Enterprise architecture improvement for virtual enterprise modeling

Nora MOUHIB, Pr. Slimane BAH and Pr. Abdelaziz BERRADO
Research Team AMIPS
University Mohammed V in Rabat
Ecole Mohammedia d'Ingenieurs
Rabat, Morocco
mouhibnora@gmail.com, {slimane.bah,berrado}@emi.ac.ma

Abstract

To deal with today competitive environment, companies tend more and more to cooperate in Virtual Enterprises where strategies, benefits, skills, resources, costs and risk are shared for a prime amount of time. Virtual enterprise is principally based on Information Technology (IT); its implementation requires modeling approach with a particular focus on business-IT alignment.
Enterprise Architecture seems adequate approach to correctly design virtual enterprise models, however, one of its big challenges is: How can it redefine itself to deal with the complexity and uncertainty of virtual enterprise? In this paper, we attempt to give answers to this question by evaluating enterprise architecture in virtual enterprise context, identifying improvement areas and exploring several promising domains to address them; our finding is summarized in five hypotheses about requirements of virtual enterprise modeling and supported by a case study of pharmaceutical supply chain.

Keywords
Virtual Enterprise, Enterprise Modeling, Enterprise Architecture.

1. Introduction

Agility and responsiveness required to survive in today competitive market are obtained by forming highly dynamic virtual enterprises; Camarinha-Matos et al. (1998) gave a common definition of virtual enterprise as *"A temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks".*

Virtual enterprise design requires formal models to improve the understanding of its complexity and uncertainty; they serve as the basis for a better management and decision-making as well as for the implementation of information technology; the effective use of information is the key element to improve financial performance and to keep peace with demand.

At first sight, Enterprise Architecture with its wide range of frameworks seems adequate modeling approach to reduce the apparent complexity of virtual enterprise and to correctly deal with the business-IT alignment; however, it is not sufficient! Virtual enterprise is a multidisciplinary area that requests a multidisciplinary approach involving multiple tools to complement or extend the enterprise architecture.

Lapalme et al. (2015) stated three Grand Challenges of enterprise architecture: 1. how to do it in the context of increasing complexity and uncertainty? 2. How it takes into consideration the new realities such as virtual and connected organizations? 3. How it must evolve and redefine itself?

This paper tries to answer those grand challenges by giving an analysis of several aspects of virtual enterprise and explore how enterprise architecture concepts can be extended or replaced to improve their adaptability to virtual enterprise.

This study is embedded in the Enterprise Architecture Management field which is the practice of continuous adaptation of enterprise architecture in order to understand complexity and to manage change; our aim is to give inputs from several associated domains, especially Enterprise Ontology, Teleology, System Dynamic and Sociology. Each one of them can place a unique perspective on virtual enterprise paradigm and give a much better understanding of its complexity and uncertainty.

The rest of the paper is organized into three parts; section 2 sketches an overview of virtual enterprise and enterprise architecture; in section 3, we lift the veil of promising areas that can complement or replace some enterprise architecture concepts, the result of our finding is summarized in five modeling hypotheses supported by a case study of pharmaceutical supply chain presented in section 4.

2. Related work

It is beyond the scope of this section to conduct a detailed review of virtual enterprise and enterprise architecture, their development, use, and ongoing maturation. We give an overview of their most relevant aspects.

2.1 Overview of Virtual Enterprise

Far from the long term strategic alliance that focuses on continuous improvement, virtual enterprise has a different look; it relies on cooperation between business units to share benefits, skills, resources, risk and information. It's an umbrella for several outsourcing operations where strategies are aligned for a prime amount of time;

Virtual enterprise is a socio-technical system which involves several partners who would work together to rethink and restructure business and information technology practices, as necessary, to provide products or services better, faster and cheaper than ever before.

Kamio et al. (2001) defined it as a group of competent enterprises that are combined to implement a project, the enterprise goes out when its role is completed; Although Esposito and Evangelista (2014) identified the same characteristics and aims, they gave a number of shared and non-shared issues on the basics of a literature review and portrayed two topologies: the hierarchical topology which means a leader company assumes the management and coordination of the network, and the holarchical topology which means a self-organization of all co-operating partners.

