INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

# Organizational Engineering

An Overview of Current Perspectives

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Dissertação para a Obtenção de Grau de Mestre em

**Engenharia Informática e de Computadores**

**Júri**

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**Junho 2007**

## Agradecimentos

Mais do que gratidão quero dirigir as minhas palavras de profunda admiração e respeito ao professor José Tribolet que me soube desafiar, cativar e ensinar melhor do que qualquer outro pedagogo no percuso pessoal que tracei no Instituto Superior Técnico. Agradeço também a disponibilidade e cooperação revelada vezes sem conta nos incontáveis pedidos que lhe dirigi durante este ano lectivo.

Ao professor Rodrigo Magalhães, que me acompanhou aconselhou e corrigiu incansavelmente durante o processo de elaboração desta tese, o meu muito obrigado. Não acredito que existam abordagens ou notações capazes de definir um processo que explique detalhadamente e de forma inequívoca todos os passos e dificuldades porque se passa na escrita de um documento deste tipo, e se o resultado do meu trabalho é inteligível e interessante é em grande parte a vós que o devo.

Não posso deixar de agradecer também aos professores Jan Dietz e Antonia Albani, com quem trabalhei directamente na minha estadia na T.U.Delft, e aos investigadores do CEO, com particular atenção à professora Marielba Zacarias, que contribuíram de forma determinante na compreensão dos diferentes temas sobre os quais tive que me debruçar.

Extendo também os meus agradecimentos aos amigos do mundo académico, em especial ao Miguel Ventura, pela infindável paciência e os com certeza mais de 1825 telefonemas (que os meus pais não perdoam) e aos amigos Pedro Neves, Miguel Mendes e Paulo Sebastião a quem peço primeiro desculpa pelos telefonemas irados, as inseguranças infantis e as conversas desinteressantes que vos fiz aturar, e agradeço depois pelas saidas à noite, as conversas parvas e bem dispostas e a companhia sempre disponível.

Fora do mundo universitário quero agradecer de forma muito especial aos meus pais pelo constante apoio nos bons e maus momentos e por todas as regalias, mordomias e facilidades com que me permitiram enfrentar a vida de estudante. Não há palavras suficientes para decrever o quanto vos sou grato.

Por razões tão especiais como difíceis de enumerar, termino dedicando este trabalho ao meu irmão com quem discuto mais do que converso e que a tantas provações tem sido sujeito nos últimos anos.

## Abstract

Organizations exist in many types, shapes and fulfilling different purposes. They are the main service providers of our present society and address most of our needs from the most basic ones such as producing food, channeling water, providing healthcare services, to our most extravagant wants such as cosmetic products, luxurious cars, fashionable clothes, etc. Organizations have always resorted on more or less advanced technological items to accomplish their tasks but only very specific technological tools have forced them to revolutionize their way of behaving and performing. Information Technology objects, which are being responsible for numerous enterprise transformations, are now pervasive items of organization's operations. They have changed the way of communicating, they have contributed to the acceleration of the interactions between people with and within organizations and they have opened doors to new ways of organizing enterprises. Unfortunately, they have also become one of the most common sources of organizational problems. This thesis address the interactions between the world of machines dominated by engineering sciences and the world of people which has been mainly the concern of social sciences. It studies the main perspectives of a discipline called Organizational Engineering and identifies the issues that they do not address and that are fundamental for minimizing the problems that arise when the worlds of people and machines collide. This study proposes a path for blending these two worlds based on existing methodologies and tools developed in the academic community.

**Keywords:** *Organizational Engineering, Organization, People, Information Technology, Interaction, Emergent Behavior*

# Resumo

Existem vários tipos de organizações, com várias formas e diferentes propósitos. Na nossa sociedade, são elas as principais responsáveis por contribuir para a satisfação das necessidades das pessoas. Há organizações que se concentram na produção de bens de alimentação, outras que se preocupam com a prestação de serviços médicos com distribuição de água e energia, etc. Desde sempre que as empresas utilizam artefactos tecnológicos na realização das suas actividades mas apenas em determinados momentos da história têm surgido tecnologias que ganham vida própria e que revolucionam completamente a maneira de operar. É o caso das tecnologias de informação que são actualmente uma constante em qualquer organização. As TI revolucionaram as formas de comunicação, aceleraram o tempo de interação entre as pessoas de dentro e de fora da organização e trouxeram às empresas a possibilidade de aumentar a sua eficiência operacional mas também de experimentar novos modelos de negócio baseados em paradigmas que não existiam numa era pré-informação. Infelizmente, para além das oportunidades que as TI despertam, são elas hoje as principais responsáveis por alguns dos maiores problemas e custos empresariais que, na maior parte dos casos, surgem do fraco entendimento das inúmeras consequências emergentes das interacções entre pessoas e máquinas. Esta tese estuda algumas perspectivas da disciplina Engenharia Organizacional que procura compatibilizar e sincronizar as máquinas e sistemas com as necessidades das pessoas nas organizações. Aqui apontamos algumas deficiências destas abordagens e sugerimos um percurso de integração que, baseado em tecnologias e metodologias existentes na comunidade académica, procura misturar melhor de cada um dos dois mundos: o das pessoas e o das máquinas, para que possamos controlar cada vez melhor as nossas organizações.

**Palavras Chave:** *Engenharia Organizacional, Organização, Pessoa, Máquina, Interacção, Propriedades Emergentes*

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# Part I

# Delineating the Path to Follow

## 1 Introduction

### 1.1 Introduction

"*An organization begins with a person who has an idea ... He or she hires people to do the basic work of the organization ... As the organization grows, it acquires intermediate managers ... The organization may also find that it needs two kinds of staff personnel ... the analysts who design the systems ... the support staff, providing services to the rest of the organization ...Put these five parts together",* Strategic Apex, Operating Core, Technological Structure and Support Staff, "*and you have the whole organization ... "* [1].

More than twenty years have passed since Mintzberg told the story of the above paragraph and although new business models and organizational structures might challenge his version of the emergence of enterprises, organizations are still human made artifacts constituted of human and technological agents [2]. Organizations are socio-technical arrangements which pursue collective goals, control their own performance and have a more or less defined boundary which separates them from the environment. Organizations act, they are expected to produce specific results, but they do so only as individual agents within them act [3].

(Organizations such as) Manufacturing firms, Schools, Hospitals, Armies, Insurance Companies, etc., are ubiquous in modern societies, they serve us on a daily basis and it is healthy and natural that we seek ways for aligning their actions with their objectives (and purpose) in the hope that they will provide us a better service, but this seems an incredible difficult task.

***Business time*** has shortened because of the increasing use of new information and communication technologies that have transformed the pace of interactions (person-person, person-machine, machine-machine). Communications that once would take hours or even days to manifest results now have visible outcomes almost instantaneously [2]. The number of transactions, information flows and quantity of information exchanged has increased and with the growing complexity of systems, there is a corresponding increase in the complexity of the enterprises that develop, operate, sustain and are supported by those systems in the business environment [4].

It seems that every enterprise is facing uncertainty and change and being pushed to the limit in every aspect of its environment [5] while most of our understanding on organizations is segmented and disperse, making it difficult to select the right knowledge to manage a particular enterprise at a particular point in time [2]. Even the recently developed knowledge on ***Enterprise Architectures*** that tries to achieve a more integrated perspective on organizations than traditional social sciences (Transaction Cost Economics [6], Complexity Theory [7], Organization Ecology [8], Actor-Network Theory [9], among others) and engineering approaches (Systems Engineering, Systems Theory, among others) seems to be lagging behind in aspects such as: real-time analysis, enterprise task uncertainty, network analysis, cultural issues, etc.

All this can only lead us to conclude that a new body of knowledge is needed. One capable of better integrating the teachings of both ***hard*** and ***soft*** sciences[1] approaches, one that will allow us take the organizational reins into our hands and prevent the enterprises of solely relying on self-regulating and subsistence mechanisms that somehow emerge and prevent organizational destruction to some extent.

The discipline we are talking about is **Organizational Design and Engineering** (ODE), which is different from traditional Organizational Engineering disciplines because it tries to merge the knowledge of social sciences and engineering sciences, allowing the **design** of the social component of the enterprise (people, groups, values, culture, etc.) while still supporting the organization with the rigor and tools of the engineering disciplines.

ODE is a study of Enterprises as social individuals who can create norms, play roles and act by means of member agents (human or technological) who play particular roles inside it. ODE will prepare the next generation of managers and workers for designing new styles of organizing and for controlling the organization itself and the people and machines within it.

### 1.2 Research Context

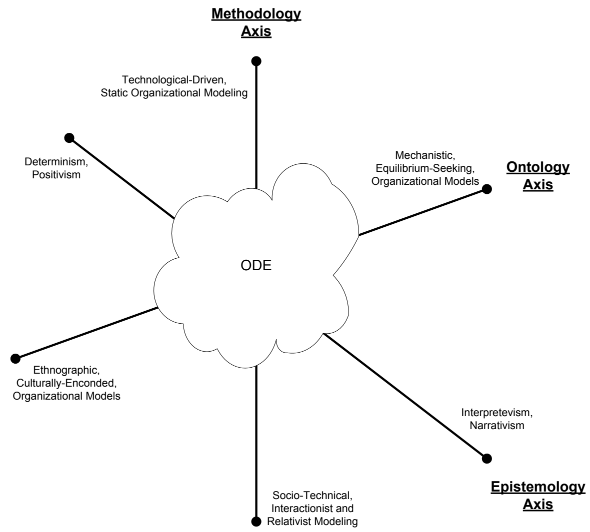


**Figure 1 the half way positioning of ODE**

This work appears in the context of Organizational Engineering, an expanding research area which "*aggregates concepts and methods from multiple areas of knowledge, including requirements engineering,*

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[1] ***Hard Sciences*** is an expression that refers to engineering disciplines, while the ***Soft Sciences*** expression refers to organizational and management sciences.

*software engineering, method engineering, management theory and systems theory to model, develop and analyze various aspects of changing organizations"* [10].

The thesis is part of project ODE (Organizational Design and Engineering) that was born at the Department of Computer Engineering of Instituto Superior Técnico in Lisbon and which is being developed at the Center of Organizational Engineering (CEO). ODE is a further development of Organizational Engineering and tries to provide an alternative perspective on information systems research and practice. It is founded upon Systems Theory, Computer Science and Engineering and Organization Science [2] and is overall supported by *Organization Holism* [11], an intellectual stance from the fields of Complexity and Evolution theory.

ODE's research agenda is an ambitious path organized in terms of three axes of analysis (1) methodological, (2) ontological and (3) epistemological (see Figure 1), for which an initial series of four papers was programmed. ***Paper 1:*** [2] started to justify the need for a new discipline on organizational studies; ***Paper 2:*** [12] situated ODE in terms of its ***Methdology Axis*** by comparing two schools of thought labeled *Technological Rationality* and *Socio-Technical Interactionism* and presenting an initial architecture to serve as starting point for a new approach on organizational modeling; ***Paper 3:*** will establish ODE's position along the ***Ontology Axis;*** and ***Paper 4:*** will target the ***Epistemology Axis*** in a discussion that will argue the need of integrating the *Positivist* and *Interpretivist* research methods.

### 1.3 Research Objectives

In the context defined in the previous section, this thesis fits as starting point of the research needed for paper 3 of ODE's research agenda (ontological axis positioning) and the objectives and research questions that this work tries to achieve are: (1) produce an overview of the current known approaches of Organizational Engineering; (2) produce an overview of CEO's research through time in order to justify its future lines of research; (3) identify the main shortcomings of current Organizational Engineering approaches; (4) refine the definition of ODE and suggest how the identified shortcomings can be overcome; (5) position the contributions of the different Organizational Engineering approaches in the context of ODE and suggest future exploration of synergies among them; and (6) link the development of ODE's concepts with the current research of the CEO's group.

### 1.4 Research Methodology

To address the research objectives described in the previous section we have focused on the study of existing perspectives of Organizational Engineering (that can be positioned inside ODE axes) that categorize the organization as the main object of their study. We have selected four different perspectives namely: (1) *Business & Enterprise Engineering* with St. Gallen [13] and James Martin [14] as protagonists; (2) *Language Action Perspective* mainly through the study of Jan Dietz's research project DEMO [15]; (3) *Computational and Mathematical Organization Theory* developed by Carnegie Mellon University through the CASOS research group [16]; and (4) the CEO perspective being pushed forward by the *Center of Organizational Engineering* of Instituto Superior Técnico [2; 12].

Because of the extent of the bibliographic review that had to be conducted in order to accomplish the present research work, a very clear and thorough synthesis method had to be followed when studying, summarizing and comparing the different perspectives of organizational engineering whose knowledge is disperse in multiple papers, books, technical releases, etc.

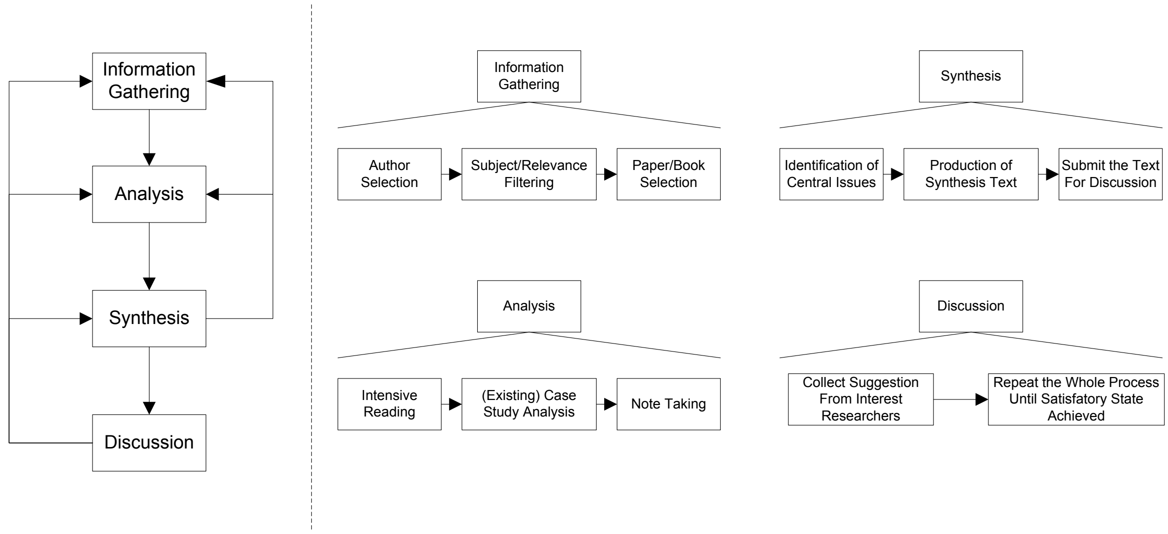


**Figure 2 Research Method for parts II and III of the thesis**

The steps of the research method are depicted in Figure 2 and represent the type of work that was done when elaborating parts II through III of this report. Part IV involved a more creative and less organized process where the participation in the doctoral classes of Organizational Engineering and the weekly meetings with my thesis advisor played a crucial role in shaping, correcting and discussing the ideas that through time and research started emerging in my head regarding these topics.

### 1.5 Thesis Outline

**<u>Part I:</u>**

The thesis is divided in four parts each composed of one or more sections. This first part concerns the discussion of the research context, its objectives and in general lines, the description of how the research work was conducted. This part also points to the core references that were taken into account when approaching the subject of this work.

**<u>Part II:</u>**

The second part of the thesis concerns the overview of the main Organizational Engineering approaches being researched outside of the Universidade Técnica de Lisboa. It has to be understood as the description of the different eyes and practices through which the organizational phenomenon is being approached in current times by perspectives of the field of engineering, some of which already inheriting contributions of social sciences disciplines.

In this part, **Section 2** addresses both the research of St. Gallen School and that of James Martin, **Section 3** addresses the studies of the *Language Action Perspective,* and **Section 4** is concerned with the *Computational and Mathematical Organization Theory.*

This part addresses the first research objective.

**<u>Part III:</u>**

The third part focuses completely on the research work conducted by CEO's perspective. It is an overview through time (from 99-today) of the different research paths and questions that were successively addressed by the group as well as the future and present directions that the research is taking.

In this part, **Section 5** addresses the temporal frame from 1999 to 2004, **Section 6** discusses the years 2004 and 2005, **Section 7** describes the present research and finally, **Section 8** starts providing the ODE's approach of organizational modeling (to blend the present with future research).

This part addresses the second research objective.

**<u>Part IV:</u>**

The fourth and last part of the thesis is a possible future approach of *Organizational Design and Engineering*, taking into account the study of the multiple contributions of *Organizational Engineering*. This part addresses the last four research objectives.

**Section 9** provides the critical analysis of the different research on *Organization Engineering* and highlights some of the tendencies which can be attributed to low hard-soft sciences synergy in the field of OE and that should be reversed; this addresses the third research objective. **Section 10** refines the definition of *Organizational Design and Engineering* and establishes a process of implementation and execution the ODE discipline in enterprise environments; this satisfies the fourth and fifth research objectives. **Section 11** links the process of **Section 10** with the current CEO's research, satisfying the sixth research goal of this thesis, and **Section 12** establishes the conclusion of this work.

# Part II

# Perspectives on Organizational Engineering: An Overview

"*The real act of discovery consists not in finding new lands, but in seeing with new eyes.*"

*Marcel Proust*

We begin our journey through the world of Organizational Engineering by studying the main perspectives of research that are conducted outside of Instituto Superior Técnico. With this study we intend to thoroughly understand how different authors position themselves in the *Organizational Engineering* domain.

We start by describing the main approaches that constitute the different perspectives and consider their origin, purpose, tools and central concepts. At the end of each perspective description we provide a summary with a brief comparison of the main differences of each approach within that perspective.

This extended synthesis will be the starting point for the broader comparison and analysis of the approaches that is conducted in Part IV where we also point the problems that we classify as urgent to overcome in the current perspectives of *Organizational Engineering.*

## 2 Business and Enterprise Engineering Perspective (BEEP)

The *Business and Enterprise Engineering Perspective* appears with some author's observations that improved hardware and network components, new standards, software packages, electronic services and new ways of sourcing and using information are triggering changes in the way enterprises work and behave both at company and market level. The concern of the authors of this perspective is the survival of enterprises in an environment of "*monumental changes going on in business, technology, and the globalization of the economy*" and both the research works we study: (1) ***Enterprise Engineering*** [14], and (2) ***Business Engineering*** [17], try to provide solutions for the transition that their authors consider necessary: the "*company of the industrial age*" to the "*company of the information age*" through different models, methods and concepts.

### 2.1 Enterprise Engineering (James Martin)

*Enterprise Engineering* is not a single theory or methodology. It is a synthesis of some of the most known and used change methods of the last decade. In his book, James Martin considered that most enterprises are in need of complete redesign and he argued that because of complex networks of inter-related activities which often originate patterns of behavior contrary to managers' intuitions that are worsened by the effect of emerging technologies, solutions such as downsizing, cutting out management layers, moving from hierarchical to horizontal structures are not enough anymore [18]. To be able to manage complexity, James Martin stated that the *Enterprise Engineer* must be able to analyze the long term causality webs and their counter-intuitive effects.

Automation, elimination of bureaucracy, simplification of work flows, refinement of information infrastructure, working smarter, reduction of middleman's intervention, and elimination of unnecessary work, which are the concern and result of *Enterprise Engineering,* imply the understanding of a broad spectrum of change methods and the critical factors that are needed to make them succeed [18]. To achieve this, Martin suggested the following approaches as fundamental for the success of required changes [18] (see Figure 3 below):

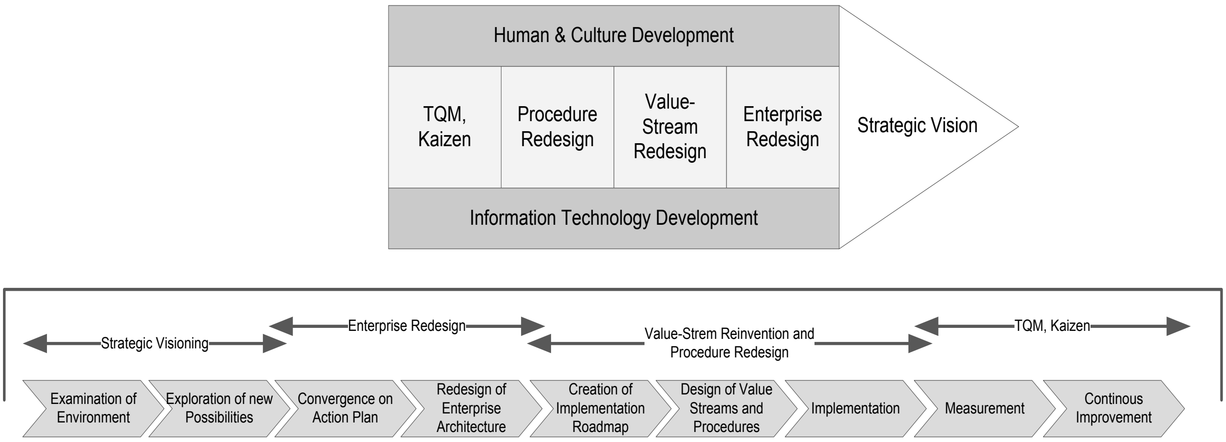


**Figure 3 the 7 Disciplines of Enterprise Engineering and the Change Roadmap**

**<u>Discipline #1 Strategic Vision:</u>**

*Strategic Vision* reflects holistic insight and creative ideas about the business and its directions [19]. It is the first step in defining and explaining the company core competencies, the necessary *Value-Streams*[2] and the clear relation between these and the defined corporate goals. The vision questions the paradigms, the beliefs, the basic enterprise structure and it translates into vision statements that help determine the structure of the enterprise as well as lower level visions for each *Value-Stream.*

Martin defines the discipline of *Strategic Vision* as a way to shape mental models in order to influence behaviors and decisions. Figure 4 explains the way Martin suggests this might happen. According to Martin

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[2] "A **<u>Value-Stream</u>** is an end-to-end collection of activities that creates a result for a customer, who may be the ultimate customer or an internal end user of the Value-Stream."

mental models, which are the result of experience of the surrounding culture, of personal beliefs and are determinant in the decisions and actions taken by people [20; 21], can be influenced by tools such as *Scenario Planning, Technological S-Curve,* among others, which are exploratory tools that allow managers to study different alternative futures of the current reality, allowing a change and improvement of their mental models.

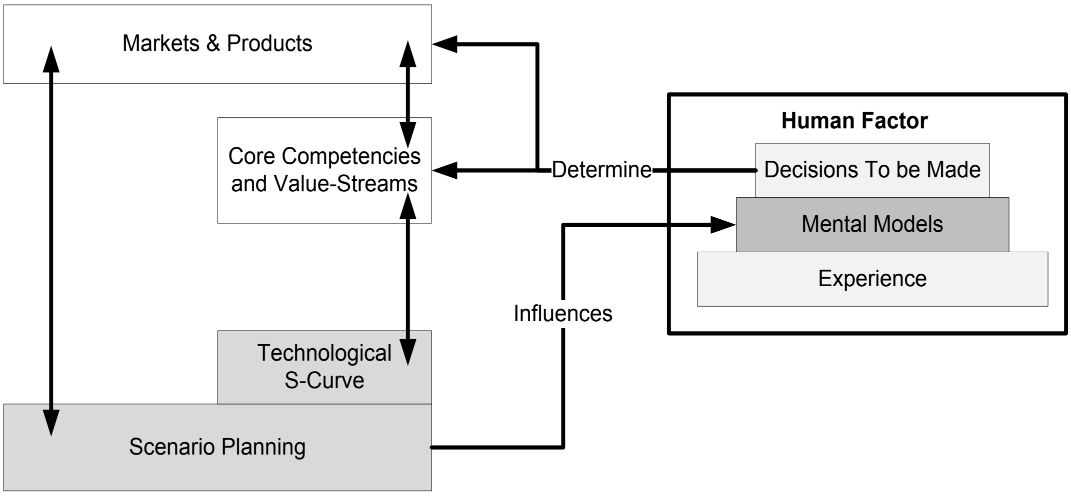


**Figure 4 Components of Strategic Vision and the Human Factor [20; 21].**

**Discipline #2 Enterprise Redesign:**

*Enterprise Redesign* is the definition of a framework to address change. It concerns the translation of *Strategic Vision* into an executable plan of action that tries to cover all the possible anticipatable problems. Decisions that are typically part of this discipline responsibility are [22]: (1) determining which business areas should be closed, sold of floated as separate corporations; (2) establishing a knowledge infrastructure that facilitates corporate learning at all levels; and (3) establishing partnerships with other enterprises.

