Information System Architectures: Representation, Planning and Evaluation

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Abstract

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. These tools are then used in order to represent, plan and evaluate an ISA of a Financial Group.

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

1. 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 the 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 section 3 a restricted collection of founding and basis operations for ISA representation are defined – the first subsection describes ISA major concepts, and in the second subsection it is proposed a UML profile for ISA modeling. In section 4 a financial Group ISA is described, applying the proposed profile. The conclusions and future work are presented in the section 5.

2. 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 import to considered the objects and classes needed for

implementing the software. SWA is a quite stable and mature field [4].

Enterprise Architecture is a group of models defined for getting a coherent and comprehensible picture of the enterprise [5]. 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" [6]. 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 [7], with the main purpose of supporting business [8].

In the 80's, software architecture (SWA) and ISA where 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 [2], is defined has the first important sign that ASW has not enough.

Quoting IEEE [9], 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 [10]. 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 [11].

ISA usually distinguish three aspects, defining three "sub architectures" [12]:

- **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 ([13], [14], [15]), in [16], proposes a framework for enterprise modeling. The CEO framework provides a restricted set of business objects, defined in an UML profile [15], used for Enterprise modeling. Though CEO framework presents some extensions in order to represent business/system dependences, it does not allow defining 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.

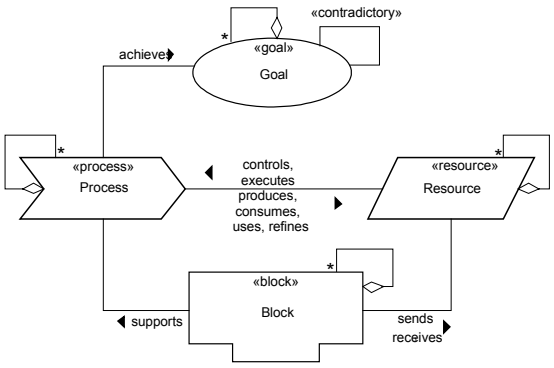

Figure 1. CEO framework meta-model profile

CEO framework provides the means for jointly IS and business modeling through formal mechanisms (supported in UML), however 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 identifies stakeholders, perspectives or views, it does not defines 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 of IS that actively contribute for business and IT aligning, defining an adequate IT strategy, ensuring IS robustness, IT independence, IS flexibility and IS adaptability to business needs.

Formerly, the software development process was focused on coding – minimizing the internal application architecture. Similarly, 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.

This ISA overview confirms 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.

3. 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, is vital for 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. 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 visual representation of the concepts introduced, supported in a formal and standard modeling language (UML) [15], described in the following sub-section.

The key concepts for the Information System Architecture are:

Business process

Based on [17] definition, a business process is collection of activities that produces value to a customer.

Business process is not part of ISA scope, however it is a key concept for the characterization of 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 the concepts commonly accepted through out the organization. Information entity data exists in different formats in different systems [18]

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 in the application architecture [12]. Also notice the technological independence that this architecture should present [12].

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 [12].

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.
- **IT 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 [19]. 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 [16].

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 [19].

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

An UML profile for ISA

The representation and visual manipulation of a model on some thing or concept is a critical tool for discussion and abstraction. In this paper, in compliance with [16], it is proposed a set of extensions to the UML modeling (standard) language [15], 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.

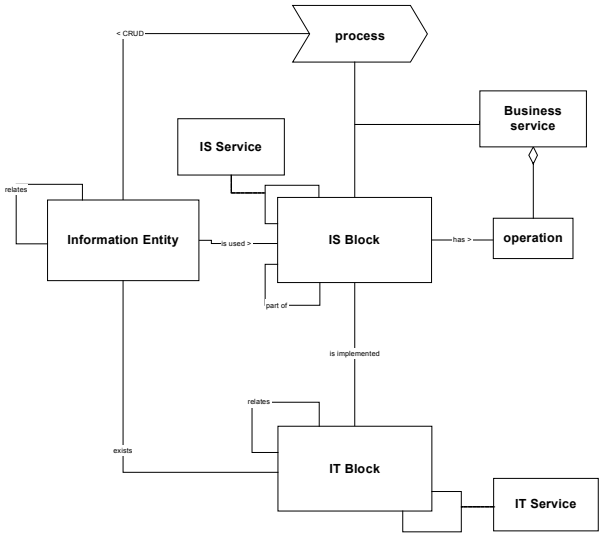

Figure 2. Proposed meta-model profile (no detail)

Each of proposed enterprise modeling 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.