Virtual enterprise is an illustration of Virtual Organization; Mowshowitz (1994) introduced the Virtual Organization Theory principal as a switching between different means for satisfying demand. He outlined a logical separation between the abstract elements which are the conception and planning and the concrete elements which are the implementation. He defined virtual organization as a goal-oriented enterprise under meta-management that consists of 1) Analyzing abstract requirements. 2) Analyzing existing means for satisfying requirements 3) developing and maintaining the allocation procedure that assigns concrete satisfiers to abstract requirements and 4) updating the mapping from abstract requirements to concrete satisfiers.

Khalil et al. (2002) supported the concept of meta-management in terms of explicit goals and dynamic switching and identified its characteristic; they outlined the role of information technology in the foundation and meta-management of virtual organization at three different levels: operational, tactical and strategic.

One important aspect in virtual enterprise is the Distributed Business Processes; Camarinha-Matos et al. (2001) defined them as a combination of various processes taking place at different nodes, their definition and enactment is not limited to a single organization, but instead to a set of autonomous, distributed, and heterogeneous nodes; their management is quiet difficult and requires a good orchestration between sub-business operations to be correctly executed. Another important aspect outlined by the authors is the Visibility Scope; How far along the virtual enterprise network can one node see? To answer this question, each node needs to understand the network design, configuration, operations, roles and functions of other nodes. It's very important to have the big picture of the virtual enterprise. Abstraction of its complexity provides a practical way for defining and decomposing it as an interconnected system and relating its disparate components.

Virtual enterprise evolves along various stages along its life cycle including: the creation, operation, evolution, and dissolution stages, figure 1 gives an illustration of its life cycle:

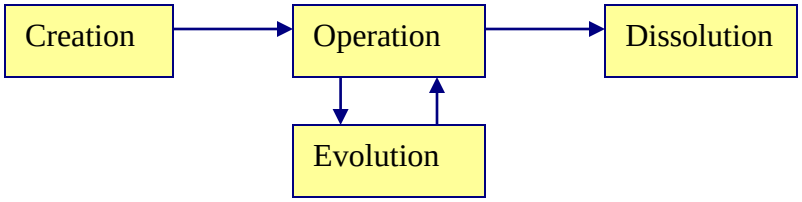

Figure1. Virtual enterprise life cycle

Virtual enterprise life cycle starts when a new opportunity arises. Depending on the context, its Creation may be initiated by a leader company (hierarchical topology) or a "primus inter pares" (holarchical topology); at this stage, an analysis of the opportunity requirements and available means, partner's negotiation and selection, configuration, strategy, business processes definition, roles and responsibilities, risks and costs analysis must be done. The next stage is the Operation; this is the phase when operations are performed by different nodes. The Evolutions might be done during the operation when it is necessary to add and / or replace a partner, or change their roles and the Dissolution happens when the virtual enterprise finishes its business and dismantles itself.

The harmony between processes is a big challenge depending on partners' selection; Kim et al. (2008) proposed a simulation-based method to evaluate and select proper partner in designing virtual enterprise; Sari et al. (2008) proposed also an analytic hierarchy process model to contribute in the selection of partner companies.
Chen et al. (2007) focused on the resource sharing and presented an Access Control model to enable collaborative operations.

Assimakopoulos et al. (2003) cited a number of concepts and proprieties of virtual enterprise including the decision-making, negotiations among participants, authority, beliefs and responsibilities, mapping of organizational entities to decisional roles, ability to identify and analyze a variety of conflict types and the existence of conflict resolution paths;

Modeling is prerequisite for abstracting the dynamic switching from one virtual enterprise to another and allows the analysis of what-if scenarios; it brings to life business processes and gives the blueprint to implement the information technology. Enterprise Architecture is a good modeling approach; however, some of its aspects need to be reviewed to deal with virtual enterprise. In this paper, we focus on those aspects (see Table1) in the sense that we will analyze theme and formulate hypotheses to address them.