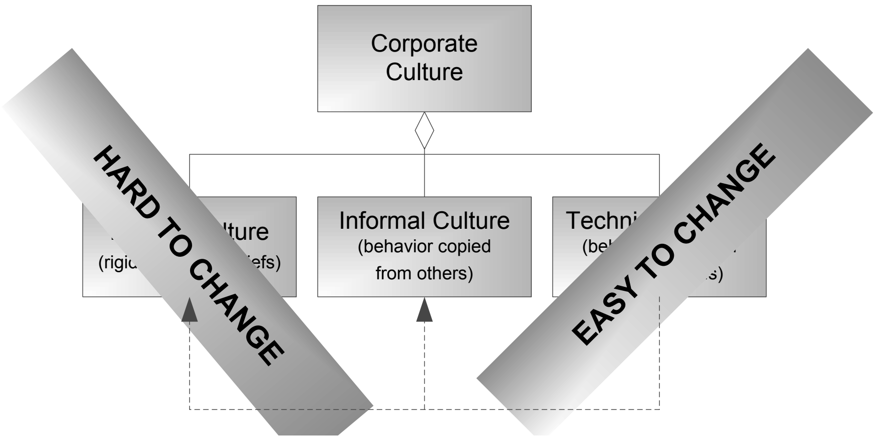


**Figure 5 Framework to address cultural change**

According to Martin the fundamental issue for succeeding in implementing the *Strategic Vision* (through *Enterprise Redesign*) is dealing with existing corporate culture [23]. Figure 5 illustrates a framework that Martin suggests for breaking and understanding the existing culture. Martin explains that as *Enterprise Redesign* will most likely replace the roles of people in the organization, the existing corporate culture[3] will often resist possibly hindering the change process. According to his framework, the *Technological Culture* can be used as a *"Trojan horse"* for changing the other more conservative constituents of the institutionalized culture [23] because of its pervasive nature.

**Discipline #3 Value Stream Re-invention:**

Martin defines this as a way of organizing the corporation around end-to-end processes [24]. *Value-Stream* reinvention is the follow up of both *Strategic-Vision* and *Enterprise Redesign* in the overall process of change. It can be about repositioning the existing corporate activities into new workflows but according to Martin, most of the time it takes a clean sheet approach where the complete workflows are redesigned [24].

*Value-Streams* extend beyond departments or functional areas, they aim at achieving specific results to satisfy particular customers (internal or external) [24]. *Value-Stream* revolutionizes the report and technological structure of the enterprise. Departments are broken/grouped into *Value-Stream* teams [25], technology is transformed in order to provide the best available information for *Value-Stream* workers [24], goals are set with customer's satisfaction in mind [25; 26], reward structures are rebuilt, etc.

**Discipline #4 Procedure Re-design:**

According to James Martin, this discipline can and usually is used independently of *Strategic Vision*, *Kaizen, Enterprise Redesign* and *Value-Stream* reinvention. It relates to existing procedures in a narrow scope and does not radically change existing jobs and has modest goals regarding performance improvements.

*Procedure Redesign* requires the mapping of the existing procedures (which Martin says is unnecessary in *Value-Stream* reinvention). Martin explains that after being modeled the existing processes can be analyzed, fixed and modestly improved. Although having a narrower scope than *Value Stream* re-invention, Martin argues that *Procedure Re-design* usually spans across multiple departments, functional areas, and divisions and it requires the building or modification of major information systems [27].

**Discipline #5 Kaizen4:**

Kaizen conveys the idea of everybody improving everything all the time. It applies not only to processes but also to other areas such as products, services, customer support, relationships with suppliers, relationships with unions, software systems, human relationships and so on [28]. According to Martin Kaizen is **the** culture that should be embedded in organizations: "*The enterprise needs much more than Kaizen, but Kaizen should pervade everything."* [28].

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[3] The way things are done, the way people behave and relate to one another, standard accepted conducts, etc.

[4] TQM (Total Quality Management) is the western equivalent idea of Kaizen.

As the previous discipline, James Martin explains that *Kaizen* can also be applied in isolation although its major benefits are better achieved if they are part of a holistic change of the enterprise (the full top down change approach).

**Discipline #6 & 7 People & Machines**

Going back to Figure 3 we can see illustrated Martin's seven disciplines. Besides the five that were already described, Martin considers, **Human & Cultural Development** and **Information Technology Development** as pervasive matters that cannot be ignored in the application of any of the other five disciplines. As described in Figure 6 Enterprise Engineering is top down approach concerned with establishing a strategic context, defining a framework for change, implementing the defined framework and continuous work every day.

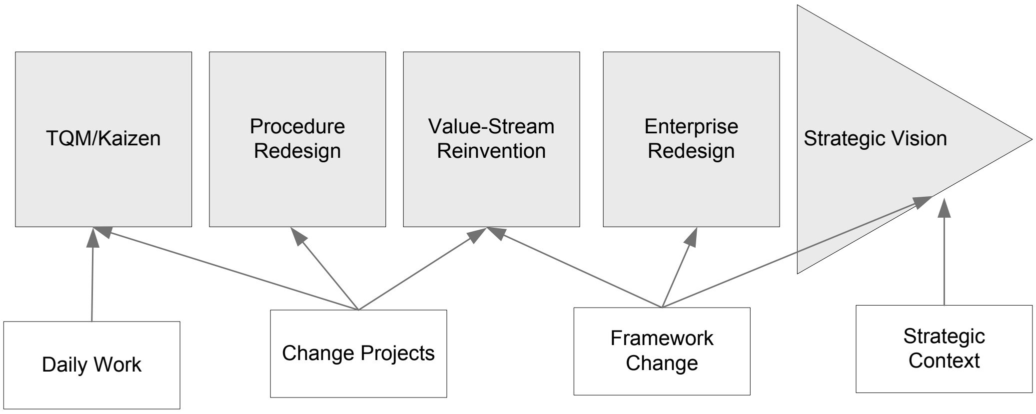



**Figure 6 Different Types of Change**

### 2.2 Business Engineering (St. Gallen)

*Business Engineering* is the second approach of the *Business & Enterprise Engineering* perspective. It is both a framework and method, developed by the Institute of Information Management (IIM) at the University of St. Gallen, to address the transformation requirements of companies facing change in their business environment [29]. *Business Engineering* has its roots in some of the concepts of James Martin's *Enterprise Engineering* and suggests models for both Organizations and Organizational Networks. Organizations are described through the use of **Enterprise Architecture** while Organizational Networks are explained in terms of specific **Industry Structures and Roles**.

**Organizations & Enterprise Architectures**

To cope with deep business strategy reformulation, business process and organizational structure re-design and appropriate implementation of information technology which St. Gallen IIM research group expects all enterprises of the "*Information Age*" to face [30], the use of ***Enterprise Architectures*** is suggested.

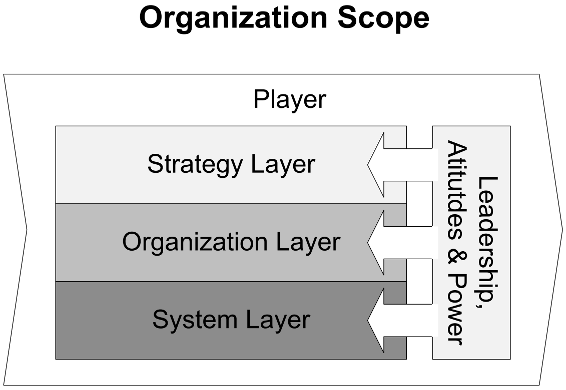



**Figure 7 The Business Engineering Framework**

Figure 7 above summarizes the *Business Engineering* approach to ***Enterprise Architectures*** where the firm is modeled as having three main architectural layers**:** (1) ***Strategy Layer:*** which aims at clarifying the position of the enterprise in the value network by describing the different value networks that provide comprehensive support for certain specified customer processes. (2) ***Organization Layer:*** that transforms the network wide specifications from the strategy layer into appropriate process models; and (3) ***System/Application Layer:*** that links information system components to business requirements and can be further decomposed in **Application** and **Software Levels** [29] for increased understandability.

Finally, the picture also displays the ***Leadership, Attitudes and Power Block*** that is the pervasive concern with issues like human relations, corporate culture, leadership views, etc. These latter concepts are not directly addressed by the Enterprise Architecture meta-model and are documented through checklists, rules, etc [30] .

The IIM considers that the above organizational decomposition helps to identify inconsistencies between product specifications, performance indicators/goals, business process specifications, informational structures/flows, application design, IS functionalities, and other architectural artifacts [31].

Figure 8 (page 13) summarizes the meta-model of the *Business Engineering* framework where: (1) regular arcs denote references between constructs, (2) dotted arrows denote primary dependencies between the framework layers and (3) broken arrows denote aggregation relationships. For a complete and detailed reference of the meta-model please refer to [31].

Besides the layers and concepts, the framework also specifies a set of predefined views to address different stakeholders' interests that the IIM group considered relevant.

The views select particular constructs of the meta-model in order to highlight certain specific aspects. The different views are represented in Figure 8 and for the explanation of their particular purposes, please refer to [31]. Through time, and because of its solid foundation in ***Method Engineering*** [32] the *Business Engineering* framework has been subject to numerous updates and modifications [29; 33; 34].

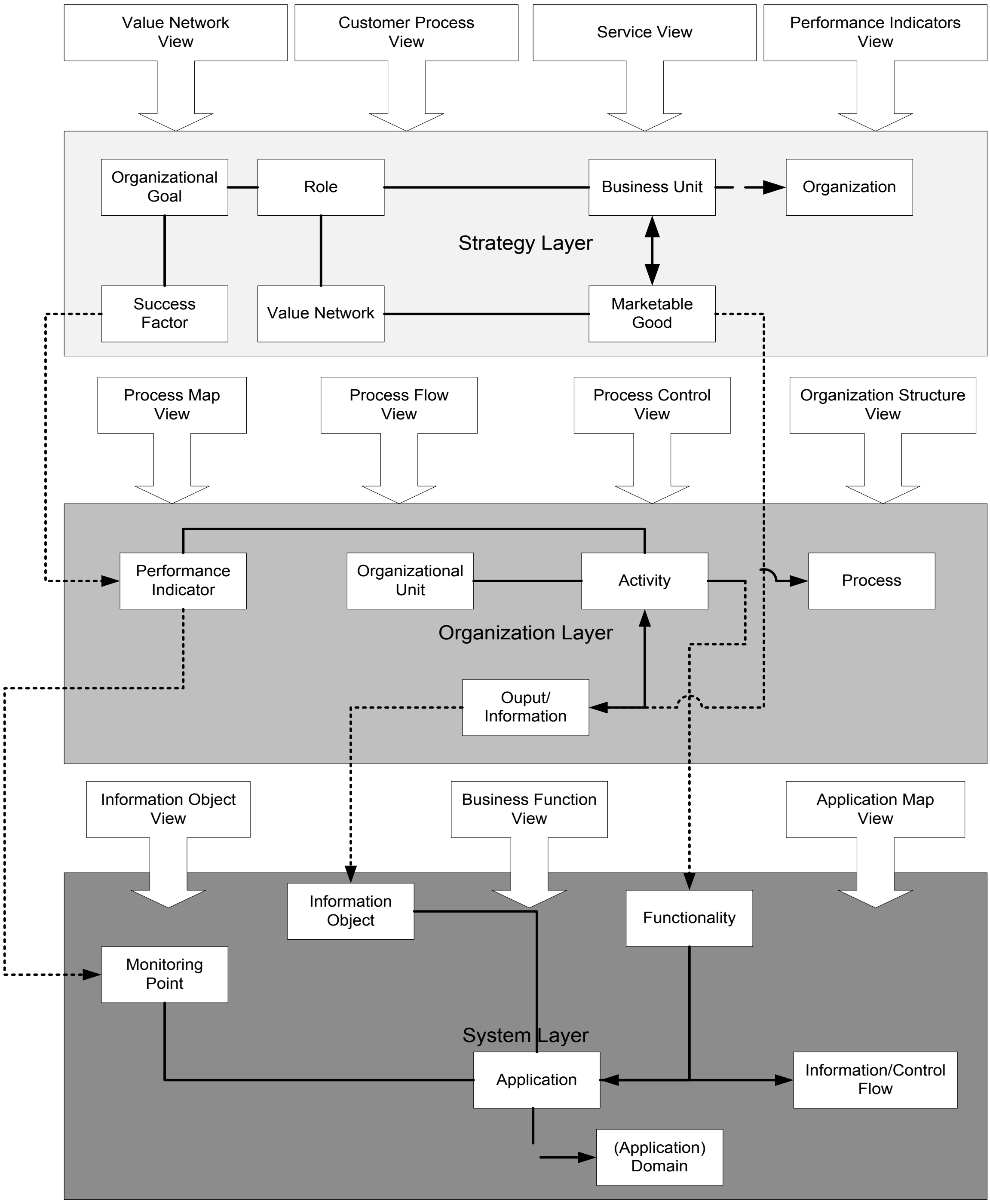



**Figure 8 Simplified Metamodel of St. Gallen's Enterprise Architecture**

## Organizational Networks & Industry Structures

Besides providing modeling mechanisms for the representation of enterprises, the IIM also suggests that one has to account for the new industry structures that emerge from the organizational networks that are appearing due increasingly technological character of business.

According to IIM enterprises will be more or less *electronic* in a near future and this will the forced them to organize according to industry roles which do not exist in traditional business architectures [30]. Figure 9 illustrates the set of components named the "*Business Architecture of the Information Age"* [30]*:*

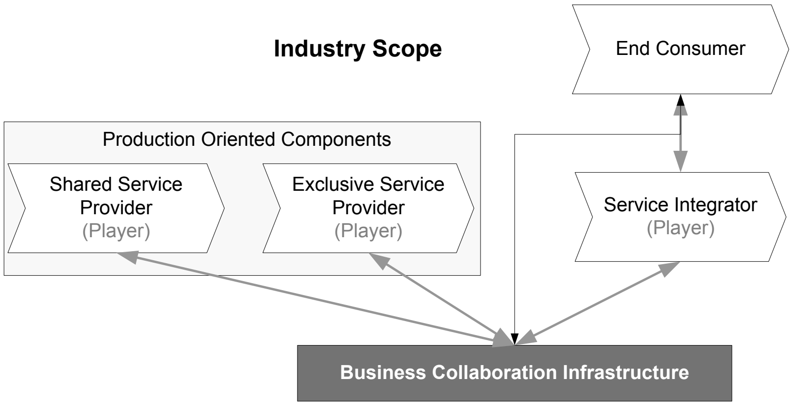



**Figure 9 A New Industry Composition**

***Service Integrators*** are industry players mainly concerned with customer oriented processes. They aggregate products and services in order to offer solutions tailored to a specific customer process (e.g. buying a car). ***Shared/Exclusive Service Providers*** are focused on the production process. *Shared Service Providers* target the bulk business (large amounts of standardized products), while *Exclusive Service Providers* create unique selling propositions by exploiting specific competencies or resources. ***Customers (end consumers)*** have access to products and services using the service integrators. They can however access the business bus directly in order to search for different product aggregations themselves. ***The Business Bus*, **also known as *Business Collaboration Interface* (BCI), supports the exchange of services and information between the different industry players. Cross-industry support services such as payment services, risk trading, payroll processing, business directories, etc. are provided by the BCI.

IIM research group believes that in the future industries will resemble more or less the schema of Figure 9 and as that soon as Organizations acknowledge this fact and adopt Enterprise Architectures to better design and understand their own business, the more prepared they will be for this "*inevitable transformation*".

### 2.3 Business and Enterprise Engineering Perspective Summary

The Business and Enterprise Engineering Perspective is concerned with the roles that information technology is playing in the organizations and with the adaptation that most enterprises have to face in order to remain competitive and lucrative in the process of change.

***Business Engineering*** is a collaborative, model base-conceptualization and design science that provides tools (both formal methods of modeling and analysis and a pervasive concern with cultural and political issues) to understand traditional business architectures (of the industrial age), envision new business architectures enabled by information technology and support and implement the transformation process of companies and administrations to the *business model of the information age*.

***Enterprise Engineering*** is a prescription of form, achieved by the application of a set of change methods, which should enable the *Old-World* Corporation into the enterprise of the *New-World.* In this approach the *Cybercorp* should be organized around value streams, supported by proper information technology and unified by a healthy culture.

Although in agreement in various points, namely on the view that technology will impose drastic changes in enterprises that intend to remain fit and lucrative while competing in the "*Information Age"* each of these approaches has its main area of concern: (1) St. Gallen's IIM Group is concerned with both industry and company structures while James Martin *Enterprise Engineering* is solely focused on the Enterprise itself; (2) IIM addresses Organizational change in very general terms while Martin details and describes methods for radical, local and step by step change; (3) St. Gallen's IIM discusses the need of understanding organizational psychology and other disciplines of human and group behavior while Martin goes a step further and describes tools and possible action plans for changing the *mental models* that according to him determine most of human behavior; and (4) finally, because of its foundation in Method Engineering, the Business Engineering approach is very formal, defining specification documents, dictionary of concepts and an Enterprise Architecture Meta-Model to restrict organizational modeling while James Martin does not speak about modeling in particular terms.

In other words, *Business Engineering* is a hard approach that tries to include soft factors concerns to ***Enterprise Architectures***, while Enterprise Engineering is a soft approach (management best practices) achieved by the implementation hard factors (technological artifacts and process re-design).

## 3 Language Action Perspective (LAP)

The core of the *Language Action Perspective* is that people act through language [35]. Communication is seen as a form of action where the use of language (natural, technical such as mathematics, or any other type) is considered rule governed behavior. Although literally the sentence "*These bags are really heavy",* spoken by a loaded parent carrying his household groceries to his empty handed teenage child, is about weight, its intent is to evoke an action by the child. Conversations cause effects and although the actual doing whatever is needed to accomplish them lies outside the conversational structure, understanding the structure of communication and its illocutionary acts is what allows people working together to anticipate each other's actions and coordinate them with their own [35].

There are mainly three schools of thought in LAP that try to understand the relation between business processes and information technology: (1) Business Design Technology (BDT) which matured in a book by Winograd and Flores; (2) Business Action Theory (BAT) that was developed by Goldkuhl's research group; and (3) Dynamic Essential Modeling of Organizations (DEMO) developed by Jan Dietz's research group.

### 3.1 Business Design Technology (BDT)

The Business Design Technology approach (BDT) understands organizations as networks of interrelated speech acts. Speech acts are exchanged by humans and responsible for coordinating their action.

According to Winograd and Flores speech acts appear in patterns. They consider four major patterns of communication namely: *Conversations for Action* (CfA)*, Conversations for Clarification, Conversations for Possibilities and Conversations for Orientation* [35]. The *Conversations for Action* model (CfA), which is the only pattern that they have developed in detail is the core of this approach. It describes communication as a *"dance in which the acts generate the structure of completion of the conversation"* [35]. CfA is thus a description of a set of states through which the speaker and hearer go through in order to successful complete an action. Figure 10 illustrates this "*dance".*

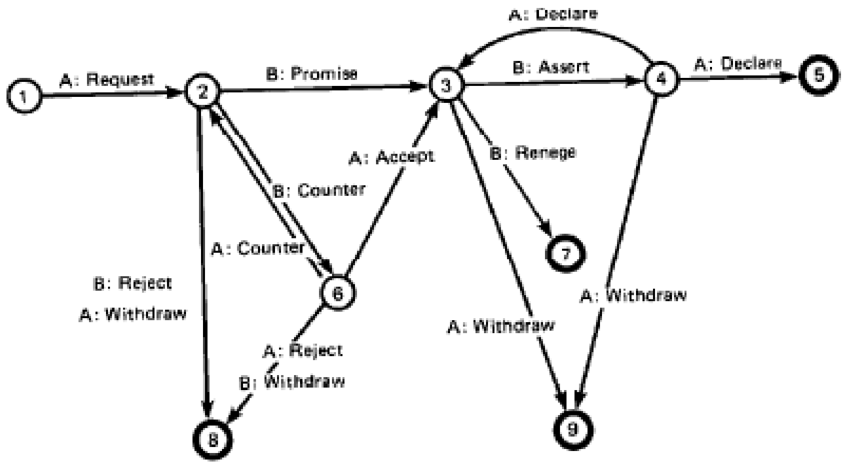



**Figure 10 Conversation for Action pattern [35]**

### 3.2 Business Action Theory (BAT)

The main purpose of BAT is to describe and explain business interaction [36]. BAT describes a generic pattern of the structure of communication that takes place between supplier and customer (which are the two main roles considered) [37]. It is oriented towards "*real business interaction*"[5] and it is not applicable to relations between different parties within the same organization (internal customers).

BAT divides business interactions (business processes) in 6 different phases namely: (1) ***Business Prerequisites Phase,*** where prerequisites for performing business are established. Here the major focus is on the exchange of knowledge (about prerequisites); (2) ***Exposure and Contact Search Phase,*** where the customer seeks some ability in a supplier that will satisfy his needs. Here the major focus is on the exchange of interests to engage in business transaction; (3) ***Contact Establishment and Proposal Phase,*** where the contacted supplier presents the available offers to the contacting customer. The focus is on the exchange of business proposals; (4) ***Contractual Phase,*** where both supplier and customer establish a commitment of conducting business. The focus is on exchanging commitments in contracting; (5) ***Fulfillment Phase,*** where both parties fulfill their commitments. The customer pays for the service while the supplier delivers the requested service. The focus is

[5] Which represent the interactions between one organization and its external customers.

on the **exchange of value**; and (6) ***Completion Phase,*** where the supplier and customer achieve satisfaction or dissatisfaction. The focus is on the exchange of possible claims or acceptance.

Figure 11 summarizes the above paragraph where the 6 different phases, each of them with focus on different types of exchanges between the customer and the supplier, are described:

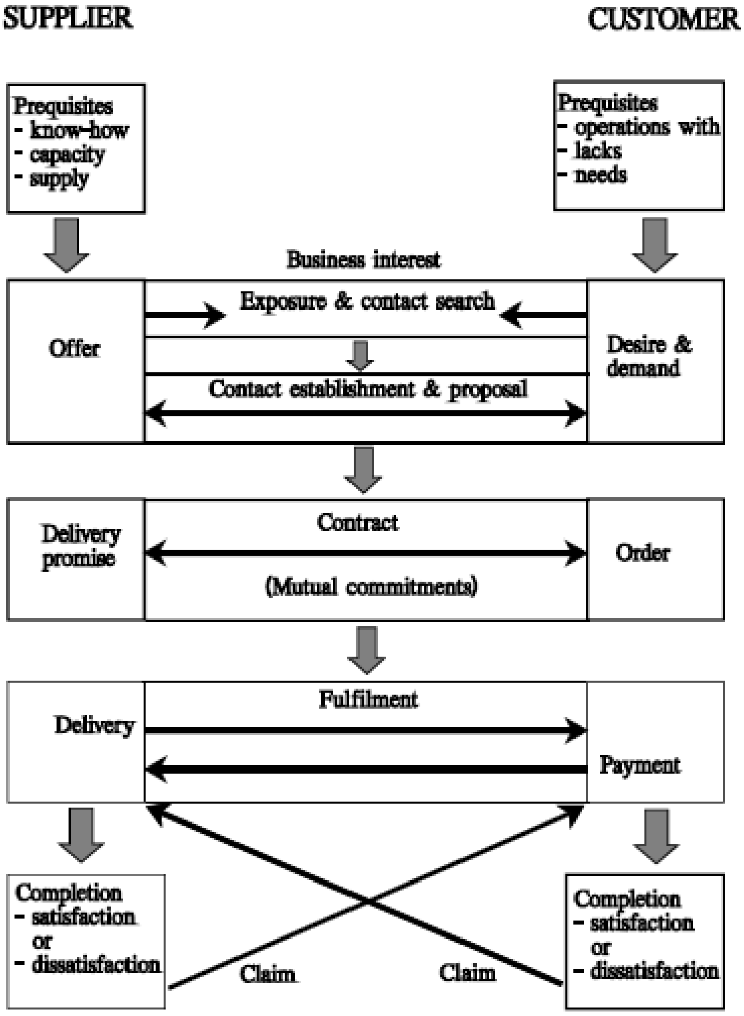



**Figure 11 the Six Generic Phases of Business Processes [37]**

BAT emphasis that business interaction is not achieved through free way communication [38]. It states that business communication has to proceed through the predetermined phases of Figure 11. Furthermore BAT describes a set of generic actions of interactive character that are used in each of the different phases of the business process [37]: *Offer, Express purchase interest, Order, Confirm Order, Deliver, Pay*, etc.