4. CASE STUDY

In order to validate the UML profile for ISA, proposed in section 3, in this section it is described an ISA of a financial holding, before 2002 and the new ISA defined in order to support new business needs. Thus, the case study presented here (an important stage of the research process undertaken), was developed during two periods: in the first, the "AS-WAS" ISA of the company was modeled (summarize in the first subsection), and in the second period a "TO-BE" ISA was defined (in the next subsection) and subsequently the IT implementation process began.

ISA before 2002

This company core business is to invest and sell stocks of other companies (its subsidiaries). Besides this core process, this holding also provides services for its subsidiaries (namely financial, human resource management and law services) and manages the holding itself.

At business level, this Financial Group major business processes are described in Figure 3.

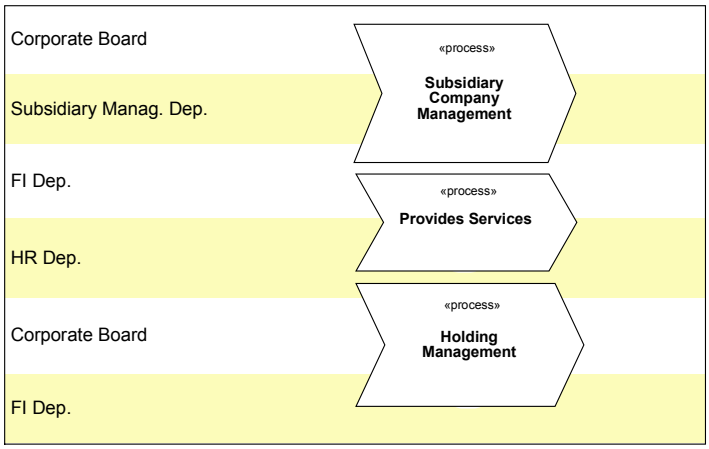

Figure 3. Major Business Processes

Provides Services business process, for instance, is an aggregation of three other business processes: human resource management, financial and law services - Figure 4.

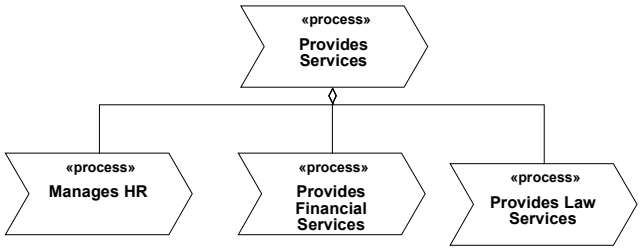

Figure 4. Business Processes (high-level)

Until 2002 this holding ISA was characterized by four major systems with manual or inexistence interfaces – Figure 5.

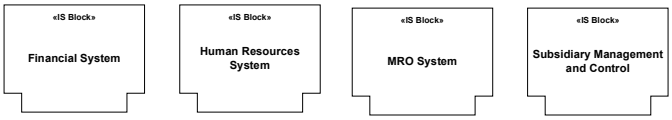

Figure 5. Application Architecture before 2002

The systems developed "in-house" on the '80s did not provide support to actual business needs. In Figure 6 it is the described the operations provided by the Human Resources Business Services (and which IT components implemented it).

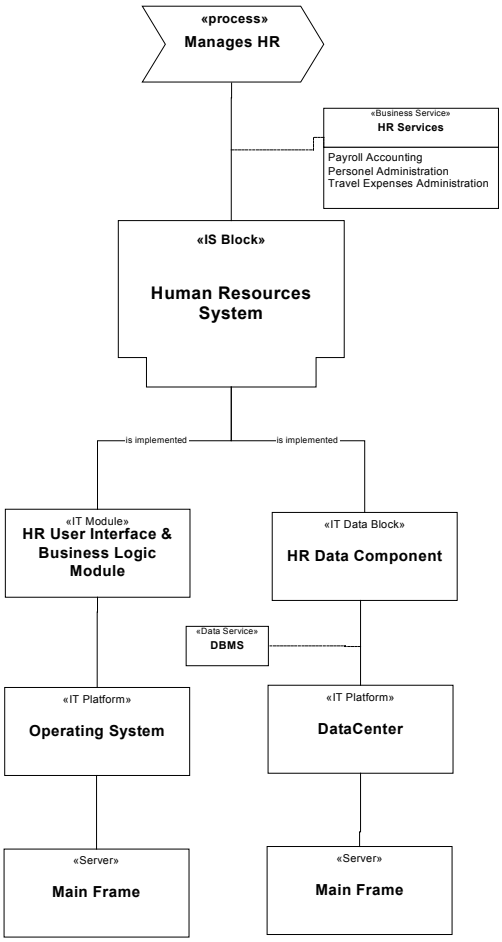

Figure 6. Human Resource Business Services, IS Block and IT Blocks

As described in Figure 6, the HR «IS Block» is implemented through two «IT Blocks» (one for data and another for logic and user interface), supported in «IT Platforms» and a mainframe computer.