Table1. Virtual enterprise aspects in focus

Aspect	***Brief description***
Repetitive transformation	Dynamic switching from one virtual enterprise to another
Goal oriented	Goals must be expressed explicitly
Information technology based	Information technology is the ultimate support of virtual enterprise; it must be in constant alignment with business goals
uncertainty	The environment in which the virtual enterprise evolves is an constant change
Operations	various sub-business processes that take place in different nodes
Socio-technical system	Actors, roles, interaction and conflicts between them

2.2 Overview of Enterprise Architecture

Enterprise architecture is a relevant modeling approach; in its simplest terms, it is the process of aligning business strategy with information technology. ISO/IEC/IEEE 42010 (2011) standard proposes neutral definition as *"being constituted of the essential elements of a socio-technical organization, their relation- ships to each other and to their changing environment as well as the principles of the organization's design and evolution*."

J. Lapalme, et al. (2015) supported that enterprise architecture is a practice and emerging field intended to improve the management of complex enterprises and their information systems; they argued that it often provides the context for enterprise information systems and prescribed its requirements, design and implementation. Lankhorst et al. (2009) stated that it is a practice of integrating structure, processes, applications, systems and technology within an enterprise; they focused on methods and techniques for making and using integrated descriptions of architecture models, visualisation of these models for various stakeholders, and analysis of the impact of changes.

Architecture in its generic meaning is simply the structure and design of a system; it consists of an analysis of a system by decomposing it into its constituent buildings blocks. Enterprise architecture gives a macro and micro view of the enterprise, the macro view corresponds to the system of systems and the micro view corresponds to the individual subsystems; enterprise architecture process starts by taking a look at the current situation, identifying lakes, creating the future architecture and then developing a roadmap to follow to move from the current state to the desired one. It's a key enabler for doing the right things the right way.

Enterprise architecture is a well-tried approach to meet business-IT alignment need and also to keep the control of the virtual enterprise complexity; there are several Enterprise Architecture Frameworks, Handley (2008) outlined that their original purpose was only to organize information technology resources for more effective business management, in other worlds, to integrate disparate information systems across the enterprise in order to provide business value, their application has evolved from enterprise information system integration toward the entire enterprise. Schekkeran (2004) published a great study of enterprise architecture frameworks and gave directives to create or choose them; Lyons et al. (2012) gave several modelling and simulation techniques, inter alia, they underlined enterprise architecture frameworks role to help managers to understand the complex and dynamic nature of supply chain. ISO/IEC/IEEE 42010:2011 (2016) regularly reviews the exhaustive list of existing frameworks; the last review contains 72 different frameworks.

Zachman is broadly recognized as the father of the enterprise architecture, the Zachman Enterprise Framework is a taxonomy of elements that provides different perspectives of an enterprise; the framework is represented as a matrix with columns and rows, each cell within the matrix provides a unique model of the enterprise from a particular point of view (Zachman et al 2003).

There are other enterprise architecture frameworks that have been derived from Zachman framework, such as the Federal Enterprise Architecture Framework FEAF, The Open Group Architecture Framework TOGAF, and the Department of Defense Architecture Framework DoDAF.

The FEAF provides a common approach for the integration of strategic, business and technology management to govern federal agencies, it describes a suite of tools to help government planners implement The Common Approach to Federal Enterprise Architecture that provides principles and standards for how business, information, and technology architectures should be developed. The Consolidated Reference Model is at the center of FEAF and consists of a set reference models that describe six sub-architecture domains, each domain describes a specific area of the enterprise and requires individual artifacts (FEAF 2012)

DoDAF has been designed to meet the specific business and operational needs of the Department of Defense; it gives a holistic view of the entire enterprise architecture, while dividing the problem space into manageable components, according to the stakeholder's viewpoints. DoDAF entails System Engineering principles and defines 51 different models organized into 8 viewpoints to meet the specific business and operational needs of the Department of Defense (DoDAF 2010)

TOGAF meets a real need for a common framework that will facilitate the capitalization of architectural practices; TOGAF contains a detailed method: the Architecture Development Method that provides a structure for the progress of architectural transformation projects and set of supporting tools for the development of architectures. TOGAF defines the Enterprise Continuum as a repository of all the architecture assets; it is divided into two areas, the Architectural Continuum and the Solution Continuum. In a very high abstraction level, TOGAF is a set of building blocks that we add to or consume from the enterprise continuum when we go through an architecture development cycle (TOGAF 2011)