**Table 1 Material and Communicative functions [39]**

| **Material** | **Communicative** | | | | |
|---|---|---|---|---|---|
| | expressive | declarative | assertive | commissive | directive |
| Transfer, Apply, Transform | express | Accept | State, Reply | Promise, Offer | Request, Ask |

| |
|---|
| Perform |

Table 1 establishes a base classification for these *"generic actions"* according to their material or communicative function and in the latter case also according to their illocutionary character (the type of actions they evoke). BAT describes the generic business logic and the exchange character of the business process. It emphasis the need for cooperation and mutual coordination of both actors (customer and supplier) and it recognizes their shared and conflicting interests.

### 3.3 Dynamic Essential Modeling of Organizations (DEMO)

DEMO is a methodology for designing and (re-)engineering organizations where the enterprise is understood as an heterogeneous system constituted by the layered integration of three homogeneous systems: *B-Organization* (from business), *I-Organization* (from intellect) and the *D-Organization* (from document) [15].

At the *documental* level DEMO describes the organization as set of collaborating actors who produce store, copy, transport and destruct documents. At the *informational* level DEMO sees the enterprise as a set of collaborating actors who exchange information and perform computations in order to create derived information. Finally, at the *essential* level DEMO looks at the enterprise as a set of actors who engage and comply into commitments to create original and new things. In other words, at the *essential level* the organization is viewed as a social system, at the *informational level* as a rational system and at the *documental level* as a formal or material system [36].

*I-Organization* becomes active whenever the *B-Organization* is and the same is true regarding the *D-Organization* when the *I-Organization* is active. The integration of the whole is achieved through the cohesive unit of the human being and his possibility of switching between his business-enabling abilities: *forma*, *informa* and *performa* (see Figure 12 below and read **Appendix C** page **89** to better understand what this implies).

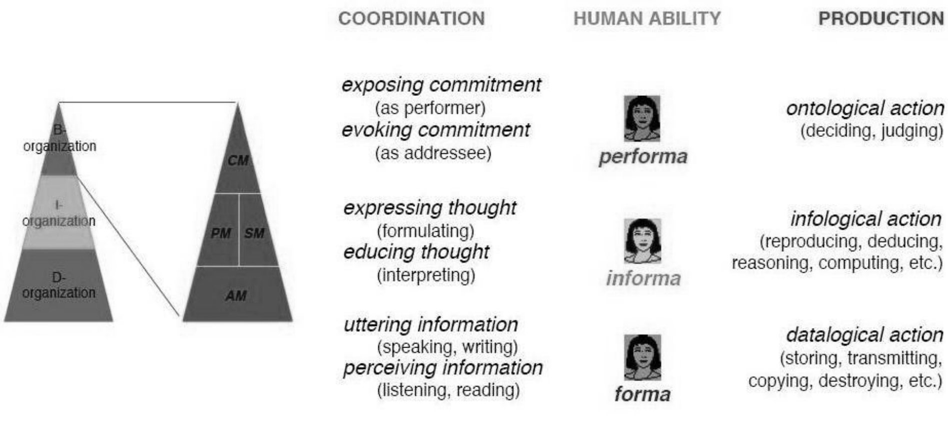



**Figure 12 Ontological Focus and Human Abilities [15]**

The notion of system of the above paragraphs is a very particular one. It follows the *ontological notion of system* as described in [40]. In other words, the essence of the organization as a system is described in terms of *Composition, Environment, Structure* and *Production* [15] at each of its three levels (*essential*, *informational* and *documental*).

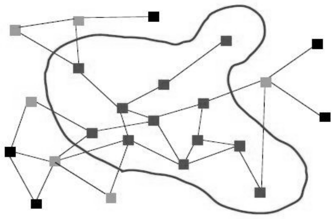


**Figure 13 Ontological System [40]**

Figure 13 tries to explain this notion by describing the four elements of an ontological definition of system: (1) *Composition:* a set of elements of some category (squares inside the line of Figure 13); (2) E*nvironment:* a set of elements of the same category such that the *Environment* and the *Composition* are disjoint sets (grey squares outside Figure 13 border line); (3) *Structure:* a set of mutual influential bonds between the elements of the *Composition* and between these and the elements of the *Environment* (Figure 13 connecting links); and (4) *Production:* the elements of the *Composition* produce things (products or services) which are delivered to the elements in the *Environment* (is the manifestation of the system's operation and cannot be captured in a static picture).

**Table 2 Connection between the *Ontological System Notion* and the real Enterprise**

| Bunge's Primitive | DEMO Primitives | Real World Object/Observation |
|---|---|---|
| Composition | *Elementary Actor Roles* | Skill, authority and responsibility needed for tasks |
| Environment | *Composite Actor Roles* | Inputs from the environment actors. |
| Structure | *Transactions*<br>*Coordination-Facts* | Communication patterns which mediate tasks<br>The social effects of transactions (commitments) |
| Production | *Production-Facts* | Results of Activities (Completing Transactions) |

Another central idea of DEMO is the concept of *transaction* which as can be seen in Table 2 is the only pattern of interaction which mediates the organization tasks. The *essential* business transaction (or the transaction of the *essential* level) organizes ***speech acts*** (the base communicative primitive) in standard patterns involving two actors: one which is the executor and other which is the initiator.

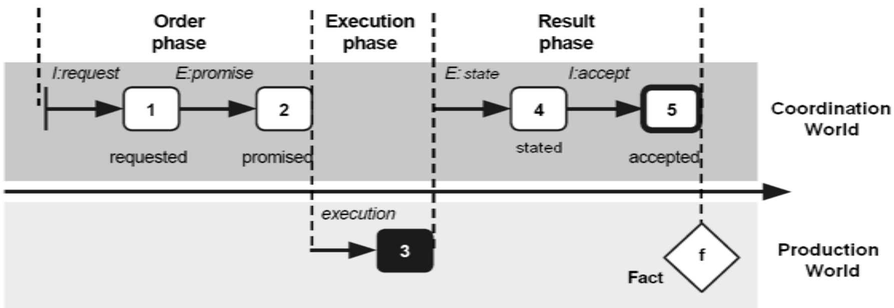



**Figure 14 General Structure of a DEMO Transaction [36]**

Transactions produce effects in two different worlds (see Figure 14): (1) *The Coordination-World,* which is composed of the set of commitments that subjects comply and engage (***coordination-facts)***; and (2) *The Production-World,* which contains the set of results that subjects achieve by executing tasks ( ***production-facts)***.

DEMO assumes that enterprises operate in a discrete linear time dimension [15] and there is only a change of state when a new fact comes into play. These *facts*, which are the outcome of executing *transactions*, constitute the state of the organization at every point in time. A *fact* may be created and canceled, but never removed from the world where it was created [15] (in DEMO the entire history of the enterprise is always preserved).

Although the DEMO theory includes the three levels (*documental*, *informational* and *essential*) described in the previous paragraphs, the modeling approach anchored to this theory is especially concerned with the *essential* level.

The triangular shape of the left side of Figure 12 (page 18) means that nothing is above the ontological/essential level. In other words, according to DEMO, the knowledge of the *B-Organization* is the complete knowledge of the essence of the enterprise [15] and the other slices of the triangle are just a matter of how *business behavior* is realized and implemented.

DEMO modeling approach is based on four main models: (1) the **Construction Model (CM):** specifies the *Actor Roles,* the relations between them (*Transaction Types*) and the organizational boundary (*Composition*, *Structure* and *Environment* of the *B-Organization*); (2) the **Process Model (PM):** describes the atomic process steps and their causal or conditional behavior; (3) the **State Model (SM):** represents the *Object Types*, the *Fact Types* and the ontological coexistence rules; and (4) the **Action Model (AM):** specifies the action rules that serve as guidelines for the actors dealing with the *Coordination Facts*.

Accepting DEMO axioms and assumptions leads to the evaluation this approach as being ***Comprehensive*** (all relevant issues are covered, the whole is complete), ***Coherent*** (the different aspect models constitute a truly integral whole), ***Concise*** (no superfluous matters are contained in it), ***Consistent*** (the aspect models are free from contradictions and irregularities) and ***Essential*** (it shows only the essence of the enterprise) [15].

### 3.4 Language Action Perspective Summary

The *Language Action Perspective* assumes that communication has effects on the real world. It describes communication as the central coordinator of human action in organizations and it defends that the understanding of communication patterns is fundamental to understand the structure of organizations and its information systems. The Business Design Technology School developed firstly by Flores and Ludlow and then extended by Winograd and Flores is the founding theory of LAP (when applied to business and information technology development). DEMO and BAT are further developments of this theory and they both extend the CfA model [38].

There are of course many differences among the approaches. Winograd and Flores were only concerned with the coordination mechanisms of communication [35; 38] while both DEMO and BAT consider information and information exchange as important factors of communication that have to be described to understand business interaction. CfA, DEMO and BAT consider that ***speech acts***, the base primitive of either of the approaches, occur in patterns although each of these approaches considers different patterns of occurrence. In BAT, speech acts are organized according to the six phase business process that was described in **section 3.2** while in DEMO the speech acts are organized around the concept of transaction (**section 3.3)**. These standard patterns describe the set of states that business communication goes through when trying to achieve some action. It is important to note that the different configurations of speech acts developed by CfA, BAT and DEMO are fully compatible. DEMO is actually a further development of CfA while BAT can be modeled by a composition of business transactions, meaning that each of the six phases of the business process are achieved by multiple DEMO transactions [36].

Another important distinction between the approaches is in the type of *illocutionary* speech acts that they consider. DEMO is based on *request, promise, state, accept* (and some others to describe non successful paths *reject, decline,* etc) which are described in [41] while BAT uses an extension of this classification [39]. Finally CfA and BAT are independent of any modeling language while DEMO is anchored to a specifc modeling notation[6].

## 4 Computational and Mathematical Organization Perspective (CMOT)

The *Computational and Mathematical Organization Theory* is a study of organizations as computational entities [42]. Here organizations are seen as compositions of multiple distributed agents that exhibit organizational properties are assigned tasks, technology and resources while knowledge, skills and communicative capabilities are distributed [43]. The CMOT assumes that organizational complexity limits the usability of analytical models for the study of organizations, while computational analysis, by allowing researchers to generate a set of theoretical propositions from basic principles, is an invaluable tool for theory building allowing the demonstration of proofs of concept and providing a legitimacy tool of various theoretical claims in organization science [43]. There are numerous authors in this perspective but we have chosen to describe the work of Kathleen Carley's research group because of its recognized influential position in the field.

### 4.1 Computational Organization Theory (Kathleen M. Carley CASOS)

CASOS is a university wide center at Carnegie Mellon where Kathleen Carley's Computational Organizational Theory (COT) is being developed. "*CASOS brings together computer science, dynamic network analysis and the empirical study of complex socio-technical system.*" [44].

This research group has developed a set of different simulations to address issues of *Organizational Design*, *Organizational Learning* and *Organizational Adaptation* where Organizations and Organizational Behavior are defined as follows: (1) **Organizations:** *"are synthetic agents (complex, computational, adaptive and dynamic) whose behavior is a function of affiliation webs linking tasks, resources, knowledge and member agents themselves complex, computational and adaptive*" [16]; and (2) O**rganizational Behavior:** is a continuous scan and observation of the environment, storage of information and procedures, communication, and transformation,

[6] BAT is usually used in collaboration with SIMM methodology [121] but this is not a requirement and thus it was not described here.

elimination and modification of information through human and/or artificial resources. Organizations are considered inherently computational.

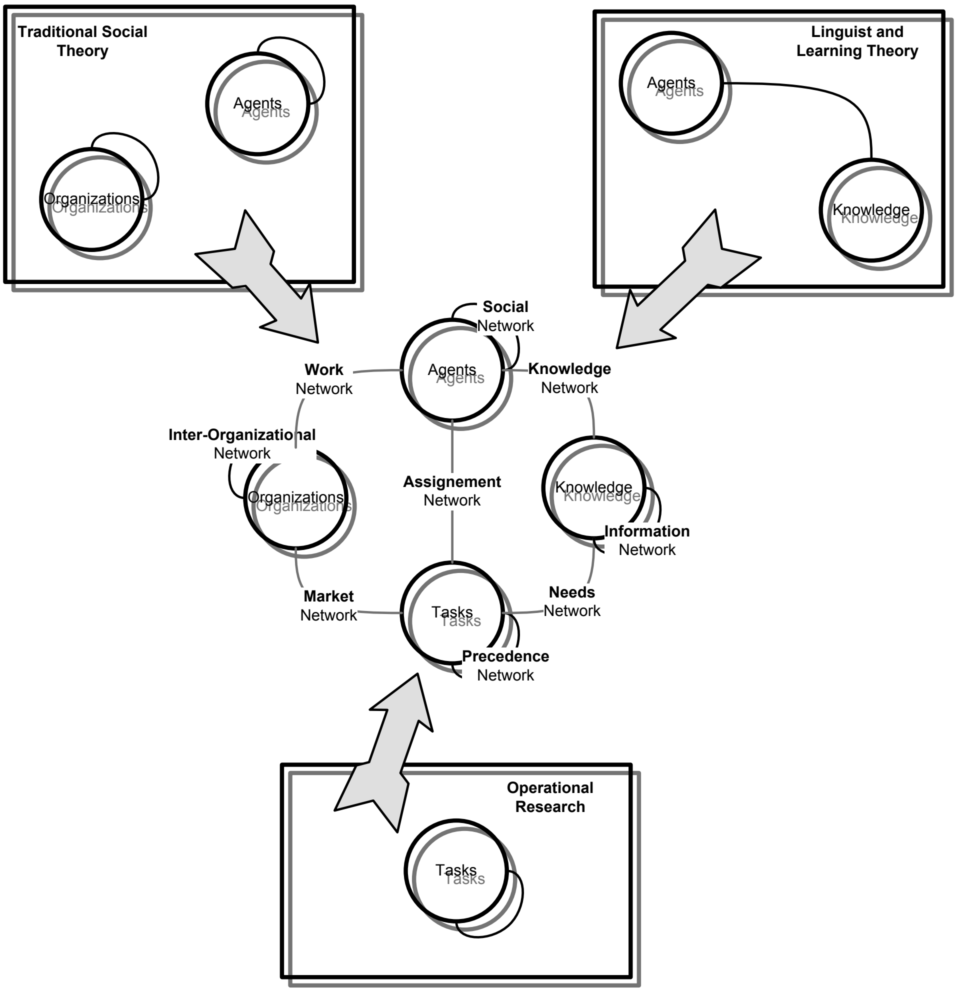



**Figure 15 Meta-Model of the constraining elements of social behavior**

Figure 15 summarizes the key entity classes and relations that CASOS group considers in its simulations. Developed in [45; 46], this meta-model is used to describe the state of one organizational structure at a particular point in time as a set of entities (people, resources, and tasks) and the established relations between them.

Each entity class represents a distinct category of concepts, and each relation class is a type of link between concepts within entity class 1 and 2. CASOS highlights the extensibility of this model, stating that in principle new entity classes and relation classes can be added as needed (to represent new concepts).

CASOS uses computational models to generate series of hypotheses, by running virtual experiments, in order to think through the possible ramifications of the complex and non-linear processes that develop in organizational and social behavior [47].

Every virtual experiment is composed of five different stages, each of them fundamental to the validity of the results obtained [47]:

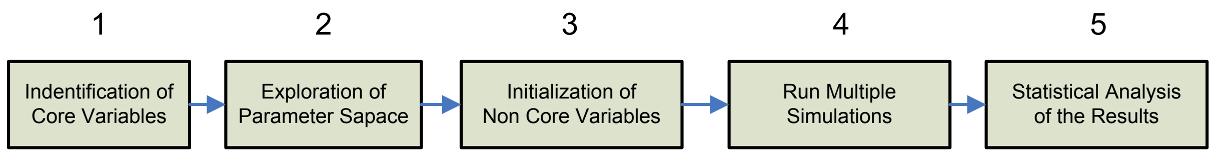



**Figure 16 Virtual Simulation Procedure**

CASOS' simulations try to reflect the real world but do not mimic it. Because of that, the extrapolation of conclusions has to be done with caution, especially when trying to predict novel organizational behavior [47]. The following assumptions/constraints try to guarantee the consistency of the simulation models [48]:

- **Agent Bounded Rationality:** organizational agents (human or artificial) are bounded in terms of their capabilities and knowledge;
- **Agent Need to Communicate:** agents in a group need to communicate;
- **Agent Task Orientation:** organizational agents are continually engaged in performing tasks;
- **Task Uncertainty:** task outcome is uncertain (tasks may succeed or fail);
- **Agent Path Dependency:** as agents and organizations learn, their intelligence is restructured. The order in which things are learned has implications in the form and the performance of organizations;
- **Information Ubiquity:** information is widely distributed across multiple agents within and among organizations. Although available, the information is not necessarily correct, timely, relevant or accurate
- **Information Distribution Constraints:** organizational performance depends on the distribution of information across the organization as well as in the processes for searching and combining that information.
- **Organizational Intelligence:** linkage among agents and the distribution of knowledge between them is where the organizational intelligence resides.

CASOS' work has led to the development of toolkits for collection and analysis of network data as well as a number of multi-agent network models. ORA [49], AutoMap [50], DyNet [46] are among the tools developed for dynamic network extraction and analysis while ORGAHEAD [51] is used to study organizational adaptation and CONSTRUCT [52] to study social network evolution. We briefly describe how these tools are used to model Organizations and Organizational Behavior, focusing more on the two latter enunciated tools.

**Simulation Model ORGAHEAD:**

ORGAHEAD is a simulation focused on organizational adaptation when all agents' communication occurs through the formal organizational networks (i.e. the formal report structure). It considers three basic **domains** and the ways they map onto each other [45]:

- **Domains:** (1) **Tasks:** units of work in the organization; (2) **Individuals:** can either be groups or individual agents and these might be Human or Artificial; (3) **Resources:** can be alternatively characterized as individual's specific skills, their access to particular equipment or some combination of the two.

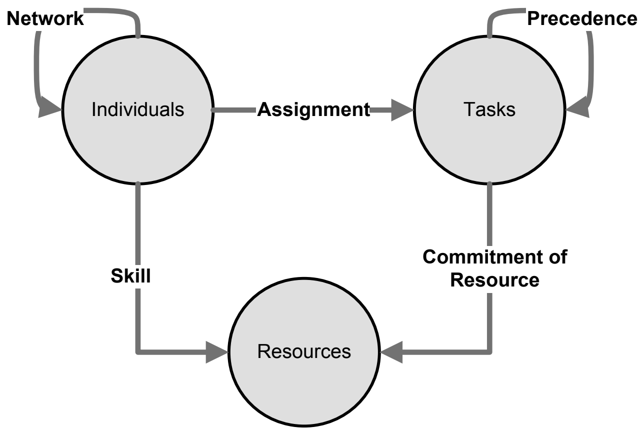



**Figure 17 ORGAHEAD Meta-Model**

- **Domain Mapping** (see Figure 17)**:** (1) **Network:** personnel have different access to each other; (2) **Assignment:** individuals are assigned to accomplish particular tasks; (3) **Precedence:** there is a temporal ordering of the tasks in the organization; (4) **Skill:** individuals bring to their work different abilities and resources; and (4) **Commitment of Resource:** certain tasks require certain resources.

Figure 17 summarizes the meta-model of the ORGAHEAD multi-agent simulation while Figure 18 exemplifies a possible report structure for an organization being simulated.

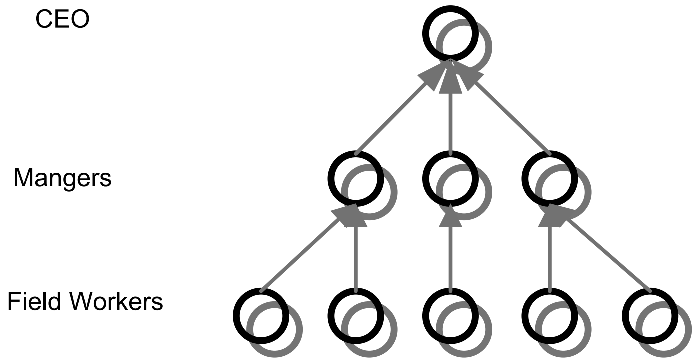



**Figure 18 Example of a Reporting Structure**

ORGAHEAD is a stochastic simulation model. Tasks are assigned a certain complexity level which will influence the probability that a certain worker will succeed in its accomplishment. Factors that also influence the success of task performance are the knowledge and resources that an agent has access to and the correctness of the outputs of tasks performed by other agents lower in the reporting hierarchy structure.

In the example of Figure 18 Field Workers, Mangers and the CEO perform certain assigned tasks. According to the specific outcome of each work unit performed, they receive feedback which allows them to learn whether they are taking the correct decisions. This learning process is named **experiential/operational learning** and tries to simulate the real life process also known as learning by doing.

Another important type of learning contemplated by this simulation model is called **structural learning.** According to CASOS' group, structural learning is forced by a change in the **organizational structure**[7]. It happens when there are changes in the assignments network (who does what), social network (who reports to whom) and the organizational network.

Events that motivate **structural learning** are the hiring/firing of personnel, alterations to the reporting structure and the re-tasking of individuals.

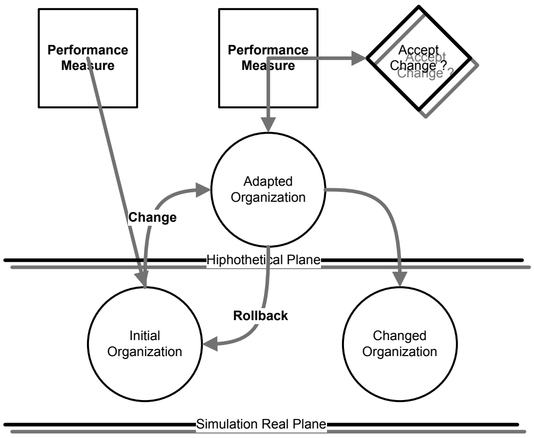



**Figure 19 Summary of one Simulation Cycle**

Figure 19 describes ORGAHEAD simulation cycle [53]:

1. there is an organizational change proposal according to the set of available moves (hiring/firing, re-tasking and changing the report structure);
2. the performance of the new organization (which is measured in terms of how frequently the right decision is made) is registered;
3. when the above steps conclude, the new organizational design is adopted/rejected with a certain probability that depends on the higher/lower level of performance of the new hypothetical organizational structure;
4. the simulation goes back to step 1.

ORGAHEAD tries to locate the **organizational structure** that maximizes a performance function subject to multiple constraints (costs, personnel, etc.). The performance or cost function varies according to what the organization perceives as important (minimizing salaries, maximizing decision accuracy, etc.). The organization performance will depend on how efficient the processes of structural and operational learning are for each of the different organizational designs.

**Simulation Model CONSTRUCT-TM:**

The CONSTRUCT-TM is a multi-agent model of group interaction where the agents communicate, learn, and make decisions in a continuous cycle. Agents interact through communication and as they do they learn new information facts and change their perception of the world. At the core of this model resides the CONSTRUCT

[7] Connections between agents and Connections between Agents and Tasks.

block [52] which is depicted in Figure 20 along with the other four building blocks that together constitute this simulation model.

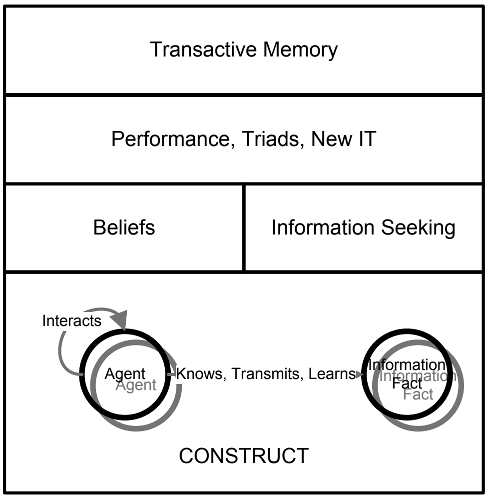



**Figure 20 CONSTRUCT-TM Building Blocks**

The CONSTRUCT block describes two different **domains**:

- **Agents Domain:** is formed by the active members of a social group that can be human or artificial;
- **Information Facts Domain:** is the available knowledge of the world that agents might possess.