A Business Redefinition

New business needs and a new strategy for the Group exposed the IT problems and poor support to business needs, starting an IS/IT major change. Using several data collection techniques [20] as one-to-one interviews with business and IT staff members, and collective discussions in a created steering committee, the authors helped identifying several problems and new business needs.

In Figure 7, the new services required by HR business process are presented (like Job Analysis, Incentive Wages, Organizational Planning & Simulation Services for Human Resources).

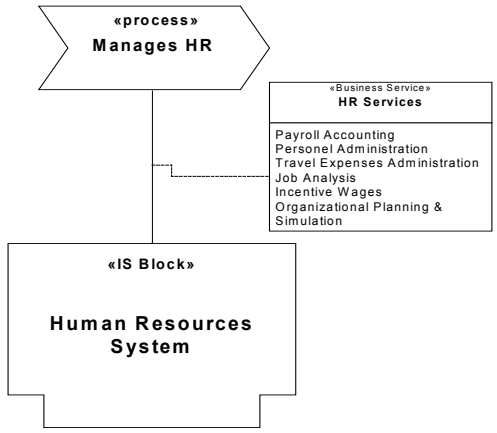

Figure 7. New Business Services required at HR level

In order to provide the basis for the new Business Process needs an ISA was proposed (Spewak Enterprise Architecture Planning methodology [12] was undertaken). In order to allow communication between all applications, a unique API (Application Interface) was defined and implemented in a broker, abolishing all peer-to-peer connections between applications. Legacy applications, when applicable, were wrapped up and new systems were built with and API prepared to be integrated with the broker - Figure 8.

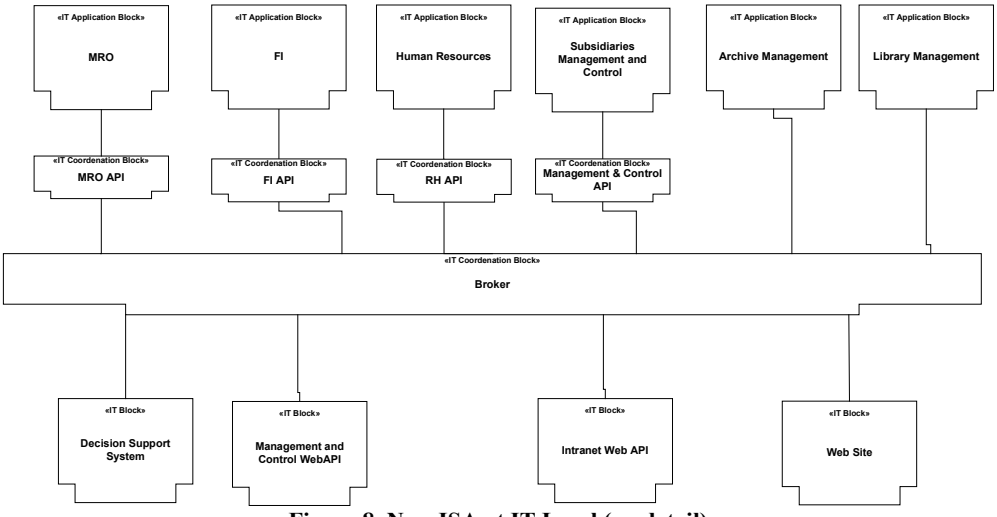

Figure 8. New ISA at IT Level (no detail)

Figure 9 presents the technological architecture big picture.