The Computer Integrated Manufacturing Open System Architecture CIMOSA is a relevant framework that provides a consistent modeling methodology and an integrating infrastructure for model execution. CIMOSA covers three inter-relating concepts: Modeling framework based on a process oriented modeling approach describing all enterprise activities in a common way; System life cycle which starts from business requirements definition to system implementation, maintenance, control and monitoring; and Integrating infrastructure that provides a set of generic services aimed at coping with the heterogeneity of manufacturing and information technology (CIMOSA 1993)

Another popular framework is the Architecture for the Information System ARIS, introduced by Professor Scheer in 1992, it is based on general business process model and comprises five views and three description levels; ARIS is a multi-architectural framework which encompasses all levels of system description. It can be used to list all required architectural elements with the business domain and links all information technology resources including network protocols, hardware, operating systems, data bases, software etc (ARIS 2006)

Last but not least, Generalized Enterprise Reference Architecture and Methodology GERAM framework, is an enterprise-reference architecture that models the whole life history of an enterprise integration project, GERAM provides a generic description of all the elements recommended in enterprise engineering and integration and unifies product models and business process design. It also offers new insights into the project management of enterprise integration. GERAM contains several building blocks to support modeling process such as Enterprise Modeling Tools, Ontological Theories, Generic Enterprise Models, and Generic Models (GERAM 1999)

Despite the wide panoply of powerful frameworks, enterprise architecture needs to be more adapted to virtual enterprise context as we will see in the next section.

3 Enterprise architecture improvement for virtual enterprise

3.1 Practical problem statement

In this paper we attempt to give answers to the “Grand challenges” (J. Lapalme, et al. 2015) about how enterprise architecture can evolve to deal with the complexity and uncertainty of virtual enterprise by analysing aspects already gone in table1. We choose to be inclusive and adopt different perspectives from other areas as part of the discussion.

3.2 Analysis and modeling requirement

Enterprise engineering is an emerged term within the enterprise architecture domains; it is largely discussed by researchers and practitioners since its introduction in nineties by CIMOSA (J. Lapalme, et al. 2015).
Dietz (2006) argued that it is derived from systems engineering and inherits its proprieties, including the definition of the enterprise as socio-technical system, and the distinction between teleological and ontological systems. Under those finding, and given the Grand Challenges defined by Lapalme, we propose a number of promising areas that we foresee to be important to correctly cope with the virtual enterprise paradigm and we believe could replace some of enterprise architecture concepts or extend them to be more appropriate to design virtual enterprise. It is not the intention of this paper to analyze in detail each area; rather the goal is to explore how they are relevant for the virtual enterprise design. Hypotheses are formalized to sum up the evidence at the end as we will see below.

One of the most widespread criticisms of enterprise architecture is the lack of some frameworks such as Zackman framework or even DoDAF of a clear and defined architecting method. Virtual enterprise is a repetitive transformation which requires a step by step method to ensure the consistence and the transparency of its design; an explicit methodology is needed in order to capitalize on previous modelling exercises; it must define in detail the major stages in the design process, the inputs and outputs of each stage and their required tools and techniques.

When we are dealing with information technology landscape, at a given time, abstract design has to be implemented and concretized. We need to produce an executable form of abstract models. Although some

frameworks draw the entire information technology life cycle from the definition of the vision that it serves to the monitoring and maintenance post-implementation, there is a lack of an explicit switching method between abstract to concrete syntax devoted to help development teams to apprehend business models; such method must be extended by a semantic definition of common vocabulary to share among actors so that everyone can understand what we are talking about. That's lead us to formulate the first hypothesis:

➔ Hyp1: virtual enterprise is in a constant state of change which requires a clear designing methodology with an explicit definition of switching from abstract design to concrete implementation and extended by semantic definition of designing assets.