The CONSTRUCT block also imposes a set of restrictions on the behavior of agents namely: that interaction leads to knowledge acquisition (an agent may connect to a new information fact whenever he interacts with one of his peers), that the tendency of individuals to create bonds depend on how similar their knowledge network is (homophily), and that individuals evaluate and determine their actions on the basis of their own characteristics and their perceived similarities to others [52]. In the long run and in the absence of forgetting, differentiation of information or demographic changes among the agents in the model, these three assumptions lead to cultural homogeneity (every agent has access to the same information facts).

A simulation solely based on the CONSTRUCT block would work according to the following cycle: Choose Interaction Partner → Communicate → Learn → Choose Interaction partner → (etc.) until the point of cultural homogeneity which would be reached sooner or later depending on the initial distribution of information facts.

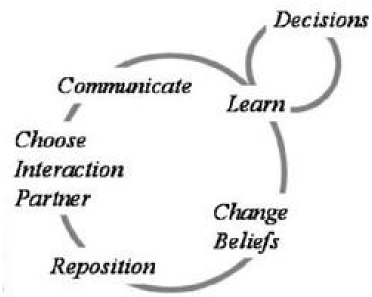



**Figure 21 Agent Activity Cycle in CONSTRUCT-TM**

Because of the four additional building blocks that were gradually introduced in CASOS' work, and which I do not describe here but refer the reader to [54; 55; 56], the simulation has a more complex cycle (see Figure 21).

The full model enforces the existence of non transferable knowledge, allows for different interpretation of the same problem when facing the same facts, demands that agents forget facts that have not been used for a long time, etc. This additional complexity reduces the probability (or even the possibility) of achieving cultural homogeneity but does not prevent the simulation to reach an equilibrium point where the social network will not be changed any further.

CONSTRCUCT-TM simulation tries to improve the ability to predict changes in the interaction patterns among individuals as well as the impact of new technology in these interaction patterns and the speed of information diffusion (in this simulation, different technologies allow different types of interactions among agents: more than one information fact may be changed per interaction, more than one partner may be contacted per interaction cycle, etc.).

**Other analysis Tools**

Besides the simulation models explained above, CASOS research group has developed multiple tools that can be used to automatically extract network data from real organizational data sources such as e-mails, employees' web-pages, enterprise intra-networks (data exchange), enterprise blogosphere, etc [57].

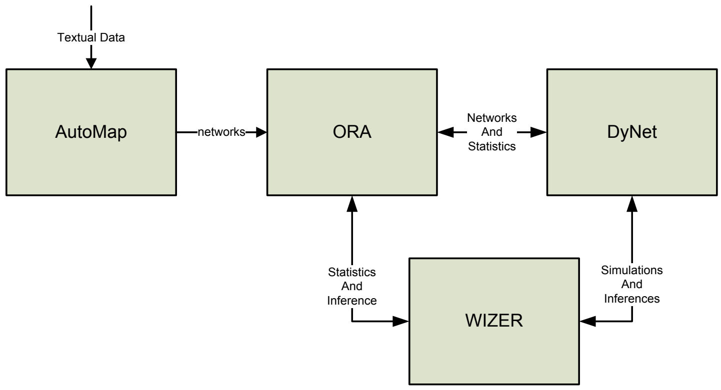



**Figure 22 WIZER working together with ORA and DyNet**

Figure 22 illustrates how some of these tools can be linked together to allow the extraction and analysis of this (social) network data. Automap is a tool to extract social network relationships from textual data [50], ORA performs statistical analysis on dynamic networks data [49], DyNet performs simulation on dynamic network data [46] and WIZER can interface with DynNet to add knowledge-based ontological reasoning to the simulation of dynamic networks. WIZER performs inferences on DyNet simulations which can be used for validation and model-improvement purposes or for scenario analysis purpose [58].

What CASOS group has come to conclude is that even with very messy and unstructured data (such as e-mail communication), these tools allow the observation of shifts in the existing organizational structures over time in response to various events (i.e. new CEO, new product, firing of personnel, etc.). What happens is that different communication contents and patterns between different divisions, different people, different organizations, emerge in these specific situations, thus changing the existing informal organizational networks [57].

These mining and analysis tools can also be used to validate or discredit the hypothesis which followed from the use of the previous simulation models.

### 4.2 Computational and Mathematical Organization Perspective Summary

Computational and Mathematical Organization theory focuses on understanding the general factors and non-linear dynamics that affect individual and organizational behavior and uses different types of simulations and computational models to analyze the main factors of concern [59].

Simulations might satisfy different purposes: description of behavior, training, hypothesis testing, theory generation, alternative explanation of phenomenon, etc. They add value to computational modeling, allowing different organizational models to be implemented and compared. At this point in time, the aim of simulations is not to reproduce one or more real organizations but to explore and model ideal-type organizations, formulate, control hypotheses about general organizational mechanisms and determine factors responsible for relevant organizational behavior [60].

CMOT simulation models usually focus mainly on four areas of study [59; 42]: (1) **Organizational Design Simulations** that address how to modify organizational design to meet task and environmental contingencies; (2) **Organizational Learning Simulations** that address the sharing and diffusion of information across organizations; (3) **Organization and Information Technology Simulations** that address the modeling of information technology and the measurement of performance considering different technology set ups; (4) **Organizational Change and Adaptation Simulations** that are tightly connected with time-dependent models and the examination of processes and the effects of their modifications in organizational performance.

Kathleen Carley and the CASOS research group are among the most influential researchers of this field. They see organizations as synthetic agents (complex, computational, adaptive and multileveled) where the key element, the human, is also complex, computational and adaptive.

In order to model one organization CASOS relies in numerous models namely: **ORGAHEAD** which describes learning by doing environments where agents interact only through formal ties of reporting and **CONSTRUCT-TM** which describes learning from others environments where the interactions patterns are dictated by homophily rather than the organizational chart.

In either of these models technology is seen as a way to influence the size and density of the different affiliation networks among the described domains but not as a solution to eliminate the bounds on Human behavior [16].

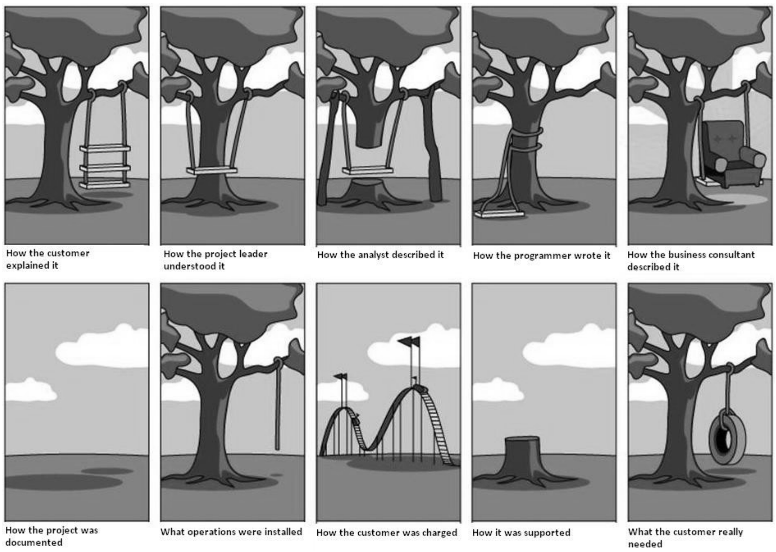
# Part III

## The Fourth Perspective: CEO's Research through Time

*"Leave the beaten track occasionally and dive into the woods. Every time you do so, you will be certain to find something that you have never seen before."*

*Alexander Graham Bell*

In the end of the twentieth century the evolution of information technology was at a peak. All over the world, enterprises were acquiring new and increasingly expensive IT solutions for their businesses. They were hoping to find the silver bullet that would increase their productivity, eliminate their existing problems and boost them up to the top of the competitive ladder. In the end however, the true story unfolded differently:




This, that became known as the *IS/Business matching problem* was the challenge that CEO's research begun tackling, but as time went by and the research programs progressed, new and even more challenging paths were envisioned in the horizon. This track of discovery through time is what we describe in this part.

## 5 CEO Framework 99: From Strategy and Operations to Time and Change (1999-2004)

FCEO99 or CEO Framework 99 was a response to the need to provide the enterprise with the best information systems to suit its strategy (known as the IS/Business *matching problem*). It was oriented for the modeling of concepts such as ***Business Goals, Business Processes*** and ***Information Systems*** and provided a formal but easy to understand language that could be used as grounds for discussing the implications of the match/mismatch between the business and its supporting system.

The framework revolved around three different layers: (1) ***Strategy layer*** which captured the translation of strategy into goals; (2) ***Operational/Process Layer*** which addressed the executable perspective of the enterprise (its business processes); and (3) ***Information Systems Layer*** concerned with the composition of different applications in a way that would support the operation of the organization.

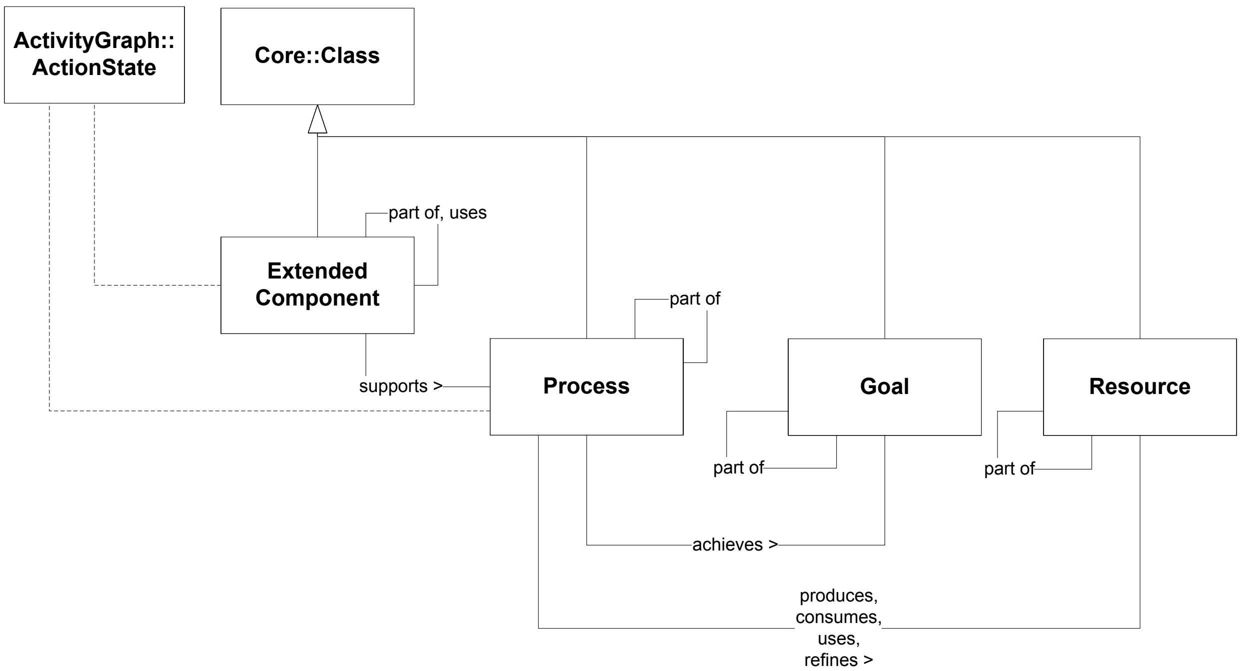



**Figure 23 Framework Meta-Model (UML V1.3) [61]**

Figure 23 summarizes the modeling profile that was the outcome of the work described on the above paragraph. The meta-model is expressed in UML (version 1.3) which was chosen as modeling language because of its tight connection to the software modeling industry, its ease of understanding and use and most of all, its evolutionary character through the powerful UML extension mechanism. The definition of this UML modeling profile was completely described in [61; 62].

The first alteration to the initial framework proposal appeared after a series of practical trials to which the above work was subject. After a number applications in the industry it was acknowledge that the existing modeling profile was insufficient, namely in the area of Information System Architectures (ISA modeling).

The framework did not provide means for describing the technologies and infrastructures used to enable the Information Systems environments, it ignored the need to specify multiple views and perspectives to better serve stakeholders with different needs, among other problems. To provide a solution for these problems, an update to the initial work was detailed in a serious of three papers where the problem is acknowledge and justified [63] and a solution is designed and proposed [64; 65].

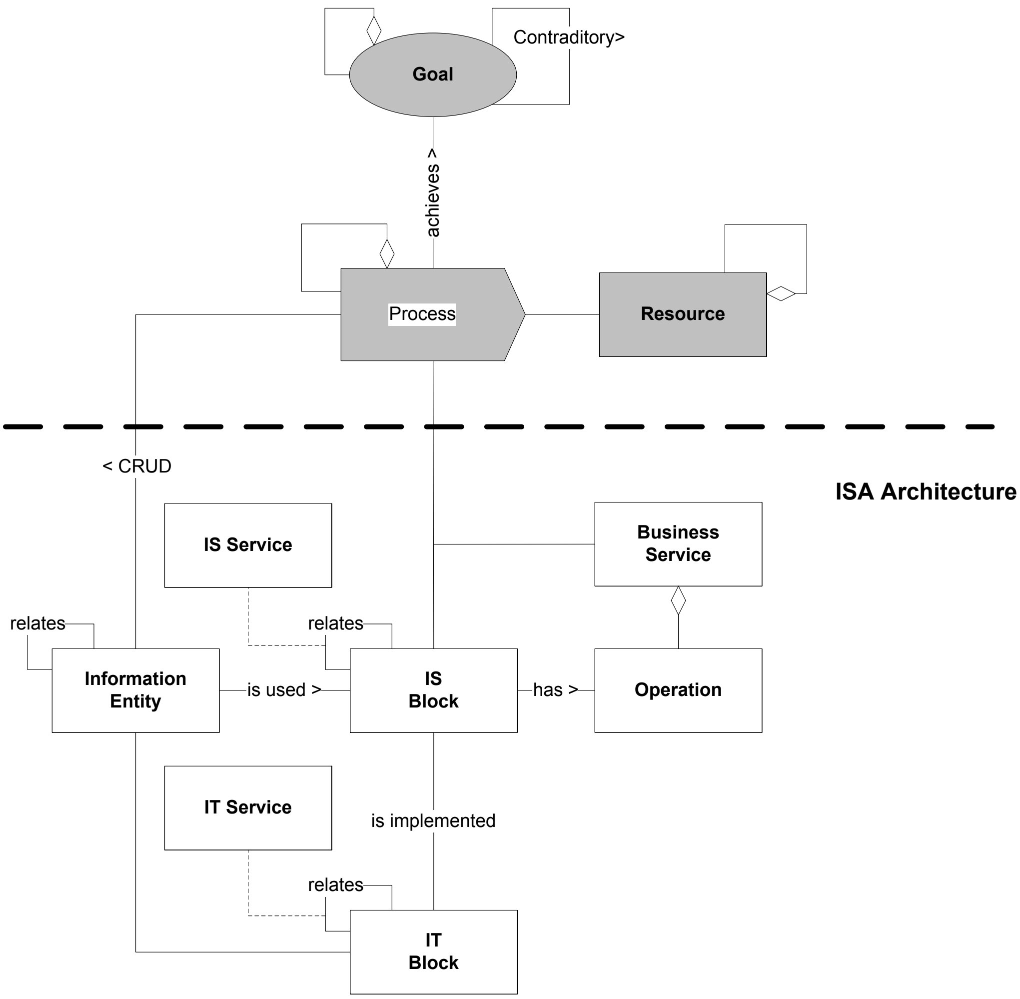



**Figure 24 FCEO + ISA profiles for business modeling (UML)**

Figure 24 summarizes the changes that were implemented to the initial framework. The gray elements represent the concepts that were inherited from previous UML profile while the white classes are the elements that were introduced to detail previously existing (but insufficient) concept of ***block/extended component.***

The improved framework maintained the existing ***Strategy*** and ***Process layers*** while it replaced the ***Information Systems Layer*** by an ***Information Systems Architecture*** composed of three architectural models: (1) ***Informational Architecture*** representing the main types that support the business and the relations between them (`Information Entity` as a the base type); (2) ***Application Architecture*** defining the applications needed for data management and business process support (`IS Block` and `IS Service` as base types); and (3) ***Technological Architecture*** defining the main technologies used in the implementation of the applications as well as the infrastructures providing and environment for information systems deployment (`IT Block` and `IT Service` as base types).

At this point CEO's research center was equipped with a tool that could describe enterprise strategy, the operations that would allow achieving this strategy and the information systems, the information types and the technological infrastructure that would realize and support business operations themselves. One of the shortcomings of this work, however, was the way it dealt with time. The framework had been thought to deal with the operational aspects of the organization rather than with change of the operational aspects themselves [66].

The models were static pictures of a dynamic reality and their effective implementation in real life projects (i.e the deployment of an information system) had usually a great impact on the way work was done in organizations (i.e. when used to delineate solutions for the enterprise, the models catalyzed a change process which was not explicitly dealt with).

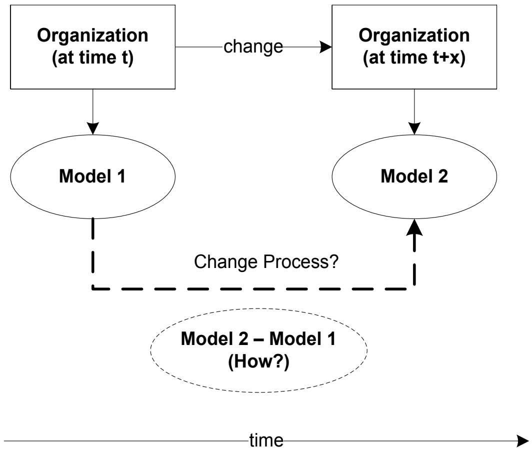



**Figure 25 Time Dimension**

Figure 25 describes the issue stated above. The FCEO was suitable for creating both **Model 1** and **Model 2** but did not explicitly support the transition between the two models.

A proposal for using the concept of ***Process*** to capture the activities and events that generated and conducted the changes that happen between time ***t*** and ***t+x*** was described in [66] and although this work was not completed, it explicitly brought the notion of time[8] to the core of the research group concerns as an explicit variable.

Until now, the management of change as a process remains an unresolved issue but there are multiple research works going on that try to address the time variable. Examples of this are a doctoral thesis related with real time auditing processes [67; 68] and other projects relating ***As-Is*** with ***To-Be*** process models [69; 70].

## 6 CEO Framework 2005: A New Maturity Stage of Organizational Modeling (2004-2005)

After 6 years of research and multiple revisions to the initial FCEO proposal, ignited by its application in numerous real life situations, CEO's research group position to organizational modeling was grounded on three conceptual basic primitives of the organizational world (see Figure 26):

[8] Although time pervades everything and was contained in the notion of ***Process*** itself (something only happens because time passes by), this was the first explicit attempt to represent its effect in the operation of the organization.

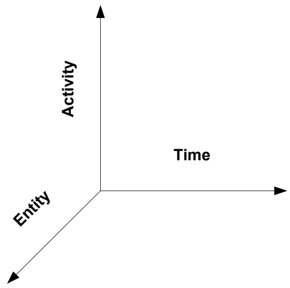



**Figure 26 Organizational Space Eigenvectors**

- ***Entity*** – as a thing that exists and is relevant to the organization under scrutiny. Entities are numerable and possess unique identifiers, they are related to names.
- ***Activity*** – as a thing that happens in the context of the work done at the organization under scrutiny. Activities are inevitably connected with the passage of time and they are related to verbs.
- ***Time*** – as a non-spatial continuum where events occur in irreversible succession from the past through the present to the future.

Until then, these primitives were modeled in UML through the concept of *Business Object* which corresponds to an object-oriented representation of the relevant organizational concepts. The concept of ***Entity*** had its counterparts in the business objects of `Goal`**,** `Resource` and `Block` while the concept of ***Activity*** was modeled through the `Process` *Business Object.*

### 6.1 A New Approach to Modeling the Organization: The Concept of Role

A particularly important observation that emerged from the use of these modeling primitives was that not every property of every *Business Object* is relevant all the time [71]. In the definition of *Business Object* `Person` of Figure 27 we can understand that Name and Age are properties which will characterize this *Business Object* independently of any other *Business Object*, but the properties Job Position and Salary will only be defined when we consider the `Person` related to another entity of the type `Organization`.

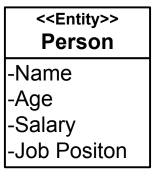



**Figure 27 Simple Example of a Class Definition**

The above paragraph points out that *Business Objects* have ***Intrinsic Features*** which describe the Object in isolation, they may change over time but always characterize the object (i.e. age of a person) independently of its collaborations; and ***Extrinsic Features*** which only become visible in the relationships that each *Business Object* establishes with its counterparts (i.e. other *Business Objects*).

This multi-dimensional behavior of *Business Objects,* whose properties and behavior may change according to the business context being considered, augments the challenge of analyzing the relationship network that each

*Business Object* establishes with the remainder ones [72]. As *Business Process Modeling* focuses on describing the relations and interactions between *Business Activities* and other *Business Entities*, a modeling approach that would explicitly separate the multiple collaborative aspects of *Business Objects* from their internal characteristics could improve reusability of representation and reduce the complexity of relationship analysis [72].

The consequence of the above observations was the introduction of the ***Role*** notion (see Table 3) as a modeling primitive in CEO's modeling vocabulary.

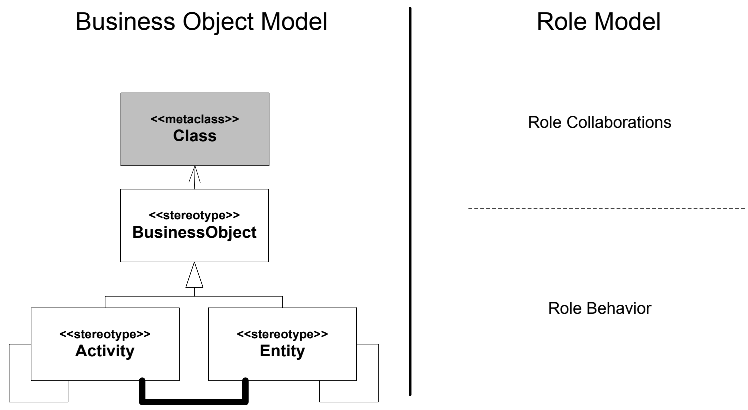



**Figure 28 Two Modeling Worlds**

Figure 28 and Table 3 illustrates the new version of the modeling tools that CEO adopted upon the introduction of the ***Role*** modeling primitive.

**Table 3 Modeling Primitives Definiton**

| **Modeling Concept** | **Natural Language Definition** |
|---|---|
| `Entity` | Represents a thing that exists in the business. |
| `Activity` | Represents a thing that happens in the business through the usage of **Entities.** |
| `Role` | Represents a set of properties and particular behavior that an Entity manifests when engaged in a particular collaboration. |

As it can be observed in Figure 28, the meta-model of the Object Model was simplified (when compared to the previous version). `Activity` and `Entity` are now the central modeling constructs while other B*usiness Objects* such as `Goals`, `Resources`, etc. can be specified as specializations of the `Entity` class according to the particular needs of each project at hand.

***Entities*** can be structurally related to other ***Entities*** being the same true for ***Activities*** while the real novelty lives in the "bold" relation between ***Entities*** and ***Activities*** in which the notion of ***Role*** comes into play (see Figure 29).

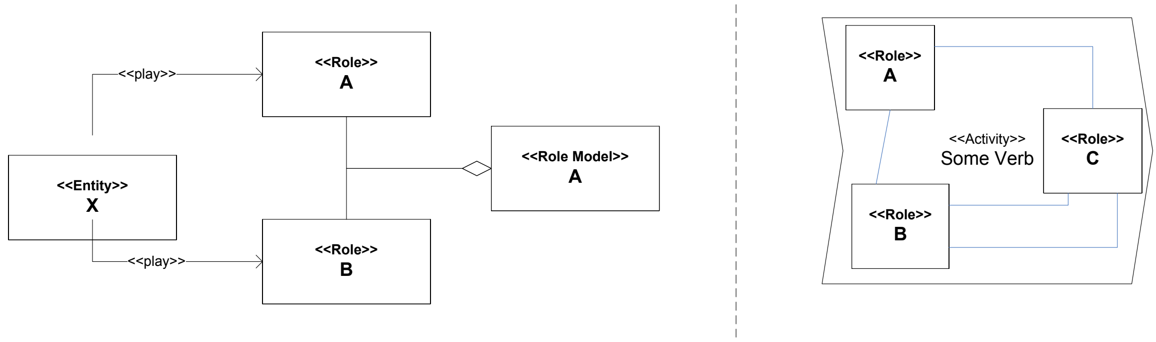



**Figure 29 The Connection between the BOM and th RM**

Figure 29 summarizes the connections between the Business Object Model and the Role Model. `Entities` play `Roles` when engaging in collaborations which in turn are the `Activities` they perform in the organization.

