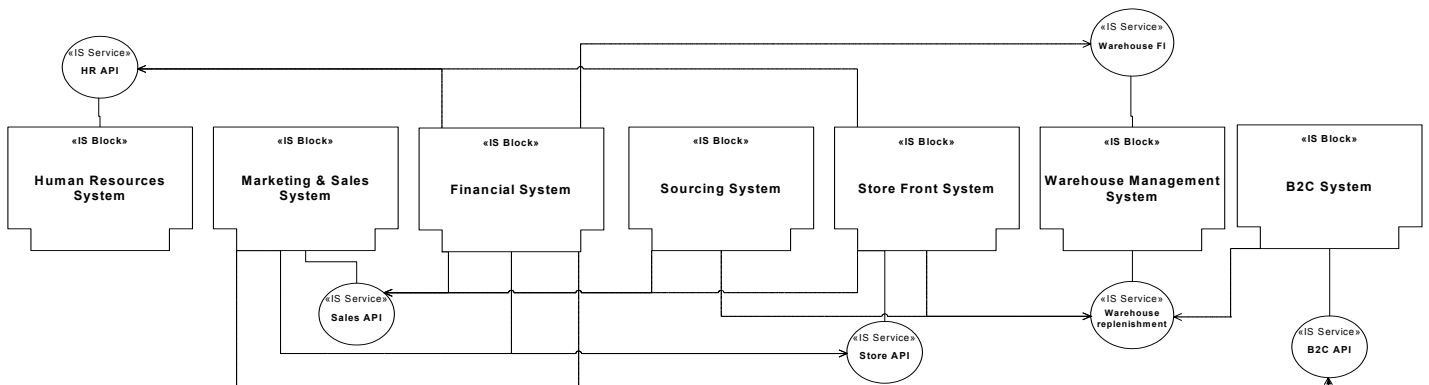
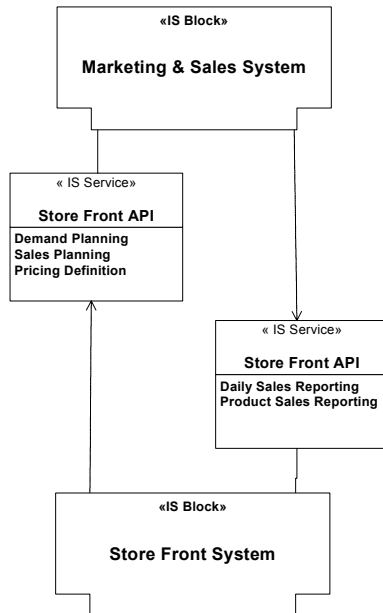


Figure 6. Application Architecture (no detail)

Figure 7 details one of the dependences between IS Block, namely Marketing & Sales and Store Front IS Blocks.



**Figure 7. Dependences between Marketing&Sales and Store Front IS Blocks**

X Company technological architecture is not described here for page number limitations.

## CONCLUSIONS AND FUTURE WORK

This paper proposes an UML profile for ISA modeling. This research, support in previously researches focused at business levels, proposes a restricted collection of founding and root concepts used for describing ISA at informational, application and technological levels.

The authors argue that the conceptual tools proposed in this paper, establish the basis for future ISA research.

As future work it is proposed the implementation of a computer-based tool that provides an simple way for ISA handling (this work is already in advance development stage).

It is also authors' aim to develop the mechanisms that allow ISA evaluation. The ISA evaluation intends to be accomplished using existing concepts in IS industry (as TOGAF ISA evaluation criterions for IT architectures [18]) and supported in current representation notions described in this paper.

Finally the definition of a process and methodology for ISA planning, at informational, application and technological levels align with organization business process and IT strategy, is another topic for future research.

## REFERENCES

- [1] Boar, Bernard, *Constructing Blueprints for Enterprise IT Architecture*, John Wiley & Sons, 1999.
- [2] Zachman, John, *Enterprise Architecture: The Issue of the Century*, Database Programming and Design, March 1997.
- [3] *How do You Define Software Architecture?*, Software Engineering Institute, Carnegie Mellon University, December 2000 (<http://www.sei.cmu.edu/architecture/definitions.html>).
- [4] Tissot, Florence, and Wes Crump, *An Integrated Enterprise Modeling Environment*, P. Bernus, K. Mertins, G. Schmidt (Eds.), *Handbook on Architectures of Information Systems*, Springer, pp.59-79, ISBN 3-540-64453-9, 1998.
- [5] Vernadat, François, *Enterprise Modeling and Integration*, London, Chapman & Hall, 1996.
- [6] Garlan, D. et al., *Architectural Mismatch (Why It's Hard to Build Systems Out of Existing Parts)*, Proceedings 17th International Conference on Software Engineering, Seattle, WA, April 23-30 1995, pp.170-185.
- [7] Maes, Rik, Daan Rijsenbrij, Onno Truijens, and Hans Goedvolk, *Redefining Business – IT Alignment Through a Unified Framework*, White Paper, May 2000. <http://www.cs.vu.nl/~daan/>
- [8] IEEE Architecture Working Group, *Recommended Practice for Architecture Description – Draft IEEE standard P1471/D4.1*, IEEE, December 1998.
- [9] Zijden, Stefan, Hans Goedvolk, and Daan Rijsenbrij, *Architecture: Enabling Business and IT Alignment in Information System Development*, 2000. <http://www.cs.vu.nl/~daan/>
- [10] Sassoon, *Urbanisation des systèmes d'information*, 1998.
- [11] Spewak, Steven, and Steven Hill, *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications and Technology*, Wiley-QED, ISBN 0-471-599859, 1992.
- [12] Eriksson, Hans-Erik, and Magnus Penker, *Business Modeling with UML: Business Patterns at Work*, John Wiley & Sons, ISBN 0-471-29551-5, 2000.
- [13] T. W. Malone et al., *Tools for inventing organizations: Towards a handbook of organizational processes*, Management Science, March 1999.
- [14] OMG, *Unified Modeling Language Specification, v 1.5*, March 2003. <http://www.rational.com/uml>
- [15] Vasconcelos, A., A. Caetano, J. Neves, P. Sinogas, R. Mendes, e J. Tribolet, *A Framework for Modeling Strategy, Business Processes and Information Systems*, 5th International Enterprise Distributed Object Computing Conference EDOC, Seattle, EUA, September 2001.
- [16] Hammer, M., Champy, J., *Reengineering the Corporation: A Manifesto for Business Revolution*, N. Brealey Publishing, London, 1993.
- [17] W3C, *World Wide Web Consortium, Web Services*, 2001, <http://www.w3.org/2002/ws>.
- [18] Open Group, *The Open Group Architectural Framework (TOGAF) – Version 7*, November 2001.