At strategic level, virtual enterprise is a goal oriented; it can be seen as a teleological system designed to achieve a survival purpose in some operating environment. The environment determines what operations and their target level of performance are expected of the virtual enterprise. It's an organized collection of many nodes that interact with each other through various links in order to collectively achieve the desired goal; the most important question then is how the structure of different interactions determines the survival objectives of virtual enterprise? List the strategic goals as recommended by some frameworks is not enough, at this stage, we need a teleological framework capable of apprehending which linkage of nodes generates desired behavior to reach survival objectives(Venkatasubramanian 2006)

At technical level, as already said, information technology is the ultimate support of virtual enterprise; going back to the late 1960's, information technology development objectives was clearly to define solutions to satisfy those objectives, it was originally very teleological; but somewhere along the line information technology implementation lost its teleological focus; actually, development teams focus mostly on technology and application consolidation, they discuss technical aspect more than discussing the purpose that they serve; teleological approach can be very helpful to guide business- IT alignment need; information modeling must be done as objective oriented rather then being technically oriented (Artz 2001). That's enable us to formulate the second hypothesis:

➔ Hyp2: Teleological approach is required at strategic level to preserve the Identity of the virtual enterprise and at technical level for a goal focus alignment between business and information technology.

Enterprise architecture frameworks turn around the same principle idea introduced by Zackman which is creating a set of models according to stakeholders' viewpoints to answer the six abstraction questions; at business level, we have to create several different models such as business functions models, business process models, business service models etc. Which involves significant costs and delivery times, and lead us to believe that the coherence between them cannot always be taken for granted! The central question here, is their another possibility? Instead of creating a set of models and trying to join them in some global view, we can possibly look for a comprehensive representation that can be understood by everyone and shows the coherence between all fields, like business processes, workflow etc. That leads us to explore the enterprise ontology field which gives a better insight in the virtual enterprise design, it focuses on operations that have to be well understood and explicitly described and presented to all nodes to identify inconsistencies. It provides a single coherent model for the whole virtual enterprise and can support the architecture exercise without being held back by node borders; it reduces time and cost and highlights the collaboration and social interactions among actors.

Dietz (2005) defined the ontological notion as a construction and operation of a system independently of its implementation. Dietz (2007) introduced the PSI-theory that underlies the enterprise ontology and defined a DEMO (Design Engineering Methodology for Organization) methodology that provides an ontological model of an organization. DEN HAAN (2009) outlined that enterprise ontology is focused on collaboration and social interactions among actors and offers a reduction of complexity over 90%. Enterprise ontology satisfies five quality requirements (C4E): Coherence, Comprehensiveness, Consistence, Conciseness and Essence; instead of designing a set of models and seeking their coherencies, enterprise ontology reduces designing time and cost by providing a model that satisfy the C4E requirements. The third hypothesis is:

➔ Hyp3: enterprise ontology can give a coherent and comprehensive representation of business design and reduces complexity, cost and delivery time.

According to Hoffman et al. (p 59, 2013) "*Enterprise architectures frameworks do not necessarily help managers understand how enterprise architectures will behave in different environments."* the authors outlined the need of a rigorous approach that can analyze the architectures behaviors. Glazner (2011) supports the same

idea that frameworks do not aid dynamic behavioural analysis of the enterprise; he proposed a simulation Modelling tool to better understand how architectures changes influence behaviours it is capable of producing; frameworks are more illustrative than being useful as an analysis tool of the behaviors that a given enterprise architecture is capable of producing.

Dietz (2007) makes a clear distinction between static, kinematic and dynamic notions, static is about the possible states in which the system is in equilibrium. Kinematic is about the possible processes in the system, so about the movement and Dynamic is about the actions that cause those movements. Enterprise architecture enables to get static and kinematic views while dynamic view still missing. The forth hypothesis is:
➔ Hyp4: Enterprise architecture can be extended by a dynamic and probabilistic method to simulate the dynamic behavior of virtual enterprise

Donaldson et al. (2015) investigated the failure of enterprise architecture projects and concluded that the major common cause is their lack to address the sociological dimension. Virtual enterprise is a complex socio-technical environment comprising interdependent resources of people, information, and technology which interact with each other and their environment in support of a common project. Any architectural transformation requires close collaboration between different people involved in the enterprise architecture; admittedly, frameworks give several views of the enterprise according to stakeholders viewpoints, even some of them give a powerful ways to put all stakeholders together, they bring to light their roles and interactions; however, this is not enough! Whatever the framework being used, we must take into consideration not only the actions of individual and who is involved, but causes of everyday organization problems, contradictions and tensions within the activities that generate conflicts and failure of enterprise architecture projects. Which conduct us to formulate the fifth hypothesis:
➔ Hyp5: modeling of sociological dimension in virtual enterprise must exceed the simple fact of representing actors, their roles and actions. Models must address their day-to-day operations including difficulties, conflicts and incompatibilities.