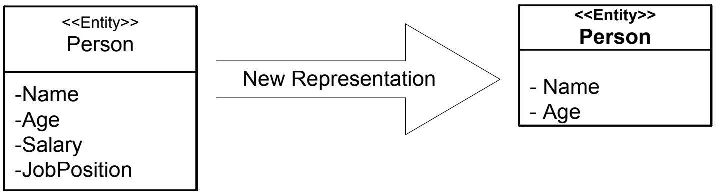



**Figure 30 Light Weight Entities**

Figure 30 illustrates that with this new approach, Entities are modeled only considering their Intrinsic features while the extrinsic features they might demonstrate are capture in the `Role` construct. A detailed description of the new meta-model can be found in [71] while refinements and applications of the model can be found in [73; 74; 75; 72].

### 6.2 A New Approach to Modeling the Organization: The Use of Enterprise Architectures

Having the meta-model of the previous section as a base platform, CEO's researchers started refining the `Entity` *Business Object* in a taxonomy of concepts to be used by each of the five different architectural views that compose an Enterprise Architecture according to the following definitions: (1) **Organizational Architecture** deals with aspects of the organization that are not directly related with the specificity of the business and its operations [76]; (2) **Business Architecture** deals with the materialization of the business strategy, defined in the *Organizational Architecture*, into business processes [76]; (3) **Information Architecture** deals with what the organization needs to know in order to conduct its operations as defined by the processes in the *Business Architecture* and provides one abstraction of the organization information requirements which is technology independent [76]; (4) **Application Architecture** deals with the applications needed for data management and business support and is independent of the actual software used to implement the different systems [76]; and (5) **Technological Architecture** deals with all the technologies behind the implementation of applications as well as with the infrastructure needed to deploy the business process support systems [76].

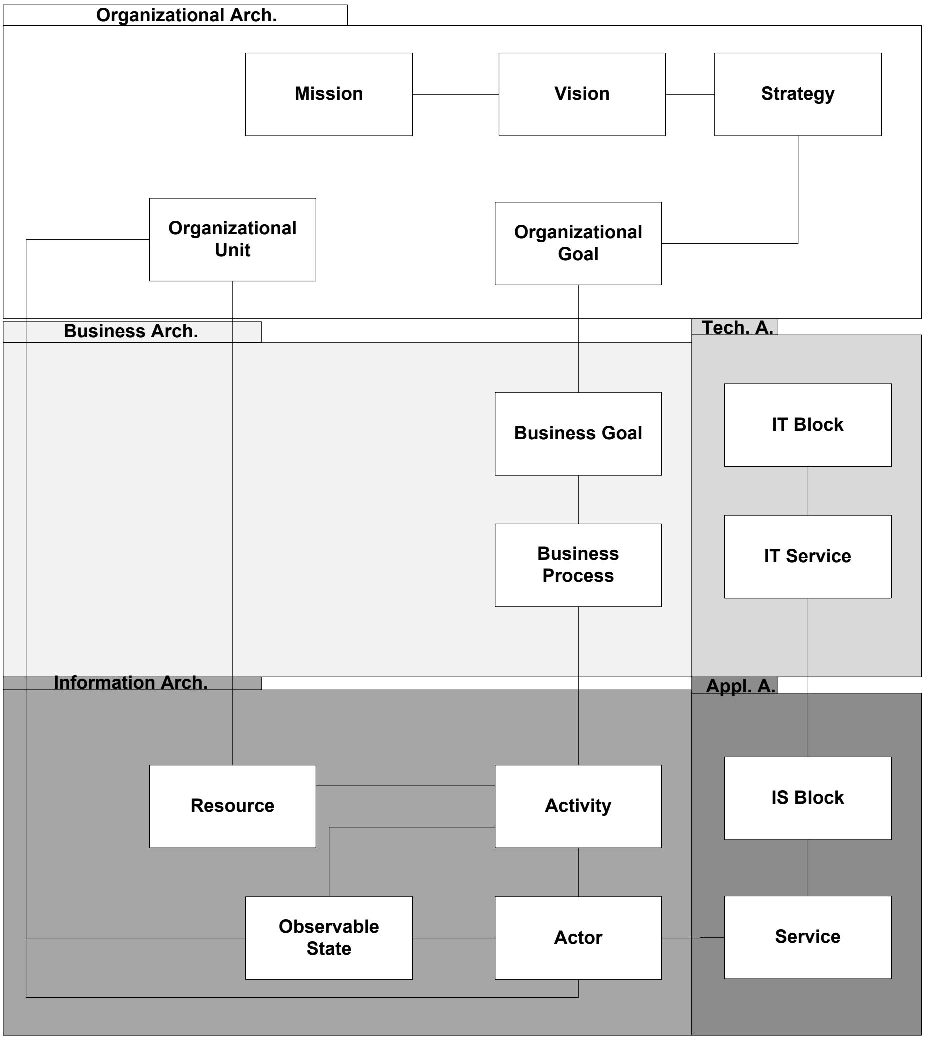



**Figure 31 Fundamental Concepts for Each of Enterprise Architecture Views [76]**

Figure 31 illustrates the five architectural views and the concepts that are recommended for describing each of them in isolation. This set of recommended *Business Object* types should be used as a starting point for building the Organization dictionary and each of them further specialized according to the specific needs of the enterprise being studied. A taxonomy for Role types was also provided in [76] most of them sharing similar names to the Entity/Activity taxonomy concepts[9].

### 6.3 The Benefits of this New Maturity Stage

By the end of 2005 CEO's research had reached a new maturity stage that benefited from the contributions of both Role and Enterprise Architecture Modeling.

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[9] This means that in the referred paper there is a Resource type which is a specialization of Entity (belonging to the Business Object Model) but there is also another Resource type which is a specialization of Role (belonging to the RM).

Through ***Role Modeling*** the understandability of business process modeling outcome was improved due to the separation of concerns that this primitive allowed for; *Business Object Models* became more stable as any alteration to the Roles does not affect the entities and the reverse is also true. Roles could also be used to model specific competences needed to perform specific business activities [77] contributing to the analysis of the alignment between activity performers and activities performed as well as a differential analysis between AS-IS and TO-BE organizational models.

Through ***Enterprise Architecture Modeling*** the set of modeling constructs was partitioned in different views concerning different business aspects and stakeholders which provided a concept structure to allow the diagnose of misalignments between the different concepts considered. Alignment assessment contributes to guarantee that people have the information they need to run their business (***Business and Information Architecture Alignment)***, that the IT department takes minimum time to ensure applications have the right data for processing (***Information and Application Architecture Alignment***), etc[10].

Summing all up, the new formulation of the enterprise modeling profile allowed a more comprehensive description and analysis of the different elements that shape an organization and the relations between them. It allowed the clustering of the different concepts that describe an organization in multiple levels of detail and according to multiple dimensions of analysis.

## 7 Current Developments of the CEO Framework (2005-Today)

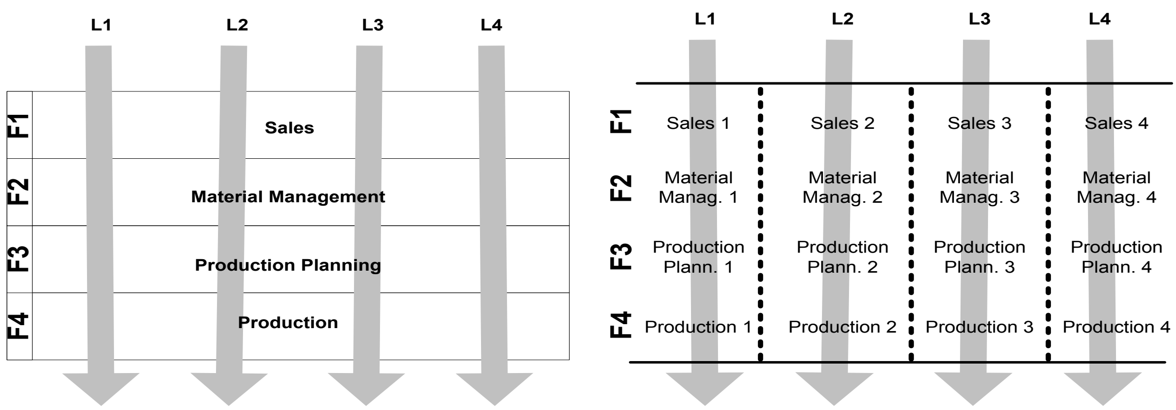


**Figure 32 Functional Enterprise (Left), Process Oriented Enterprise (Right)**

The type of enterprise representation presented so far, which is consistent with the state of the art of enterprise modeling, is mainly oriented to a process view of the organization. When this type of approach is mixed with the traditional partitioning of business into *functional areas,* we have a *matrix structure* enterprise representation that is becoming common nowadays (see Figure 32).

[10] For a set heuristics to assess alignment between the different architectural views refer to [76].

Theoretically, the division of the enterprise into *business functions* (see left of Figure 32) allows for high level of *resource efficiency*[11] [78] while the organization around *process structures* increases its ability to achieve corporate goals [78] with more efficacy.

Enterprise efficiency parameters are usually at odds, but despite that and because customer focus is nowadays one the main concerns of every organization, process orientation is becoming a ubiquous reality across enterprises that coexist with the functional decomposition of business (so often tightly connected with its departmentalization).

What CEO's research group has come to conclude is that this partition of the enterprise in processes and functions may suffer from a couple of problems, namely: (1) The *process orientation* perspective of the enterprise is excellent for understanding what the organization does and how it does it but it does not help to understand peoples' behavior within it. As put by Thompson: "*organizations do nothing except as individual members within them act*" [79]. The problem here is that *business processes* do not necessarily reflect people's behavior. In real organizations, people perform tasks in the context of activities that will belong to specific *business processes* and only in very particular and simple cases will an individual be responsible for every activity of a given business process. Most of the time he/she will be a participant in multiple processes and the unique performer of none; and (2) *Organizational Functions* are usually defined as sets of activities that support a specific aspect of the enterprise operations [80], but the value added of this notion is not clear: What makes a set of activities a function? Why call it a function? This group of activities constitutes a process or not?

To address the above issues there are two lines of research going on: (1) One which is defining new modeling primitives called ***contexts*** whose intent is to capture the fined grain behavior of people in and around organizations. And (2) another for which the object of study is the notion of function and that tries to answer questions such as: What is a function? What is an Organizational Function? How can we model Organizational Function? Is it valuable to model Organizational Functions?

The following sections detail the contents of the above research topics.

### 7.1 New Modeling Primitives: Action and Interaction Contexts

As it was stated in the above paragraphs, at work, people typically handle several independent, sometimes unrelated tasks and the current work dynamics enforce the switching among these task according to personal or work specific criteria [81]. In order to better understand the behavior of the human organizational actor in the work environment, CEO's research embraced the challenge of capturing and modeling multitasking behavior, considering the concept of ***context,*** which is a network of things (people, artifacts, etc.) characterized by a set of state variables that address both individual network elements and network emergent properties, as a fundamental primitive for this end [81; 82].

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[11] This is the efficient utilization of enterprise resources such as human output and operating resources and occurs mainly through task specialization.

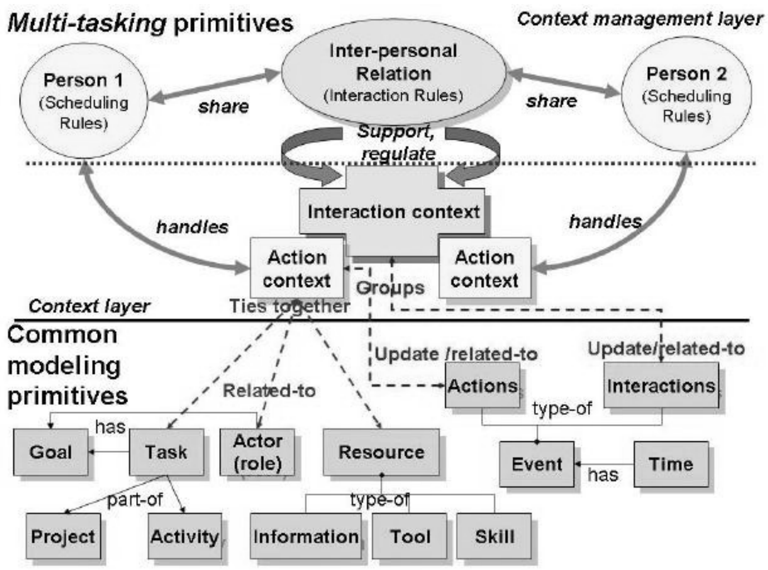


**Figure 33 Linking Multitasking to Common Modeling Primitives [81]**

Figure 33 describes the set of concepts that were drawn from models of human multitasking and social and cognitive sciences which are now being considered to enlarge the vocabulary of CEO's modeling language [81]:

- ***Action*** **–** an atomic act that changes the state of something in the organizational environment;
- ***Task*** – set of several actions directed at the achievement of some goal.
- ***Interaction*** – set of acts involving a sender and a receiver where the sender tries to change the state of something related with the receiver;
- (Personal) ***Action Contexts*** are sub-sets of organizational ***Entities*** along with their state and the relations among them for a particular individual during specific time intervals;
- (Inter-Personal) ***Interaction Contexts*** are defined as the history of interactions between two actors (sender and a receiver) and the set of commitments and state produced by interactions in specific ***Action Contexts.***

Figure 33 also illustrates the connection of ***Action Contexts*** and ***Interaction Contexts*** with the common modeling primitives used at CEO research center (Role, Activity, Entity in the form of Resource, and Time) and with other primitives extracted from human multitasking models (Action, Task, Interaction, Event) that can also be related to first set of primitives through the concept of ***Activity***. The picture shows that interacting individuals share a set of interaction rules defined by their inter-personal relation and as individuals can interact from different ***Action Contexts*** their interactions can be mediated by multiple ***Interaction Contexts*** [81]**.**

### 7.2 New Type of Architecture: The Function Architecture

To understand what a function is and whether the classification of *Marketing*, *Sales*, *Finance,* among others as *Organizational Functions* had any rational or value added to the operation of the organization, David Aveiro initiated a doctoral thesis on this subject as part of the CEO group research topics.

Until now, his research is defending the two following statements: (1) the usual classification of management theories of *Marketing, Sales, Finance, Technology*, etc. as *Organizational Functions* should be dropped; and (2) function is something responsible for the self maintenance of a system, therefore, in organizations, a functional dimension is something responsible for ensuring that the enterprise is "*doing well in a regular way"* [83].

These conclusions were grounded on essence of the function concept as approached by biology, sociology and philosophy of biology are summarized in [83; 84; 85] and lead to the following definition of *function*: a *macro-activity* responsible for the emergence of: *non-locality* (activities which are dependent on mechanisms that pervade the organization), *interdependence among activities* (the well being of the systems requires the "*good health"* of a set of activities in the organization whose proper behavior influences one another), *norm* (evaluative principles which restrict the behavior of the systems), *resiliency* (self correcting behavior which originates higher level activities that try to guarantee the norm) and the need for *control* (continuous evaluation of the system's behavior).

Accepting the above definition implies that looking to an enterprise through the eyes of the *Functional Dimension* might yield the following possibilities:

1. **The enterprise is executing its business processes in a regular way:**
    a. The set of variables under observation are all contained within the expected range of values.

2. **The enterprise is executing its business processes but a known irregularity occurs:**
    a. One or more of the variables under observation have departed from the expected range of possible values:
        i. The enterprise tries to correct its behavior by enforcing the existing rules known to solve the identified problem.

3. **The enterprise is executing its business processes and an unknown irregularity occurs:**
    a. One or more of the variables under observation have departed from the expected range of possible values:
        i. The enterprise tries to correct its behavior by enforcing existing rules that were applied to similar but known situations;
        ii. The enterprise is forced to create a solution to the problem by sometimes chaotic and difficult to predict activities.

Observation one illustrates the normal *operation* of the enterprise, observation two illustrates a violation of the enterprise *norm* and the utilization of *resilience* mechanism to reestablish it while observation three illustrates the same situation as observation two but where the *resilience* mechanism does not provide an answer to the problem. In this case it is necessary to resort to a *microgenesis* mechanism. Throughout all the examples controlling the state of the enterprise through feedback mechanisms and variable monitoring is a necessity; otherwise it would be impossible to determine that the system has become dysfunctional.

**Table 4 Main Concepts of the Functional Dimension**

| Concept | Definition |
|---|---|
| *function* | Process interdependency relations that determine the viability of the organizational system. |
| *norm* | Desired value of one or more variables of a system |
| *resilience* | Capacity of a system to respond to *out of the norm* conditions. |
| *microgenesis* | When the *Resilience* property of a system is not able to cope to some *out of the norm* conditions, a more complex mechanism is necessary to assure the well being of the system. |
| *exception* | An event triggered by the occurrence of *out of the norm* situations. Exception might be expected and dealt through *resilience* mechanisms or unexpected and require the intervention of mechanisms of higher complexity such as *microgenesis*. |

Together with Table 4, Figure 34 describes the 4 major building blocks that one needs to understand in order to elicit, describe and model this newly identified *Organizational Dimension.*

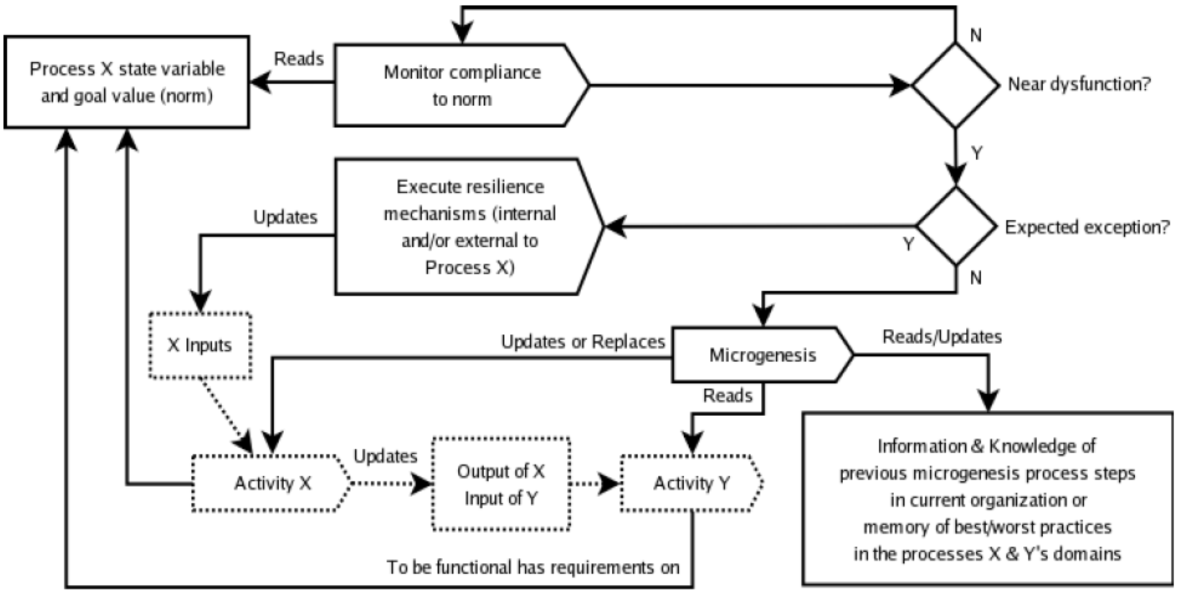


**Figure 34 Organizational Function's Artifacts Dynamic [85; 83]**

Being mechanisms of the organizational system's *self maintenance*, *Organizational Functions* are themselves activities which can get dysfunctional (or out of the norm). Because of this, the described mechanism is itself recursive and might require the elicitation of its own *Functional Dimension.* In extreme exceptional cases where the *Microgenesis* and *Resilience* activities get out the *norm,* the system might have to be completely reconfigured or even collapse due to the inability to cope with new environmental conditions [84].

## 8 The Next Step of Organizational Modeling: A Three Layered Architecture

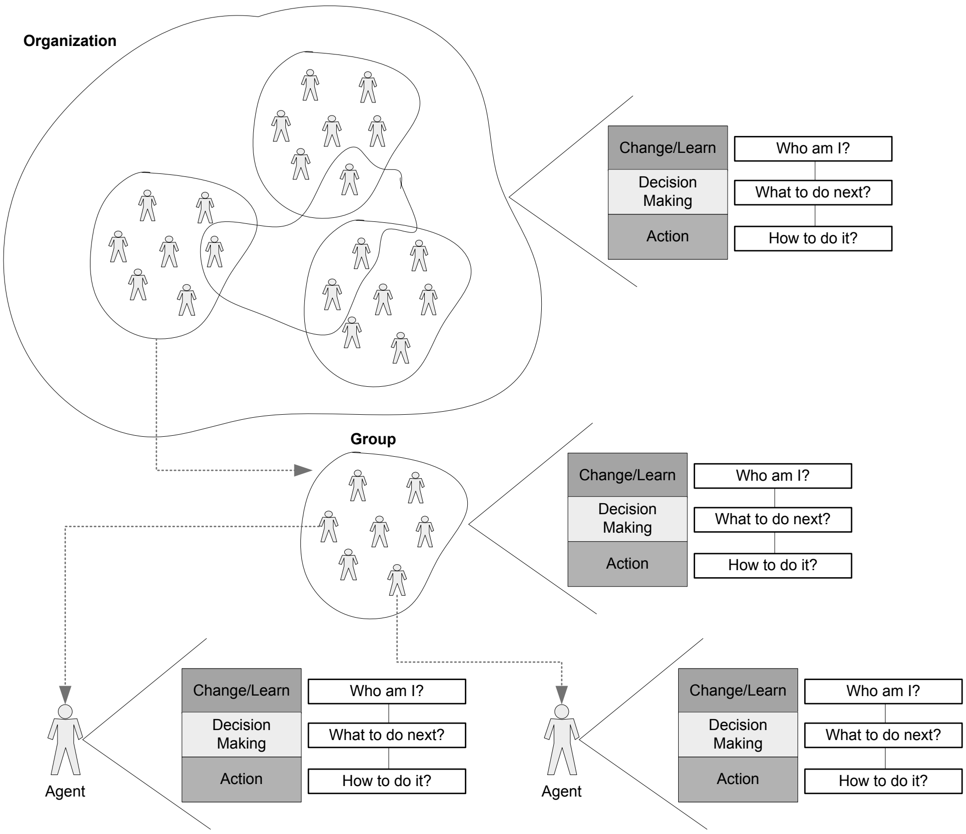


**Figure 35 Agent General Architecture**

Using the ***Enterprise Architecture*** representation model defined in **section 6** and considering the new research directions defined in **section 7** CEO's research group is developing a innovative agent architectural model that, unlike tradition approaches to enterprise architecture, is concerned with the capture of behavioral specificities of individual agents, groups and the organization itself.

Figure 35 illustrates the basic structure of this three layer recursive model which is to be applied in a bottom up fashion and is expected to enhance the shared understanding of the organizational structure and dynamics [86]. In this architecture, individuals, groups and organizations are considered *autonomous, interactive, adaptive* and *proactive,* have <u>*bounded rationality*</u> and are capable of displaying *non deterministic behavior.* Each of them is modeled as an agent [86].

In CEO's terminology, an ***agent*** is a special ***entity type*** with the ability to perform, coordinate and change activities, provide, consume manage and change resources and monitor, coordinate and change their own activity and the activities of other agents [86; 87]. Agents decide what to do through rules activated by their monitoring and deliberation capabilities. They interact with others through patterns established by their learning capabilities. Agents may be forced to alter their action and interaction patterns based on measures of performance attributed to their behavior [86; 87; 82]. Agents are modeled in terms of three different layers (***action, decision making, change/***learn) which have specific ***roles*** associated with them.

Focusing on the three depicted layers in Figure 36 we can see that the ***action layer*** is responsible for capturing behaviors (i.e. the active element of each organizational level), the ***decision layer*** is responsible for interpreting the motivation for the behaviors captured in the ***action layer*** while the ***decision/learn layer*** aim is to capture the changes in the motivations and in the agent's active behavior.