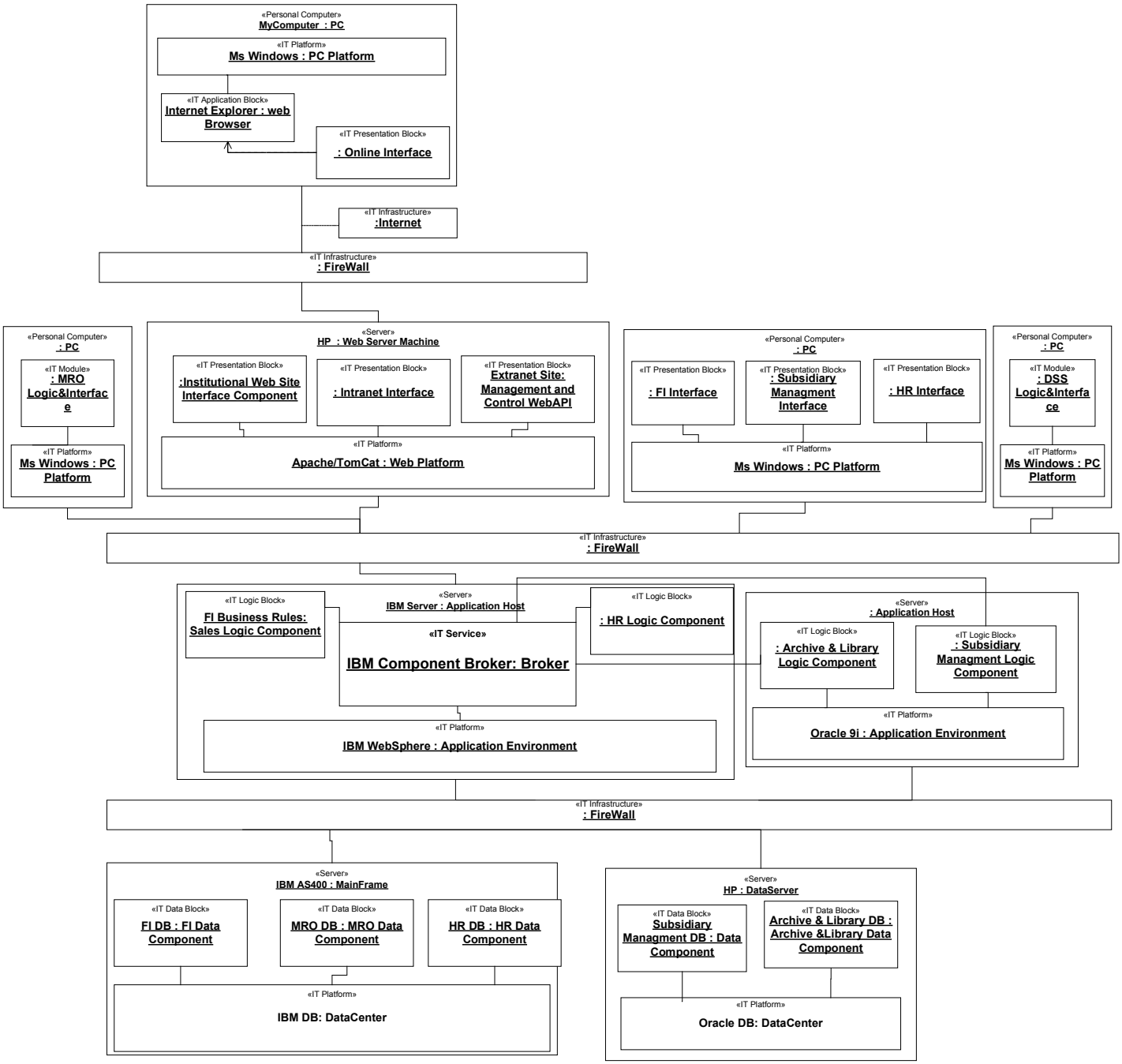

Figure 9. Technological Architecture

As Figure 9 illustrates, all the systems, at logical level, interact with Broker Component, but not directly with each other. Some systems present a three-tier architecture (clearly separating data, business logic and user interface), while others are two tier (having the business logic and the user interface tied together in an IT block).

Prior to using the standard set of concepts proposed in this paper the researchers and the company IT and business staff were not able to address IS issues and business needs. The proposed UML profile for ISA, used in this case study, provided the tools for ISA modeling in AS-IS and TO-BE phases.

Two other case studies are being carried out using the UML profile proposed in this paper, and similar results, for the moment, are being obtained.

5. CONCLUSIONS AND FUTURE WORK

This paper proposes a UML profile for ISA modeling. The main contribution of this research is a restricted collection of founding and root concepts used for describing ISA at informational, application and technological levels.

The paper also presented a real-world case study (taken from a project in which we are involved) in order to illustrate the proposal with concrete information systems, analyzed from informational, application and technological perspective.

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 for automatic ISA evaluation. The ISA evaluation intends to be accomplished using existing concepts in IS industry (as TOGAF ISA evaluation criterions for IT architectures [21]) 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.

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