Table2 summarizes the foundational modeling requirements discussed above:

Table 2. Foundational Virtual enterprise modeling requirements

Need of :	***To Address:***
Methodology describing: - Step by Step modeling process - Explicit transition from abstract to concert design - Semantic definition of common vocabulary	Repetitive virtual enterprise modeling exercise Information technology implementation
Teleological model	Goal oriented – Business-IT alignment
Ontological model	Reduce operations complexity, modeling cost and delivery time
Dynamic and Probabilistic simulation	Future behavior – uncertainty
Sociological model	Actors'roles, interactions and Conflicts

4. Illustrative example: Case of the public sector pharmaceutical supply chain in Morocco

To further explain the hypotheses proposed above, we give in this section an illustrative example of public sector pharmaceutical supply chain in Morocco;

a. Pharmaceutical Supply Chain:

The Moroccan Ministry of Health is the institution through which the State guarantees its citizens the constitutional right to health. The ministry accords a huge attention to the drugs supply chain; 40% of the total health budget is allocated to pharmaceutical products acquisition. However, the increasing

demand for healthcare services, new technologies, and new drugs continue to drive up the total healthcare cost. The need of a public health rationalization, especially for meeting the increasing quality demand requires a profound transformation in the pharmaceutical supply chain management.

The Division of Supply operates as a part of the ministry and conducts the management of the pharmaceutical supply chain; it performs the acquisition, storage and distribution of pharmaceutical products to public hospitals and outpatient units while manufacturing and transport are made by third parties in the context of outsourcing contracts. Pharmaceutical supply chain managers play a crucial role in protecting patient safety; only guaranteed products can enter a hospital ward, that's must be done at the right time because a delay of a few second can cost a life. One of the biggest challenges facing them is maintaining sufficient inventory levels to sustain quality and timely patient care and reducing wastages.

The current structure has a hierarchical topology with a central organization where the division acts as the central entity. It ensures all activities ranging from drugs selection through negotiation with suppliers, payment, storage, transport, and distribution; and also the management of the upstream and downstream relationships with laboratories, provincial delegations, hospitals and outpatient units. The distribution network design used to move drugs from laboratories to hospitals is presented in figure2.

Pharmaceutical supply chain managers make three kinds of decisions: Strategic, Planning, and Operation depending on the time frame during which the decisions made apply; at the Strategic phase, long-term decisions are made like network design and optimization, partnership, information technology investment; Planning phase include drugs demand planning, supply planning, production contracts for the next year; At the operational phase, current operational activities such as distribution scheduling, storage, inbound/outbound operations are performed. Supply business processes can be divided into intra-processes that take place within internal services while the inter-processes occur with external partners.

The pharmaceutical supply chain life cycle starts with an annual budget allocation to buy drugs and pharmaceutical products; the division of supply aggregates the global procurement order. It selects producers on the basis of request for proposals; at the delivery time, pharmaceutical products are inspected and stored in central warehouses. The division also sets the delivery schedules and distributes products to provincial delegations for a short storage before their redistribution to hospitals and outpatient units. Several actors operate together to direct drugs to patients as illustrated in Table3.