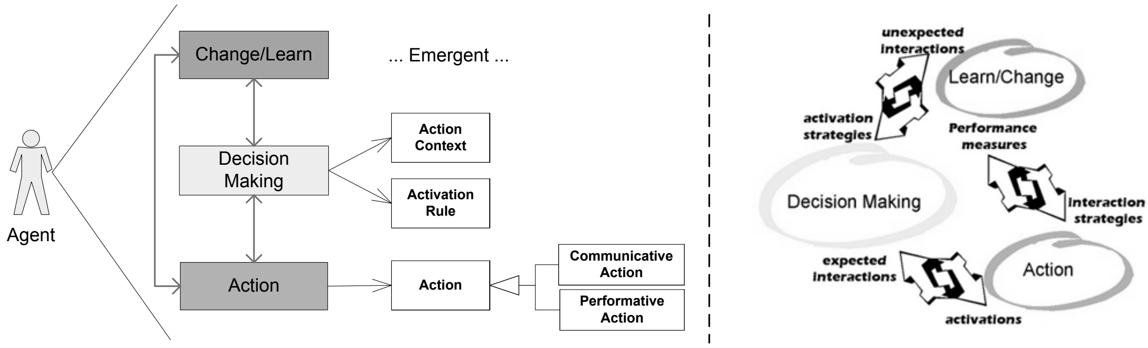


**Figure 36 some relations between Layers [86]**

Although the application of the architecture is recursive and can be used to any level of granularity, the primitives and concepts used to represent and understand each of the three layers have to be slightly adapted to the three main granularity levels of concern: **individual, group (2 or more individuals), organization** and **other higher levels of granularity.**

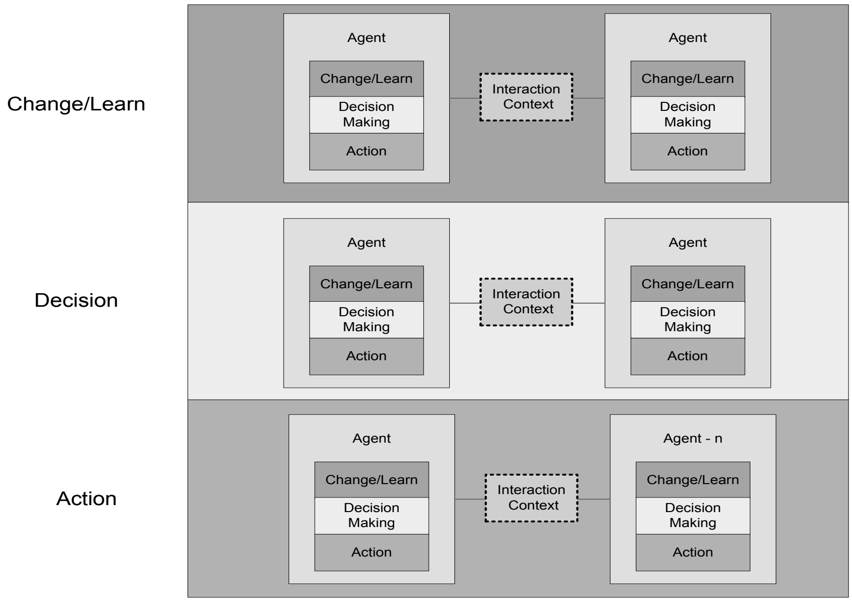


**Figure 37 Recursive nature of the model**

Figure 37 explains how this model can also be recursively applied to its own three layers. Regardless of the granularity level being addressed, the architecture assumes that the purpose of each layer is carried out by agents which may themselves be modeled according to the architecture (agents play the specific roles associated with each particular layer). This has numerous implications, namely that it is at least in principle possible to define process models to describe very complex dynamics such as the “things” that trigger change[12].

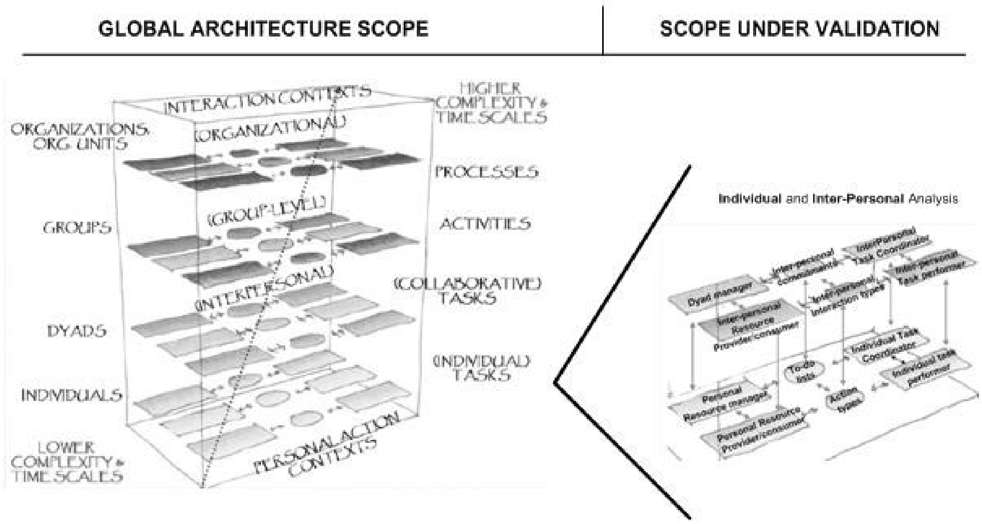


**Figure 38 All Granularity Levels and the Object of Current Validation [86; 12]**

Figure 38 was included to illustrate that although the architecture under development is being considered general enough to apply to all the organizational granularity levels, only the Individual and Inter-Personal levels of analysis are being tooled with modeling primitives and validated in practice. Due to their added complexity, higher levels of granularity than the Inter-Personal one are not yet being addressed by current research.

The following sections describe in more detail how this architecture is being applied and the problems that are identified at high organizational granularity levels.

### 8.1 Granularity: Individual and Interpersonal Levels

At the granularity of the individual organizational actors are modeled as agents who perform tasks which can be decomposed into actions of *performative* or *communicative* nature. At this level, the interactions patterns among individuals (which are sets of communicative actions involving a speaker and a hearer) are not considered (only the speaker or hearer perspective is addressed).

When considering individual agents the architectural layers have the following roles: (1) the **action layer** captures the *Tasks* that are performed and the way they are performed by the different agents (i.e. the artifacts that are used in performing the *Task*, the *Roles* needed to perform it, etc.); (2) the **decision layer** captures the *Personal Action Contexts* involved in each of the performed *Tasks* and the *Rules* that motivate and co-ordinate the agent’s multitasking behavior; and (3) finally the **change/learn layer** should capture the changes that occur in the performing of *Tasks* and in the scheduling of *Personal Action Contexts* but at this point there are no defined primitives to address this layer of the framework at any granularity level.

[12] This stems from the fact that the agents responsible for these complex dynamics also have an **action layer** which can be described in terms of deterministic modeling techniques such as UML process models.

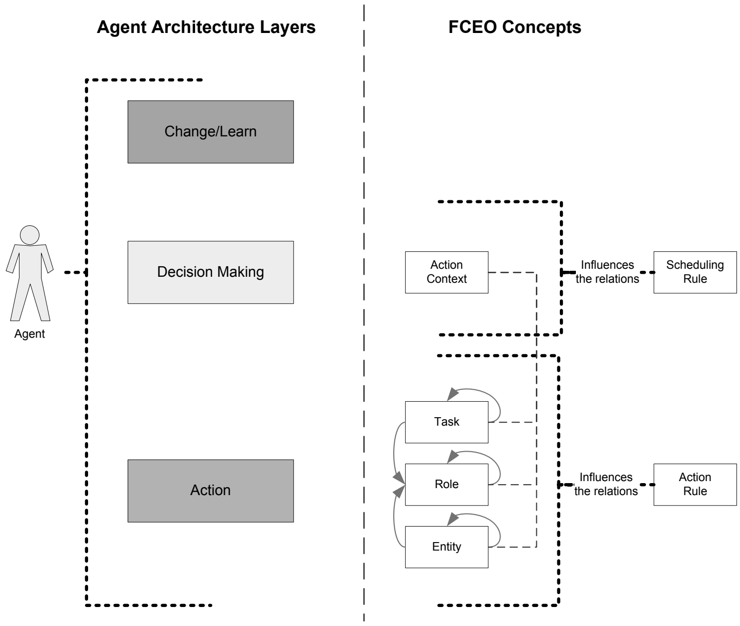


**Figure 39 Layered Architecture at the Individual Level and CEO's primitives**

Figure 39 establishes the connection between CEO's modeling primitives and the generic agent architecture described in the above paragraphs. As the picture denotes, while the ***action*** and ***decision making layers*** have well defined modeling primitives, the ***change/learn layer*** has yet to be studied and defined.

Until now, David Aveiro's research on the *self-regulating* role of the Organizational *Functional Dimension* appears to be a promising path to capture at least part of the emergent behavior of organizational actors using concepts of *Business Rules*, *Unexpected Exceptions* and *Microgenesis* processes, however this research is in too early stages for any strong conclusion to be drawn.

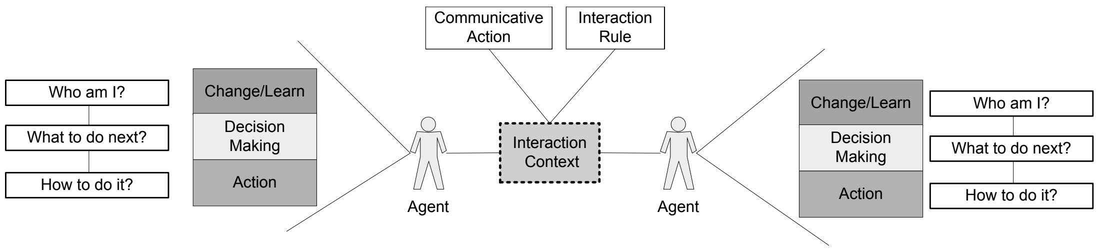


**Figure 40 Interpersonal Level**

Figure 40 illustrates the application of the agent architectural model to analyze the behavior of two individual agents considered together, this is, when they behave independently but their communicative actions are grouped in interactions patterns[13]. This type of study, which is called *inter-personal analysis*, allows for the elicitation of contexts that mediate agents' interactions.

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[13] Two agents acting together could also be modeled as a unique agent (group of two) but at the inter-personal level we are concerned with interactions among individual agents not in the individual agent that they may or not constitute at higher levels of granularity.

These *Interaction Contexts* concern different concepts depending on the architectural layer being considered: (1) at the ***action layer*** the contexts are seen as networks of expected interaction types and resource types exchanged; (2) at the ***decision making layer*** the contexts are seen as the networks of commitments that the agents establish in their interactions; and (3) finally, at the ***change/learn layer*** the contexts are seen as the set of rules that restrict and condition agent's interaction.

As it was explained in the previous section, the individual and inter-personal levels of analysis are being validated in projects within firms. The practical applications of this framework at the individual level of recursion can be found in [81; 88] where the details regarding the clustering of *Tasks* and *Resources* (entities) into particular *Action Contexts* are also fully explained. Besides these, there are currently three ongoing practical applications of this work that are contributing to its refinement and validation at the individual and inter-personal levels of analysis.

### 8.2 Granularity: Group, Organization and Other Levels

When applying the architecture at higher levels of granularity than the inter-personal level, additional problems for which CEO group has no answers yet rise: (1) groups are composed of multiple individuals and groups while Organizations enclose multiple Groups implying parallel processing behavior instead of multitasking behavior, this is, many Activities (Group Level) and Processes (Organizational Level) occur simultaneously without the need of interleaving; (2) parallel processing behavior implies that multiple action and interaction contexts will be active at the same time probably influencing each other in non explicit or visible ways; and (3) applying the framework at group level implies that we are able to identify the group as an agent. The problem is that organizations enclose multiple types of groups: work teams, informal group structures, decision making boards, etc. Determining which groups are relevant and their mutual influencing bonds is not at all trivial.

Complexity increases with higher organizational levels of detail and for each particular level the same is true from the ***action*** to the ***change/learn layer*** [86]. While at Individual and Interpersonal levels the behavior of agents can be directly observed, the same cannot be said about higher levels of analysis. Individuals are usually related to Tasks, groups with Activities and Organizations with processes but there is no linear path of analysis that can lead from the observation of the Individual to the understanding of the whole organizational behavior.

The CEO group has yet to develop the set of tools for the observation and analysis of these higher granularity levels so that this architecture can be validated at these same higher levels.

# Part IV

# Organizational Design and Engineering: An Utopist Manifest

"*We Choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one we are willing to accept, one we are unwilling to postpone, and one we intend to win"*

*John F. Kennedy, 25/05/1961*

Until now we have described a vast set of *Organizational Engineering* approaches and have categorized them according to four different perspectives. From now on we will continue the analysis of these researches by establishing a comparison between the approaches *Business Engineering, Enterprise Engineering, DEMO, CASOS* and *CEO99-2005*.

In this discussion the *Business Action Theory* and the *Business Design Technology* (from the *Language Action Perspective)* are only marginally addressed because of their wide compatibility with *DEMO* (remember **section 3.4** page 20). We also exclude *CEO2005-2007* approach from the direct comparison because we consider it as part of the solution being delineated for the problems that this analysis identifies.

After the initial comparison we refine the CEO's definition of *Organizational Design and Engineering* discipline (CEO2005-2007 approach) and try to contribute to the development of the models presented in **sections 8** of the previous part by defining a process of application for ODE and by instantiating it in terms of the agent architecture that was presented there.

Through this process we also engage in the difficult task of trying to delineate a possible path for the future formal integration of both hard and soft science disciplines, and justify the importance of such a blend which inexistence causes most of the problems of the *Organizational Engineering* approaches that we will identify here.

## 9 Comparing the Four Perspectives

The synthesis of the previous sections has given the general idea about the way of thinking of the different *Organizational Engineering* perspectives and approaches within them. As we have seen, each of them serves a more or less distinct purpose and takes different assumptions regarding the essence and operation of organizations.

Having reached this point we face the problem of comparing the approaches when there are no formal frameworks and metrics of evaluation that can be meaningfully applied to establish an unbiased evaluation of these research works, and there are too few published real life case studies so that we can really certify how well they have actually resulted in practice.

Assuming these limitations we have established our own method of analysis by choosing to focus on four different observable aspects of these approaches and continue our study from there:

(1) Purpose and tools of the different approaches.
(2) The ontological definitions of organization.
(3) The process of application of the approach.
(4) The theoretical achievements in organizations after their use.

This simplified analysis system was selected, not because we want to assign a possible meaningless grade to the approaches being studied, but because we want be able to understand the main tendencies of the approaches and draw meaningful conclusions of ways of intervening to better develop the body of knowledge in this field.

### 9.1 Different Purposes and Tools

We begin our analysis of the perspectives of *Organizational Engineering* by explicating the goals of the main approaches described here.

Purpose is a fundamental variable in understanding the different approaches within each perspective because it constrains the ontological positioning, their process/procedure and of course the possible outcomes of their practical application in enterprise environments. Table 5 initiates this description and also presents the set of tools that are used by the approaches when reaching for their goals.

**Table 5 Purpose of Organizational Engineering Approaches**

| Approach | Approach Purpose | The Tools/Knowledge | |
|---|---|---|---|
| Business Engineering (BEEP) | Support enterprise change and redesign enabled by IT innovations. | **Hard** | Method Engineering;<br>Enterprise Architecture. |
| | | **Soft** | Management Training;<br>Technological Training;<br>Understanding of Human Factors;<br>System Development Experience. |
| Enterprise Engineering (BEEP) | Support enterprise change and redesign enabled by IT innovations. | **Hard** | Technological S-Curve;<br>Scenario Planning;<br>Process Modeling. |

| | | | |
|---|---|---|---|
| | | **Soft** | Management Training;<br>Technological Training;<br>System Development Experience;<br>Understanding of Human Factors. |
| DEMO (LAP) | Design systems that will augment people’s capacity to act within the organization. | **Hard** | Systems Engineering;<br>DEMO Methodology;<br>BCI3D Method [89]. |
| | | **Soft** | Philosophy of Language. |
| CASOS (CMOT) | Study the nature of human and technology interactions and their impact on organizational behavior. Confirm or disprove organizational theories. | **Hard** | Textual Data Analysis;<br>Statistical Data Analysis;<br>Stochastic Simulation Models. |
| | | **Soft** | Organizational Behavior Theories;<br>Sociological Theories of Behavior; |
| CEO99-2005 (CEO) | Support enterprise redesign and change and prepare the organization for information system deployment and implementation. | **Hard** | Role Modeling;<br>Enterprise Architecture; |
| | | **Soft** | Ethnographic Studies;<br>Human Computer Interaction Theories; |

As the table above explicates, the *Business & Enterprise Engineering Perspective is* concerned with deploying new business models in organizations enabled by IT innovations. This perspective addresses not only the identification of potentially new business model opportunities but also the management of the change process that becomes necessary when such opportunities are spotted.

A different purpose is addressed by the *Language Action Perspective* whose approaches are mainly concerned with explaining the business in such a way to extend employees capacity to understand it and to act within it more effectively. It is a fact that in the process of designing the models that will allow the explanation of the organization and possibly the deployment/configuration of tools, changes to the design of the enterprise might be needed, but that is not usually the main concern of *LAP*.

*CEO99-2005* from *CEO Perspective* is also concerned with the challenges of organizational change, but unlike the *BEEP* its focus is on tooling the enterprise with the items that it needs, rather than of looking for potentially new business models enabled by technology.

Finally, the last perspective left mentioning is CASOS research of the *Computational and Mathematical Organization Theory* which much unlike all the others is not an intervention approach. The goal here is to explain, hypothesize and study organizations and their behavior. Of course that it is possible that from this study, organizations demand for intervention and change, but this is done a posteriori and not a direct responsibility of CASOS’ methods.

### 9.2 Different Ontological Definitions

As the objectives of the different perspectives have already been clarified, we can proceed to dig deep into understanding how each of them classifies the essence of the common object of their study (the organization).

The ontological position of the approaches allows drawing some boarders regarding the assumptions and concerns that each of them focuses the most. This is in part a consequence of the purpose being targeted and together with the analysis of the previous section allows for the positioning of the approaches on the ***ontological axis***.

Table 6 below describes the ontological definition of each of the approaches regarding the organization as an individual entity in the world.

**Table 6 The Different Ontological Definitions of Enterprise/Organization**

| OE Perspective | OE Approach | An Organization is: (Ontological Definition) |
|---|---|---|
| BEEP | Enterprise Engineering | An organism system of interacting people and technology; |
| | Business Engineering | A complex system of interacting people and technology; |
| LAP | Business Design Technology | A network system of interrelated ***Speech Acts***; |
| | Business Action Theory | A System of ***Actors*** who engage in **Business Processes;** |
| | DEMO | An heterogeneous system of ***Actors*** who engage in ***Transactions;*** |
| CMOT | CASOS Sim. Research | A complex adaptive system; |
| CEO | FCEO99-2005 | A System of ***entities*** who ***play roles*** when engaging in ***activities***; |
| | CEO2005-2007 | A complex adaptive system *(Widely Defined in Section 10.2).* |

The common pattern that first comes to sight is that all the approaches describe this socio-technical arrangement (enterprise) as a system. This has direct implications, namely that the research works assume that it is possible to apply decomposition and partitioning principles to enterprises, or in other words, that enterprises can be explained in terms of smaller parts of themselves (sub-systems).

Other consequences appear according to the different classifications that the approaches attribute the system enterprise, for example, a differentiating factor regarding the approaches from the *Language Action Perspective* and *CEO99-2005* (from *CEO Perspective*) is that they discard the *complex* category classification to the enterprise system and in doing so they ignore the possibility of emergent properties and behaviors that are inherent to the social (human) nature of organizations. It can be said that they address a more restricted domain and set of problems[14].

A last remark regarding Table 6 is that all the perspectives assume that organizations themselves are actually an active part of their definition of the enterprise essence: in DEMO (*LAP*) for example, ***Composite Actor Roles*** can be technological items, people or even organizations, the same is true in *CEO99-2005 (CEO Perspective)* where organizations can be seen as ***Entities***, in *CMOT* organizations appear as ***Agents***, and in *BEEP* the *multi-organism* metaphor states that organizations are people, technology and other organizations.

[14] We are not however saying anything about how well do any of the approaches do in their respective domains (restricted or broad).

All the approaches give a high relevance position to the relations that organizations establish with one another. This seems to be justified by the increased industry network structures that, just as St. Gallen school exposes, appear in the *information age*. Drawing from the Table 6 and discussion above we have used Figure 41 to locate the different approaches in terms of the ontological axis defined in [12].

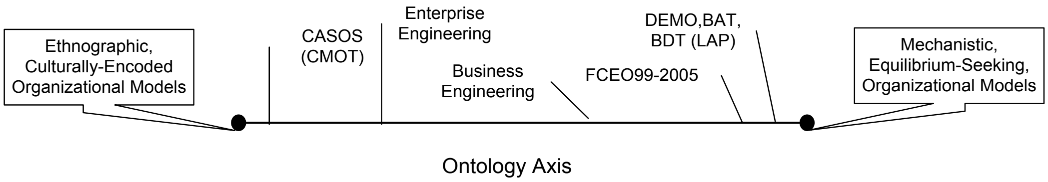


**Figure 41 positioning along the ontology axis**

As can be seen, CASOS's research lies far to the left on the ontological axis. Although it is heavily supported by advanced statistical and mathematical models (engineering tools), its focus on organizational and group behavior positions this approach in the group of the culturally-encoded models. To its right lies Martin's *Enterprise Engineering* which focus on changing organizational culture and employees mental models through the use of process reengineering and information systems deployment.

The approaches closest to the mechanistic and equilibrium-seeking organizational models are the ones from the *Language Action Perspective* since they try to establish repeatable patterns for all types of business communication interaction (the only one they consider relevant for their models). Finally, collecting the position closer to the axis center is St. Galen's *Business Engineering* which is the first attempt to mix the formalism of *Enterprise Architectures* to concerns with social factors like power structures and cultural elements, although this integration has been only done informally through training and document checklists.

### 9.3 Different Processes of Application

The description of the different processes of the organizational engineering approaches is next in our list of discussion items. It is important to notice that in this section we have opted to cluster the approaches that have similar processes of application in order to better establish the biggest differences among the processes, rather than de details. Schemes for the effective processes of each approach are provided in **Appendix A**.

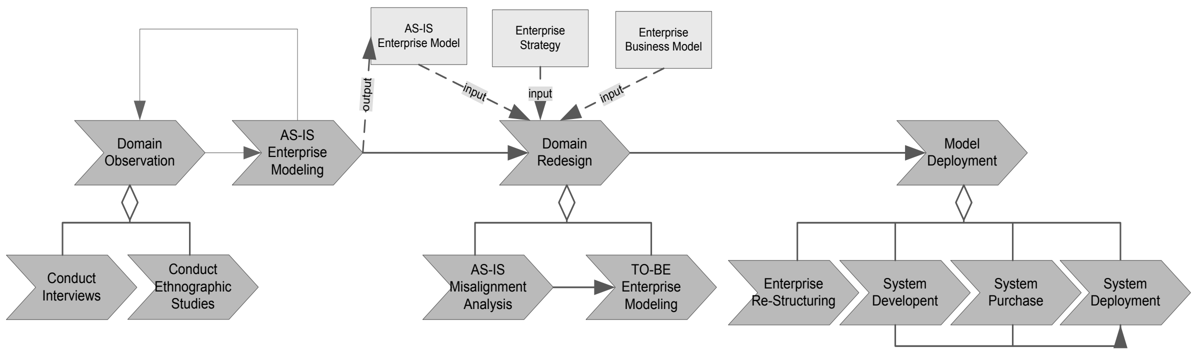


**Figure 42 LAP & CEO99-2005 Simplified Process**

***Language Action Perspective*** **and** ***CEO99-2005*** perspectives follow more or less the process defined in Figure 42. Their approaches start with the observation of the organization operations (`Domain Observation`) which result is the production of a set of ***as-is*** models of the organization.

The ***as-is*** models are validated against the organization personnel own view and together with the enterprise strategy and business models, they serve as the input for the sub-process of organizational domain redesign. This model validation phase of the process is iterative and can lead to the re-definition of the ***as-is*** models produced. This is a very important and differentiating factor of these approaches, as the modeling outcome is a constructed reality by both analysts and enterprise employees (the ones who know the truth).