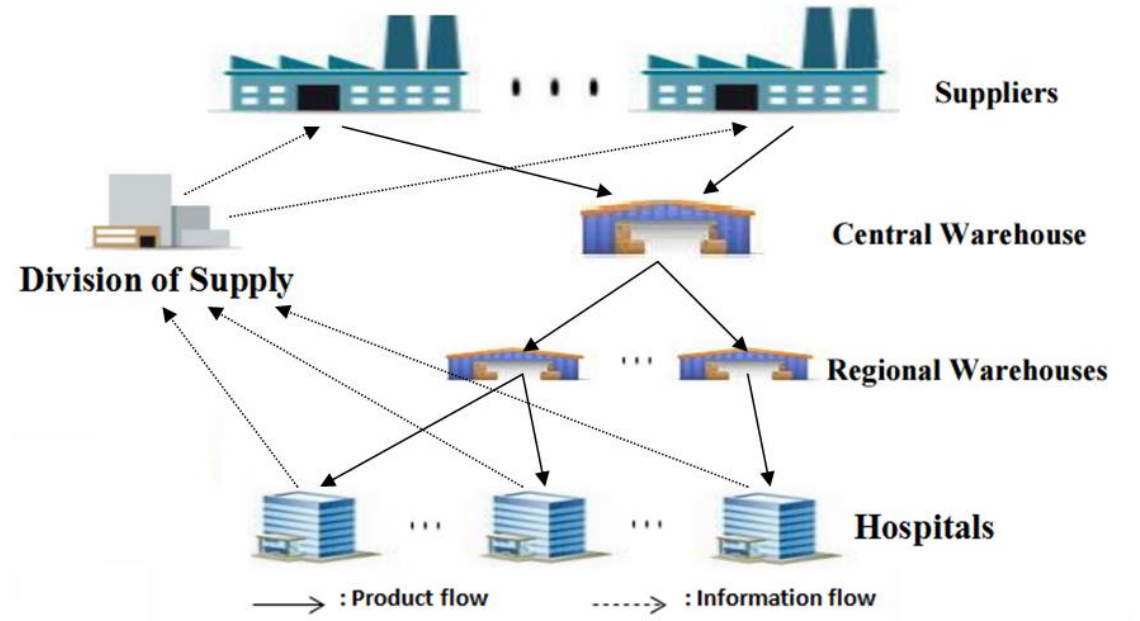

Figure 2: Moroccan Pharmaceutical Supply Chain

Table3. Moroccan pharmaceutical supply chain actors

Actor	***Role***
Pharmaceutical laboratories	producers
Division of supply	Dealers/ Purchasers/ Whole storage/Distributor
Transporter	Drug's transporter
Provincial Delegation	Regional Storage/ Redistributor
Hospitals and Outpatient units	Providers

The increasing complexity that characterizes the supply chain, the increasing budget allocated to buy pharmaceutical products and the increasing patient expectations lead the division to set up a reform project that consists of the redesign and reorganization of the entire chain to make radical changes in the way it operates and to provide a support for decision-making processes; whereupon great research efforts have been made to optimize inventory (Mouaky et al. 2016), to design transportation network (Haial et al. 2016) and select transportation suppliers (Laghrabli et al. 2016), to evaluate supply chain performances (Chorfi et al. 2016), to support strategic outsourcing decisions (El Mokrini et al. 2015), to analyse risk (Elamrani et al. 2016) and drugs consumption (Serbout et al. 2016).

At the other side, as a part of the reform project, the division focuses on the Information System improvement for accurate collect and report data to support decision-making when and where needed; An efficient Information system enables managing a large volume of data operations related to planning activities, estimating demand, allocating resources, distribution activities, monitoring, coordinating and controlling operations, storage organization and transportation system implementation across the entire supply chain; it must synthesize data into information and key performance indicators for use in decision making process.

It is very important to underline two major components of the required information system; the first one is the division internal system devoted to support internal business; the second one is the pharmaceutical supply chain information system devoted to support the business of the entire supply chain as a single and coherent company. The first component is an integral part of the second where the division is considered as a single node among others except that it oversees the hierarchical topology of the network.

b) Hypotheses illustration

The management of pharmaceutical supply chain is very hard due to the increasing complexity of logistic flows; the division of supply manages several different product categories with different requirements and different suppliers according to different healthcare programmes. The decision-making process is dispersed among several organizational units with coordination and visibility scope issues.

Given this critical prevailing situation; it is a matter of priority to manage the pharmaceutical supply chain as a virtual enterprise with an integrated and collaborative perspective using an adequate modelling tool; the hypotheses proposed above can direct the supply chain modelling. It is notable that following hypotheses illustration can be recursively adapted to the division of supply internal design:

- Annually, the division of supply has to manage different supply programmes at the same time with different suppliers; each programme can be directed us a virtual enterprise, its modelling requests designing tool with a step by step describing method to ensure consistency and to capitalise on previous modelling practices. Obviously, it is ultimately important to create a common repository where all modelling artefacts are stored and accessible by all nodes; models must be semantically understood and transition from abstract level to concrete level must be clearly defined to facilitate the implementation of information technology.

- The division of supply operates in a large complex network, such a network is usually represented as a graph which is a collection of nodes and links between them; each node is receiving from and sending to, other entities some value which can be money, effort, efficiency, information, time, product…

Through such interaction, the supply chain accomplishes some overall required value to meet drugs demand. Its structure must be adapted to the function that it serves. The environment in witch it operates defines its proprieties and its behaviour. Teleological model at strategic design level is needed to define which proprieties, function and structure are needed to produce external behaviour required to meet patient demand.

Designing the change is not limited to strategic level; information technology adaptation is required to "escort" the supply chain, this adaptation should begin by problem statement, the problem should be decomposed into objectives which are sub problems affected to each node. Rather then modelling information as entities or reusable objects which are more specific to development teams, modelling information as objective decomposition is more general and more abstract, especially when we are dealing with a set of heterogeneous nodes with different information systems. Once the overall purpose of the system is understood by everyone, sub objectives may be translated into sub problems and analyzed by development teams which are mostly technically oriented, even the enterprise architect; teleological approach could change their focus from things they could do to things they should do.

- In order to simplify business modelling of the entire supply chain without being curbed by node borders, enterprise ontology modelling tool such as DEMO can be very useful to design the entire supply chain operations consistently, coherently, comprehensively and faster independently of their implementation.

- Teleological strategic design can expect future behaviour of the supply chain while dynamical and probabilistic design can simulate this behaviour in changing environment and copes with uncertainty.

- Sociological dimension modelling is very important to the supply chain success; conflicts and differences between actors must be designed and resolved before going through a supply life cycle.

4 Conclusion

Virtual enterprise is the leading paradigm of 21 century; its design is prerequisite for successful management and information system alignment; in this paper, we discussed promising areas to improve the adaptability of enterprise architecture as modeling approach for virtual enterprise. We summarized our finding into five hypotheses and we illustrated them with a pharmaceutical supply chain case study.
In future works, hypotheses from 2 to 5 will be translated into comprehensive models with an explicit methodology of their use as recommended in hypothesis 1. All those models will be organized in an effective way to give a detailed understanding of virtual enterprise complexity.

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Biography

Nora MOUHIB is currently a fulltime PhD student at Ecole Mohammedia d'ingenieurs at the Mohammed V University in Rabat, Morocco, and his research interests are in enterprise architecture improvement. She was graduated as an engineer from Ecole Mohammedia d'ingenieurs in 2008; she has 6 years of experience as IT project manager in banking sector, she was responsible for the design, development, implementation and maintenance of software programs.

Abdelaziz BERRADO is an Associate Professor of Industrial Engineering in the *Ecole Mohammadia d'Ingénieurs* at the Mohammed V University, Rabat, Morocco. He earned MS/BS in Industrial Engineering from Ecole Mohammadia d'Ingénieurs, an MS in Industrial and Systems Engineering from San Jose State University, and a PhD in Decision Systems and Industrial Engineering from Arizona State University. Dr. BERRADO's research interests are in the areas of Supply Chain Management, Data Mining, Quality, Reliability, Innovation and Safety. His research work is about developing frameworks, methods and tools for systems' diagnostics, optimization and control with the aim of operational excellence. He published several papers in international scientific journals and conferences' proceedings. In addition to academic work, he is a consultant in the areas of Supply Chain Management, Data Mining and Quality Engineering for different Industries. He was also a senior engineer at Intel. He is member of INFORMS and IEEE.

Professor Slimane Bah holds a Ph.D. in computer networks from Concordia University - Montreal. During his Ph.D. research he was an intern at Ericsson Canada. He also holds an M.Sc. in computer networks from University of Montreal and an engineering degree in computer science from l'Ecole Nationale Superieure d'Informatique et d'Analyse des Systems (ENSIAS - Morocco). Currently, Dr. Slimane Bah is an associate professor at the computer science department of Mohammadia Engineering School (Ecole Mohammadia d'Ingenieurs) – University Mohammed V in Rabat. Furthermore, he has an experience as adjunct professor at the University of Moncton. His research interests include end-user services, self-organizing and challenging networks, service and protocol engineering.