The ***to-be*** enterprise models that are the result of the `Domain Redesign` stage of the process are used for requirements definition and system development/acquisition to which follows their deployment in the enterprise environment. `System Deployment` and Enterprise `Re-Structuring` can happen in a more or less continuous fashion but are seen as the end of the organizational engineering process.

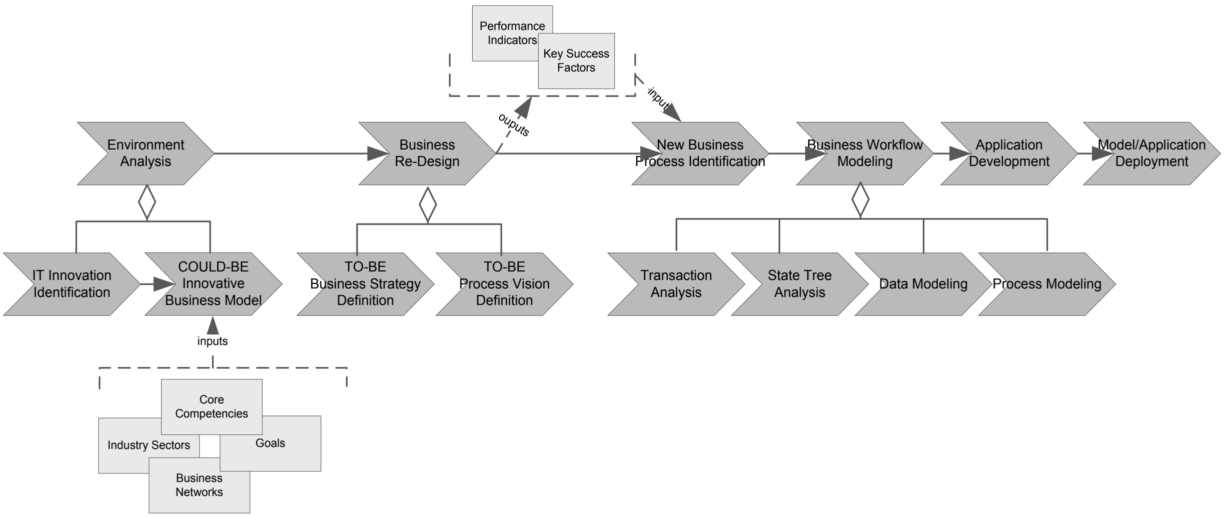


**Figure 43 Business & Enterprise Engineering Simplified Process**

The ***Business & Enterprise Perspective*** (BEEP) follows the process of Figure 43. It differs from the *LAP* and *CEO99-2005* process in the fact that (1) it considers the definition of strategy and business models to be a result of the organizational engineering rather than an input, (2) it is a top down approach that does not consider feedback loops from process step to process steps[15] (e.g. clean sheet approach vs. ***as-is*** modeling with the participation of employees in the model definition) and (3) it includes soft organizational factors concerns (systems are used to modify the informal culture of the enterprise) and explains them over training sessions and checklists.

Another important aspect of this perspective is the fact that it considers that the organizational engineering process initiates with the identification of IT innovations (considered the main drivers for potentiating enterprise

[15] If the process is executed more than once the effects of previous executions of the process are considered (in this sense there are feedback loops).

change), but as with the case of *LAP and CEO99-2005* the deployment of the produced enterprise architecture and developed enterprise systems is seen as the last step of the organizational engineering process.

A radically different process is followed by the ***Computational and Mathematical Organization Theory,*** whose protagonist is the CASOS research group (the process described in Figure 45).

Instead of aiming to promote alignment between the organization competences and the supporting systems, or serving as a starting point for the requirements definition to be used in the implementation/acquisition of information systems, this approach intent is to study the impact of deploying technological systems and new organization designs (structures of communication and reporting) on organizational behavior.

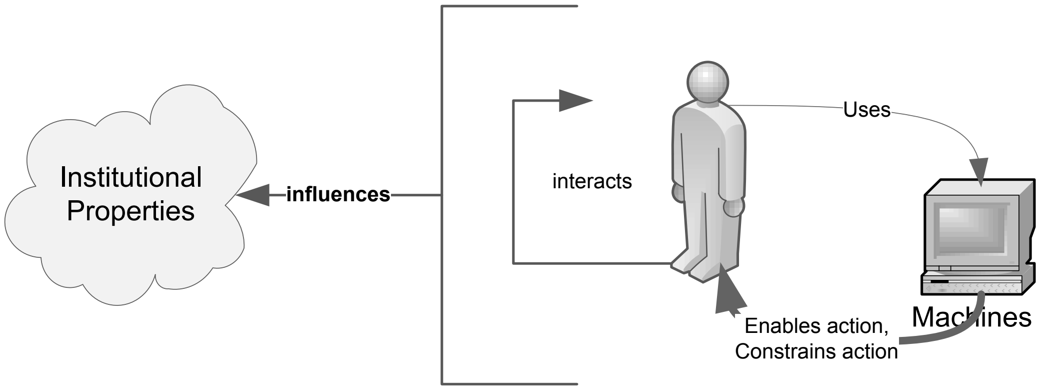


**Figure 44 Technology Influencing Institutional Properties**

Figure 44 illustrates the main links between enterprise elements that the CASOS approach tries to analyze. The link given higher relevance is the constraining/enabling effect of technological elements on human interaction (another link in the picture).

It is important to notice that for the previously described perspectives this type of analysis was only taken into account when establishing the ***to-be*** models of the organization (a onetime event and without formal tools of analysis). Here as long as the simulation process is running the technology is continuously constraining and enabling human behavior (in the simulation) which sometimes leads to the emergence of unexpected/unaccounted behaviors that the other approaches would miss.

The outcome is a set of hypotheses that can be used for analysis and as decision making aids.

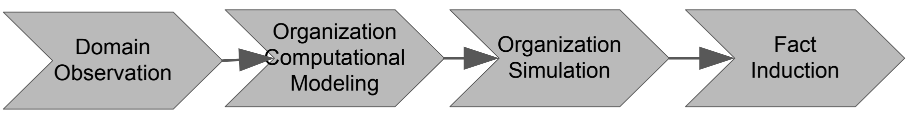


**Figure 45 CMOT approximated process**

### 9.4 The Results of the Processes and the Identified Tendencies and Problems

The discussion of the previous sections has denounced that the approaches differ in terms of concepts, models, processes and tools but they all discuss the alignment between the business processes (the work being done) and their supporting systems (the tools being used), and Table 7 which describes the theoretical results of applying the processes of the previous section is a further confirmation of this fact.

**Table 7 Outcomes of Practical Application**

| **Approach *(Perspective)*** | **Description of the result** |
|---|---|
| Enterprise Engineering *(BEEP)* | Process oriented enterprise and redefined, optimized and automated workflows (Process Teams and Reporting Structures)<br>Defined Information Infrastructure |
| Business Engineering *(BEEP)* | IT Based/Enabled Strategy<br>Organizations assume one particular industry role<br>Defined Enterprise Architecture<br>Process oriented enterprise and redefined, optimized and automated workflows |
| CEO99-2005 *(CEO)* | Defined Business, Information, Application & Technological Architectures<br>Process, Application and Information alignment enforcement |
| DEMO *(LAP)* | Defined Enterprise Information Dictionary<br>Redefined workflows according to the transaction pattern structure and divided in three different levels of abstraction (*essential, informational, documental)*<br>Clarification of formal Business Rules |
| CASOS *(CMOT)* | Elicitation of organization informal structures<br>Elicitation of hypothesis regarding communication and Information system deployment in particular enterprise environments<br>Elicitation of hypothesis regarding business process changes and organizational performance |

Except for *CMOT,* all the perspectives provide a basis for the development/selection of the information systems that will support the enterprise operations.

*Business Process* intervention takes the central role among the perspectives and process-machine synchronization is the pervasive concern, while less unanimous is the problematic of understanding how technology influences people and organizational properties (human-machine-organization synchronization) which appears to be the concern of only the *CMOT* and informally also of *Business Engineering*.

Taking all this into account we can identify the following facts:

(1) Business Process intervention is a general concern of OE;
(2) Information-Process-Machine interaction is also a pervasive concern in OE;
(3) These approaches regard people as users which systems have to support;
(4) Organizational Engineering is applied in enterprises following processes that have well defined beginnings and ends;
(5) The formal integration of engineering and social sciences is still very insipient (almost inexistent).

***(we argue that in the combination of these five tendencies lay the current most relevant problems of the organizational engineering approaches, but it is not at all obvious why)***

Notice that process interventions usually require that information systems be redesigned and changed. This implies deployment of new technological artifacts in organizations and the simple modification of organization business processes causes organizational change.

According to literature on organizational interventions [90; 91] change often fails, but we would hope that approaches of organizational engineering would tackle the problems of organizational change, and the truth is that to some extent they actually do. Change inhibitors like: (1) **wrong reengineering scope,** seem to be addressed by the different approaches through clear definition of enterprise models and misalignment analysis; (2) **lack of a proper reengineering methodology**, does not apply when we have a method for change; and (3) **lack of understanding of the change process both by managers and employees**, can be solved by the explanation of methods as the ones described here.

It would seem that these approaches have their angles covered when considering the particular purposes for which they were delineated, but the fact is that they are forgetting some pieces of the puzzle, namely answers for the questions: (1) Is change a onetime event or a continuous process of adaptation? And (2) Why is soft-hard integration an important issue?

To answer these questions we have to highlight that the current perspectives of organizational engineering are ignoring the ongoing developments of some social theories grounded on Giddens's ***Theory of Structuration*** such as the ***Structuration Model of Technology*** [92] which describes the relations of people, technology and institutions as continuous mutual influential loops that originate emergent unexpected behaviors and can only be understood through continuous appreciation and analysis.

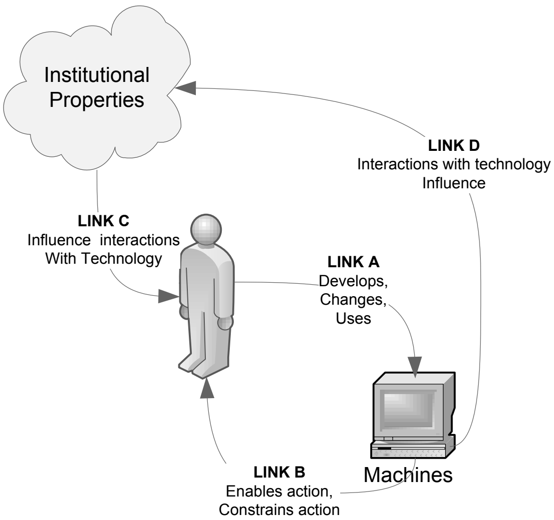


**Figure 46 Technology People Institution Loop [92]**

Figure 46 illustrates this recursion which is explained by Wanda Orlikowski as (**Link A**) technology is the outcome of human actions such as design, development, appropriation and modification; (**Link B**) technology enables and constrains human action; (**Link C**) institutional properties (i.e. design standards, professional rules and norms, state of the art in materials and knowledge, etc.) influence humans in their interactions with technological elements (***link C***); and (**Link D**) these same interactions influence the institutional properties of an organization through reinforcing or transforming the structures of **signification** (production of meaning), **domination** (production and exercise of power) and **legitimation** (production of moral order).

In other words, in organizations people are no longer mere users of systems (tendency 3) they are an integral part of the system. The system IS really the enterprise as Zachman phrased in one of his papers, but not only because enterprises cannot function without systems, but because they are continuously shaped by systems, and shaping the people who use them whom in turn will also shape the systems themselves.

So to be able to (1) prepare employees for these processes of continuous evolution (change and adaptation) and (2) to achieve even better outcomes than the current approaches of organizational engineering are able to conquer, we will try to refine the definition of the a new discipline called ***Organizational Design and Engineering*** whose goal is precisely to overcome the problematic tendencies that the perspectives of ***Organization Engineering*** are following.

### 10 The Process and Scope Organizational Design and Engineering[16]

As was referred to in the introductory chapter, ***Organizational Design and Engineering*** (ODE) takes a central position on the ontological axis. This happens not because ODE is superior to the approaches that have been presented so far, but because it is more embracing and tries to involve every Organizational Engineering contribution in a global scheme so that of all the approaches can contribute to its objectives together as a whole. In other words, ODE is about orchestrating the most efficient and up-to-date knowledge on organizational engineering in a way that each approach will benefit from the others.

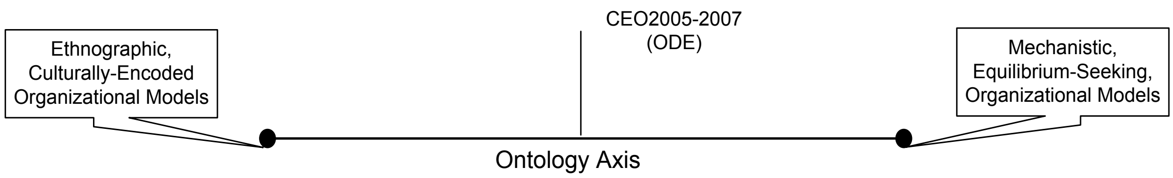


**Figure 47 Organizational Design and Engineering in the Ontological Axis**

We will explain the role of *Organizational Design and Engineering* in the life cycle of enterprises by (1) explaining its purpose and ideal objectives; (2) defining its ontological position; (3) defining a possible process of ODE and explaining its phases; and (4) by highlighting where do the previously studied approaches and other knowledge may fit into this process.

#### 10.1 The Purpose of Organizational Design and Engineering

The ultimate objective of *Organizational Design and Engineering* is to develop the body of knowledge needed to model the organization in such a way that will allow understanding the organization and its behaviors as well as to predict and control the outcomes of the different organizational design and operation activities with a known degree of certainty (or uncertainty).

[16] This section uses the terminology of the CEO2005-2007 approach in the discussion.

Achieving this far-reaching goal will have numerous consequences namely: (1) the ability to predict some of the potential tensions among organization stakeholders; (2) the ability to understand employees' motivations and interests and establish ways to align them with the organization purpose and strategy; (3) the ability to design, develop and deploy technological systems suited for supporting the organization activities while minimizing the risk of disrupting enterprise healthy operations; (4) the ability to better understand organization institutional properties (formal and informal culture, technological culture, environment restrictions, etc.) and to design plans to act upon them whenever a change is needed/imposed…

In other words, fulfilling the purpose of *Organizational Design and Engineering* will reflect in the ability of **real time business driving.** This will allow optimizing the organization around various properties in order to prepare it for present and future moments of change through constantly analyzing, designing, operating and changing (only when needed) the enterprise processes and systems in a predictable and manageable way.

### 10.2 The Ontological Positioning

In the **section 9.2** we have exposed different definitions to the essence of what an enterprise/organization is. We have seen that some Organizational Engineering authors choose more focalized views while others approach it in broader terms. But because we want to be able to embrace all the contributions, it is mandatory that our ontological positioning be wide and embracing.

We have chosen to describe enterprises as complex adaptive systems whose components are networks of people, processes, machines and other organizations. This has numerous implications: (1) The first implication of is that we assume that it is possible to apply principles of decomposition to the organization (system classification); (2) The second implication is that we assume that these systems change and self manage (the adaptive classification); and (3) Other implications come from classifying enterprises as social and complex: this means that enterprises will have particular system properties namely: (1) ***System Properties*** such as *scalability*, *flexibility*, *stability*, *accuracy*, *robustness*, among others, which may be selectively targeted and most of the time imply the favoring of certain aspects over others (tradeoffs); and (2) ***Emergent Values*** or ***Soft Properties*** that are related to categories of social systems and result from the human dimension inherent in any enterprise. We are talking about properties such as *trust*, *motivation, loyalty, dedication,* and others.

The last matter of relevance about our positioning, and that cannot be directly inferred by our ontological position is that we assume that it is possible to apply the rigor of engineering sciences to approach organizational problems such as design and change.

### 10.3 The Process of Organizational Design and Engineering

Following from the analysis of **section 9** and the goals defined for ODE in **section 10.1** we have focused on defining an application method that is able to accommodate the specific contributions from each Organizational Engineering approach and to increase the formality and explicitness of the engineering and social sciences integration. Inspired in the field of systems engineering [4; 93; 94], control theory for self managing systems [95] and double loop learning methodologies [96], we have established a circular meta-process of Organizational Design and Engineering to which we called ***ODE Loop*** and have depicted in Figure 48.

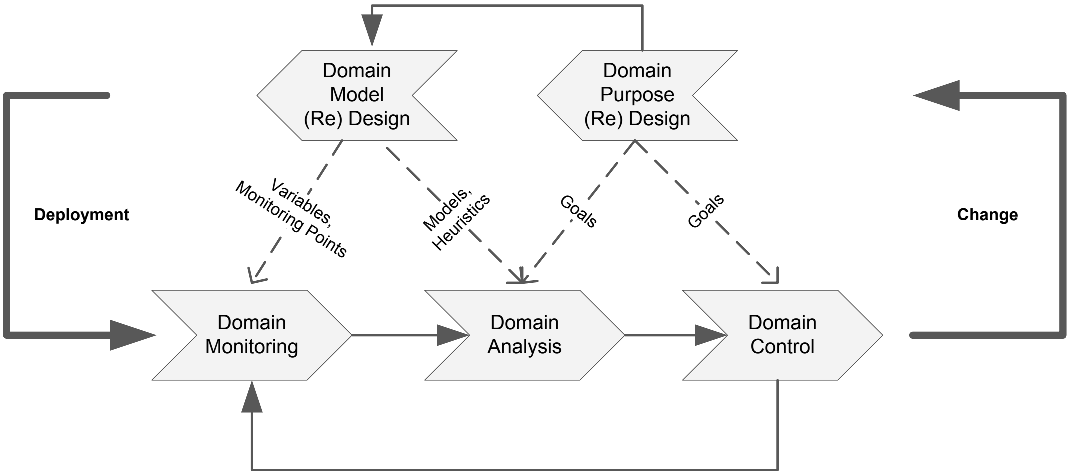


**Figure 48 ODE's Double Loop Meta-Process**

The five step process contemplates sub-processes related to system design and effective doing. On the action side, we have sub-processes of effective action, monitoring and analysis, while on the design side we have contemplated sub-process of domain purpose definition and design. We call **first loop** to the set of processes related to effective doing and **second loop** to the processes related to design activities.

The core concept of the **first loop** is that it continuously monitors its own action and takes additional actions based on its monitoring. This simple process is the same that people use in all their daily tasks like for example driving a car, riding a motorcycle, writing a text, or the same processes that are used in electronic devices like air conditioning thermostats, etc. The basic needs of this loop are ways for conducting the monitoring activities, physical components to take effective actions and ways of remembering the results that are desired. In terms of control theory nomenclature: (1) sensors, (2) actuators, and (3) memory. This loop is about ***doing things right*** which can only works as time passes and the system acts and responds to changes coming from its past actions and/or random disturbances that might occur.

The core of the **second loop** is that it establishes the structures that are used as inputs for the sub-processes of the **first loop**. This loop is about defining the frameworks of monitoring, analysis and even action. The needs of this loop are not easily explainable, but they include organizational representational schemes (both regarding soft and hard system properties) as well as a clear definition of purpose and objectives. This loop is about **doing the right things** based on specific medium/long term objectives.

This way of defining the process of ODE is very particular when compared with the processes that we have described so far and with others from traditional engineering disciplines such as mechanical engineering, civil engineering, etc. In this case, the success is measured in terms of the good health of the enterprise system and rather than one engineer executing the process we have to ensure that every employee is doing it (from field workers to top managers).

Notice that each of the sub-processes in Figure 48 refers to **Domain** instead of **Enterprise/Organization** this is so because we want to explicit highlight the fact that from the *Organizational* to the *Individual level*s there are different meanings associated with the activities of the process, and that all have to be orchestrated in order to achieve Organization Design and Engineering's success.

Organizations have defined purposes and follow specific strategies implemented by what they are able to do (their processes). Organizations have employees who are managers and who are not solely responsible for their actions but also for the actions of others (their subordinates). Every employee plays specific roles in the organization and has to achieve certain goals that are expected to contribute to the organization overall objectives. This top down description also applies to ODE's loop which concerns all levels of the organization from the whole to all of its parts. What we are stating is that every individual in the organization is responsible for managing at least one ODE Loop and some individuals have to implement more than one: team leaders in a consulting firm, for example, have to perform their jobs relating their specific trade (consultancy) but are also responsible for performing activities of team management (controlling the work of others). In the first case, they are dealing with their own personal ODE loop while in the latter case they have to deal with the loop of the group they are managing. As a rule of thumb, as the employees authority (the number of people for which he/she is responsible for) in the enterprise increases so does the complexity and possibly the number of ODE loops in which he/she is engaged.

Paying attention to what it is happening in organizations leads us to conclude that this loop is already running. Whether this is acknowledged and well dealt with, that is another problem: the problem of ***Organizational Design and Engineering***.

Summarizing this discussion, the role of ODE is to explicate the loop by enforcing some standard sub-processes in this macro-process and tooling the enterprise with the right mechanisms to better accomplish each of the above described phases. The next sections will explain how we suggest this be done.

### 10.4 Detailing the Design and Engineering Loop

When studying the loop steps in detail it is important not to lose the perspective that we are always describing a circular process. This means that we assume that there are outcomes coming from the other steps of the process that are already there for input. This simplification will be dealt further in this document when we try to explain how to bootstrap the deployment of the organizational design and engineering process in organizations.

#### 10.4.1 ODE Process: The 2$^{nd}$ Loop

**Domain Purpose Design**

`Domain Purpose Design` is about deciding what to do and translating the organization strategy into organization goals and critical success factors.

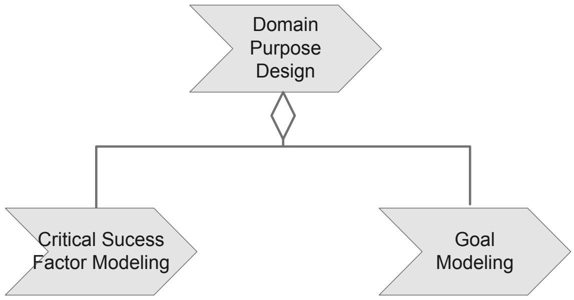


**Figure 49 Domain Purpose Design Process**

`Domain Purpose Design` has always to the conducted considering the whole organization, otherwise conflicts and incompatibilities might be introduced: A bank whose purpose is to provide its clients with investment solutions might define the goal of increasing its revenue by 10%. To achieve this it can increase the prices in price inelastic products, decrease the prices in price elastic products (to increase quantity sold), offer new products to attract new clients, or maybe a mix of the previous solutions or even others. If for some reason the bank does not want to decrease its prices in any product whatsoever (to keep its margin), that has to become obvious in the overall goal definition of the bank, otherwise its product managers might consider reasonable to lower prices in order to attract more clients to increase revenue (probably degrading the banks margin).

Outside the global organizational scope, `Domain Purpose Design` translates into providing specific views over the overall enterprise goal definition. This allows for each employee to understand the target of his/her own job in a way that will contribute to achieve the overall organizational wants.

In terms of strategy modeling Organizational Design and Engineering can rely on the early work of CEO99-2005 [62] as well as the method for strategy representation from the St. Gallen Group [13] and other works like the LEARN method from Jorge Coelho [97; 98].

## Domain Model Design

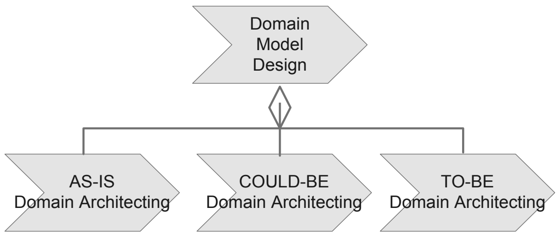


**Figure 50 Domain Model Design Process**

Domain Model Design concerns the architecting of the business universe, this is, building "*that set of* design *artifacts, or descriptive representations, that are relevant for describing an object* [organization] *such that it can be produced to requirements as well as maintained over the period of its useful life"* [99], and this is the process step where the core of Organizational Engineering approaches have been focused.

**Enterprise Architectures** are the tool of reference for Enterprise Modeling and Design. As a whole, they have been the object of study of the CEO99-2005 approach [76], of St. Gallen's Business Engineering approach [31] and of multiple other authors [99; 4; 100]. Partially, they have been studied by other authors such as those from the *Language Action Perspective* which are mainly concerned with matters of communication, information and work assignment [89; 101; 39].

In terms of granularity, **Enterprise Architectures** have always to be built at the level of the whole organization, otherwise redundancies and discontinuities might be introduced [99]. At lower levels than that of the enterprise, the second loop is concerned with the **minimum cockpit of operability** needed by each of the organization agents (groups and people), this is, a set of meaningful views collected from the whole Enterprise Architecture representation.

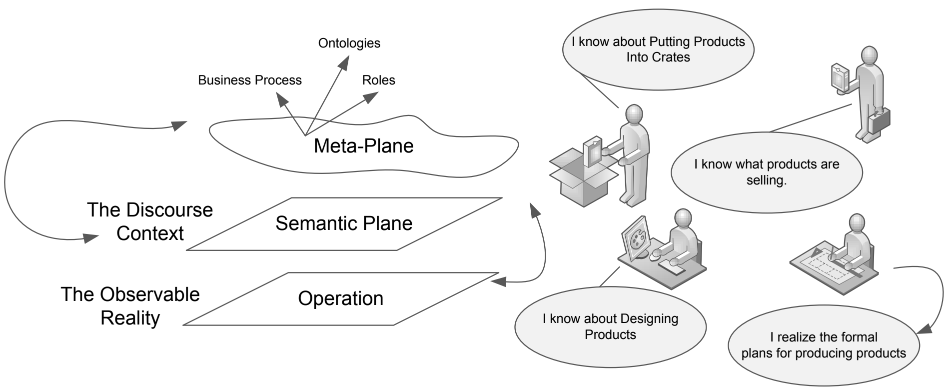


**Figure 51 the multiple semantic planes**

Figure 51 illustrates a set of employees of one organization each of them concerned with the particularities of their own jobs. Enterprise Architectures guarantee the fit among the different activities (i.e. they assure that the employee packaging products have big enough boxes to fit the designed products which in turn are buildable from the product engineer point of view and marketable from the marketer perspective), while views on the Enterprise Architecture allow for the employees to understand their job and the frontier that connects it to others.

### 10.4.2 ODE Process: First Loop

**<u>Domain Analysis</u>**

`Domain Analysis` is about tooling the organizational agents for evaluating the result of the action outcomes against the reference standard that was defined by the `Domain Model and Design` sub-processes. This intends to provide the means for determining the possible alternative courses of action that will allow keeping the organization needs aligned with the employee's performance. Although it is possible to jump to the **second loop** at any step of ODE's **first loop**, it is in this sub-process that this happens most often, especially when there are no possible courses of action respecting the current standards that can suit the desired path for achieving the enterprise targets. In these cases, changes in the design or even purpose may occur.

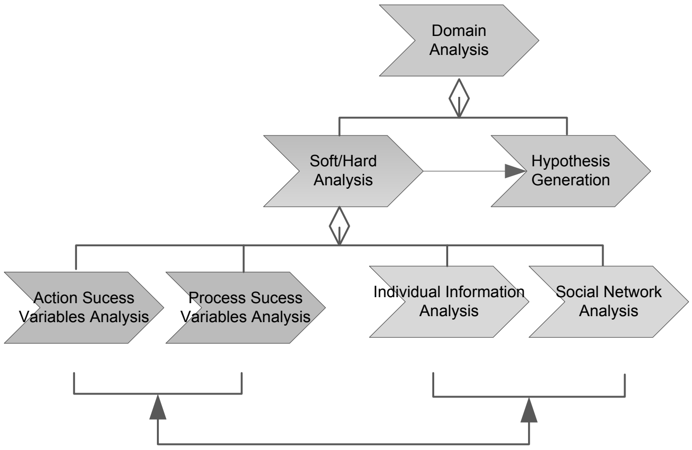


**Figure 52 Domain Analysis Process**

As was noted in **section 9.4** one of the main shortcomings of the current Organizational Engineering approaches is the lack of attention given to the feedbacks that the technological elements of the enterprise cause in terms of shaping individual's behavior and institutional properties (see Figure 53).

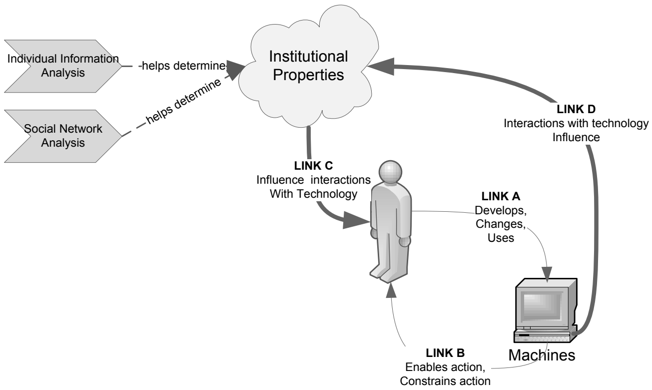


**Figure 53 Hard/Soft Analysis and the Structuration Model of Technology**

But as social sciences are increasingly about collecting, organizing and transforming information, and technological and scientific developments are enabling the representation of large portions of reality in terms of information [12], it is becoming possible to explicate some organizational soft phenomena in graphical languages and representations (associated with engineering disciplines) that can and should be used to diagnose and predict problems at the level of the emergent properties (soft) of the enterprise system .

The `Soft/Hard Analysis` sub-process is especially concerned with this fact by taking into account Hard and Soft organizational factors and explicitly considering them in the hypotheses that are generated.

`Soft/Hard Analysis` studies the outcome of action in terms both hard and soft monitoring variables. For the first case, the core tool of analysis are the *Business Process, Activities* and *Task* models, which come from the Enterprise Architecture representations and serve as the main action guide for employees at all organizational levels. The latter case is achieved by the use of a mix of tools of Social Network Analysis & Visualization and Individual Psychology that try to determine the informal network structures through which work gets done outside the formal organizational design and that may compete with the formal enterprise structure and undermine its operational excellence [102].

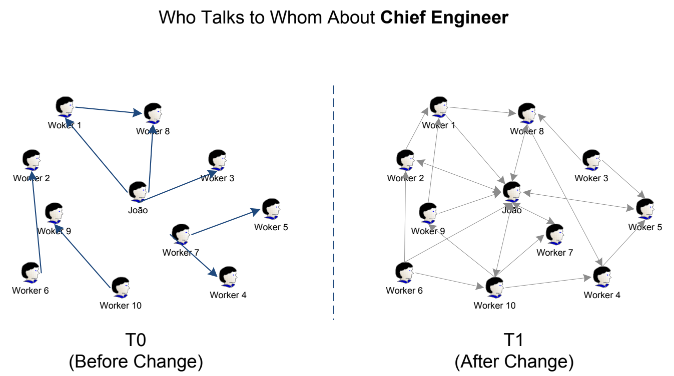


**Figure 54 social network example**

Consider an example in a paper factory where the Chief Engineer responsible for scheduling eleven other engineers and deciding their work teams, etc., has been replaced by a newcomer. Figure 54 illustrates a possible social network analysis for the question "***who talks to whom about topic x"*** where the topic in question is in this case Chief Engineer.

As can be seen in the picture, when the factory was operating with the previous chief engineer (T0), there was no real fuss about this question, people were used to him and complained/commented to each other but it is not really possible to identify any pattern. After the change however (T1), we can clearly see that João centralizes most of the talks. This might mean a number of different things namely that João is probably the opinion maker of this group (the informal leader).

Being able to mix this information with the general knowledge of how João feels about the new chief engineer and other variables like his usual level of commitment to his job, his trust on the current management, etc, might lead us to infer with some degree of confidence what might his behaviors be and then take the appropriate response (for further examples, **Appendix B** illustrates a real social network case example that was dealt with by social network researchers as well as the solutions that were delineated).

The example above describes a Social Network Analysis that is most suitable for manager levels of the enterprise, however other examples exist that can be used by every employee. As an example, knowing **who knows what**, and **who has what skills** as well as **who is willing to share information in usable way** can be invaluable tools when approaching a problem that might have already been solve by another organizational member.

**Individual Information** and **Social Network Analysis**[17] help determine the organization invisible institutional properties (remember Figure 53 page 62) such as friends network, enemies network, people who carry opinion maker roles within organization informal groups, etc. Research has also shown that these informal settings can be changed by effective action [102] namely: (1) information systems deployment, (2) office space

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[17] **Appendix B** describes some possibilities of social network analysis along with the rationale and questions that they try to give answers for.

configuration, (3) nature of tasks, (4) formal reporting structures, (…) among others. The problem is that there is currently no mixed use of Enterprise Architectures (the core tool for enterprise design) and Social Network Analyzers (the current core engineering tool for informal analysis/inference), and this can only be done through time with large databases of past cases and analysis.

Like the doctor who can only diagnose a certain disease because he knows patterns of symptoms that occur, Social Network Analysis allows uncovering some patterns, but prescribing the cure involves knowing the effects of the medicine and there is currently no research that precisely tells "if you introduce this system here, then the informal structure shifts to that".

Only through the continuous monitoring of changes in the formal structural properties accompanied by the respective monitoring of the informal network structures might we improve the accuracy with which informal aspects of the organization are dealt and changed (see Figure 53 page 62).

For analysis of hard variables there is currently research going on in **action contexts** [88; 82] as well as **Enterprise Architectures** [31; 64; 76], **Alignment Heuristics** and CEO's **Real Time Auditing** [67; 68] while regarding social network analysis ***Computational and Mathematical Organization Theory*** researchers are the core developers [48; 102] as has been shown in previous sections.

**Domain Monitoring**

The set of monitoring sub-processes of the Organizational Design and Engineering discipline are crucial because they provide the senses that allow employees (whatever their authorities and responsibilities may be) to assert whether or not their behavior is producing the outcomes they are hoping to achieve and whether these outcomes are aligned with what the organization wants.

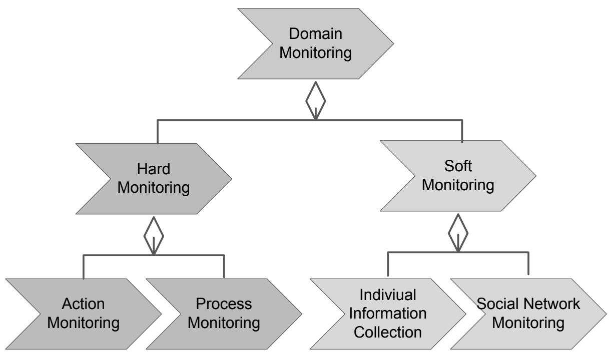


**Figure 55 Monitoring Related Processes**

In terms of design, monitoring involves choosing the set of meaningful variables for each particular stakeholder in the organization (please remember Figure 51 page 61) as well as the set of properties/attributes which those variables will be composed of and that will determine the respective monitoring points. Designing the monitoring architecture is done at the level of the Enterprise Architecture definition.

In terms of effective runtime monitoring, ***Organizational Design and Engineering*** is interested in capturing values for variables of both **Hard** and **Soft** organizational factors for the analysis that were described in the **Domain Analysis** processes of the **first loop**.

For **Hard** variable capture, there are numerous research and applications namely the work on *Business Process Management* [103] by IDS Scheer and the LEARN Method by Jorge Coelho and more recently the work on Action and Interaction Contexts of the CEO2005-2007 [82; 81; 88].

For **Soft** variables there are yet very few applications in the business world [102]. A possible path that we suggest is capturing individual and network analysis elements as was described in the **Domain Analysis** process. Variables such as the **level of employee's commitment** to the enterprise, their **levels of trust** on their peers, their **level of work satisfaction**, etc. can be elicited through **surveys** respecting standard scales of analysis that should be defined by psychologists and experts on organizational behavior disciplines. Variables for Social Network Construction, on the other hand, can also be drawn through **surveys**[18] but there are already automated engineering tools for the elicitation of these networks based on e-mail text mining, patterns of computer network traffic, etc. An excellent example of this automated social network capture is the combination of Automap [50] with ORA [49] which is research conducted by Kathleen Carley's CASOS group.

**<u>Domain Control</u>**

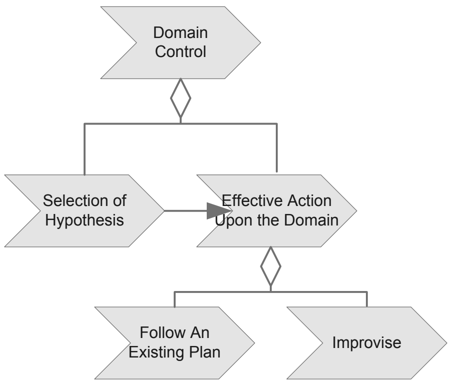


**Figure 56 Domain Control Process**

`Domain Control` is about enabling the organizational actors to change the variables of the real world in the best possible way to server their own goals. In practical terms, enterprises execute *Business Processes,* groups execute *Activities*, and individuals execute *Tasks* and these performances require specific actions taken by specific people at specific times respecting specific contexts.

The danger with organizational action is that it tends to get stored in people's procedural memory: as *Tasks* become more practiced and familiar they become easier to perform but harder to verbalize or explain [104]. People tend to forget what they are doing and simply just do it. To avoid this, ODE is concerned with enabling people, groups and organizations to think through their actions, thus giving them the opportunity to decide whether or not to modify their behavior in subsequent performances. `Domain Control` is executing the `Domain Monitoring` and `Domain Analysis` sub-processes and then providing the organizational actor with the right amount of information for it to decide which actions are need to be put in practice.

[18] Check **Appendix B** for examples social network types and questions related to their elicitation, as well as the result of applying such techniques in a consulting firm.

### 10.5 Bootstrapping the ODE Process

The previous sections have gone through each of the steps of the loop process describing what we consider are the main activities of ***Organizational Design and Engineering*** and highlighted the specific research that is addressing each of the particular activities. This has positioned most of the contributions of the different perspective of *Organizational Engineering* in their due place in ODE.

The problems not solved by the previous discussion are the related with the circular nature of the process that we have defined. In order to address this and explain how this loop can really be implemented we need to describe its ignition considering at least two different situations: (1) a new born organization (where the process is not running yet) and (2) an existing organizations where process is already running (but implicitly).

**<u>Case 1: The New Born Enterprise Case</u>**

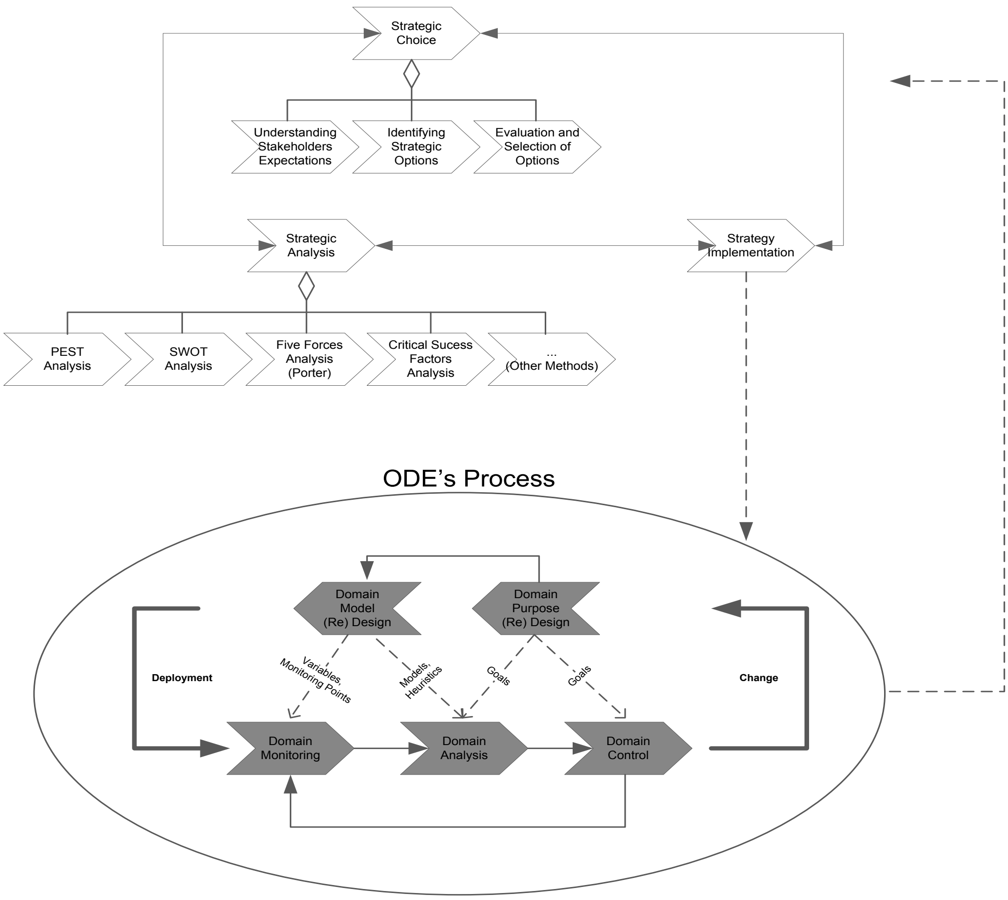


**Figure 57 Defining the Scope of ODE**

The case of the new enterprise is the ideal starting point for the Organizational Design and Engineering loop. In this case we are assuming that the organization does not have any existing informal structures defined, it is a completely new built from scratch organization (not a spinoff of a bigger company).

For this case, we will recall the process of organization emergence described by Mintzberg: *An organization begins with a person who has an idea for a business and who then collects and orchestrates the set of resources needed to put it in practice* [1].

The **idea** is the purpose of the enterprise, the product or task that this future organization will exist to produce. The **idea** in Mintzberg's process is also the **strategy**, the target that the enterprise is aiming for in the long run. The **collection** and **orchestration** of resources is the full operation of the ODE's loop.

Collection and orchestration of resources are also of strategic nature. According to Michael Porter strategy is (1) creating a unique valuable position (choose activities which differentiate the company from its competitors) (2) making tradeoffs in competing (choosing what not to do) and (3) creating fit among the company activities (doing many things well) [105]. So the collection and orchestration of resources are about the fit of company activities, are about **doing the right things** to accomplish the unique valuable position and **doing them right**.

The previous paragraphs have shown that according to Mintzberg's process, bootstrapping the loop involves receiving inputs from a stage of strategy definition. Acknowledging this fact we have studied the loop that we have defined and introduced an additional loop to create what we call the ODE's triple loop and which only applies to the organizational level of granularity (see Figure 57 page 66).

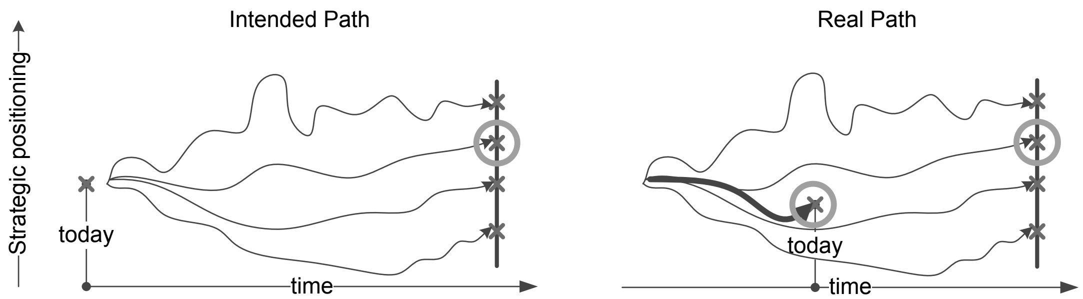


**Figure 58 Defining the Static Future Positioning**

The third loop attacks the problem of Figure 58. It starts by defining an intended future strategic positioning but it does not do so lightly! It uses simulation tools from the field of ODE to simulate multiple scenarios such as the one illustrated in the right side of the picture: we want to get to point x but what if something happens and we deviate from the path? What will happen then? Are we prepared for those events or should we take a less ambitious but safer path?

These types of simulations could follow the loop of Figure 57 (page 66) and this would establish a recursive and intelligible process that is reused in numerous ways along the Organizational and Design Engineering roads.

Defining the strategy is not directly the concern of ODE although as we have seen ODE also contributes to it. Accomplishing it however, is absolutely ODE's responsibility.

Having selected the strategy, the bootstrap process of the ODE Loop begins **top down**. The Business Goals and Critical Success Factors are used to start designing the TO-BE ***Enterprise Architecture***. In this case, it is not possible to define/capture the social architecture (the way people will group in informal structures) because it still isn't there! But as the strategy planning phase took into account many types of simulation models, for a set of different contingencies, we hope to have understood to some degree of confidence the possible set ups of social networks that might be formed. Nonetheless, this will be continuously analyzed and monitored in the ODE

Loop so eventually we will be able to diagnose the diseases and prescribe "medicines" to the seek parts of the system if they emerge. After their definition the ***Enterprise Architecture*** models are deployed and the enterprise begins its operation that will now fully work against the loop that we have defined.

**Case 2: The Existing Organization Case**

The case of the already running organization is usually much more complex problem. Occasionally, in small very well organized enterprises it can be easier, but this only happens when the elicitation of the AS-IS **Enterprise Architecture** coincides with the TO-BE Enterprise models.

When the enterprise already exists and is in operation, we define the bootstrapping the ODE's loop in terms of a middle out approach. The focus is on the elicitation of the running business processes and the remaining architectures that compose the overall enterprise architecture. Existing organizations have defined strategies and business processes executing which are the only elements capable of supporting the organizational goals. They are the quality patterns which allow the measurement of the response quality of the enterprise to the set of stimuli coming from the environment [2].

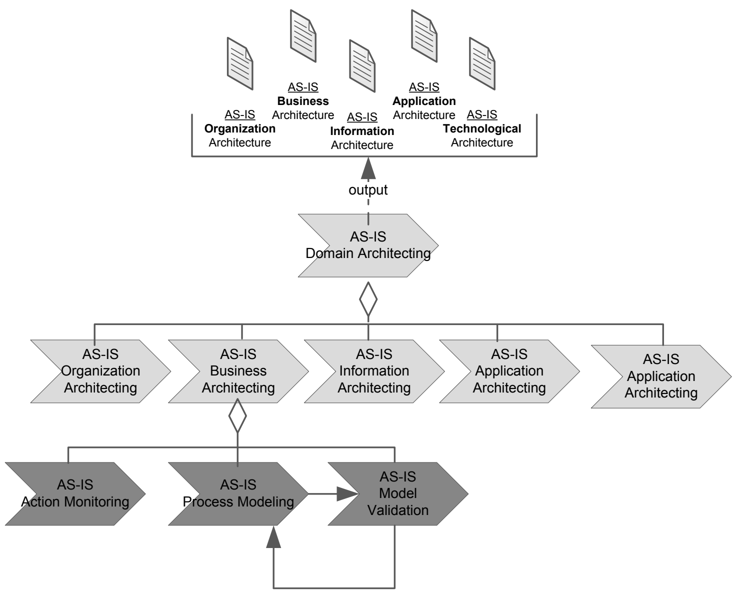


**Figure 59 Elicitation of the AS-IS Enterprise Architecture**

Figure 59 illustrates the elicitation process for the AS-IS architecture model using the nomenclature of the CEO99-2005. Great emphasis is given to the action monitoring and capture of personal action contexts [81] as described in **section 7.1.** The as-is models are always constructed in strict collaborations with the enterprise employees because they are the ones who better than anyone else know what is actually being done.

If no misalignments are found in the elicited Enterprise Architecture, then we are in the optimum case. The remaining parts of the bootstrapping process are only concerned with furnishing the enterprise with the right monitoring tools to allow it keep the good track in a more accountable way.

On the other hand if there are misalignments, the work environment will have to be changed. This can mean the need to redesign business processes, information architecture, application architecture the technological architecture and in some cases the strategy of the organization might be also changing[19]. When this is the case, the process of initiating the loop is much more complex because it has to take into account the feedback loops that will occur: changes in the design will influence the informal structures in ways that might be unexpected and unwanted and might even fail if not sufficiently prepared.

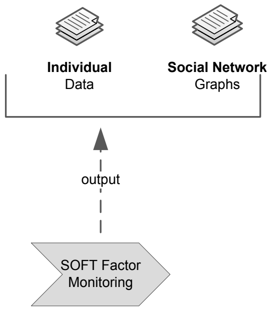


**Figure 60 Accounting for soft factors with a Hard perspective**

In this case, the next step is to elicit the social network information that might be considered relevant (see **Appendix B** for more information on social network analysis). Once some of the relevant informal structures of the enterprise have also been elicited and visualized with the proper tools, it is time to start designing and simulating the various alternatives of possible future designs. This is described in Figure 61 below.

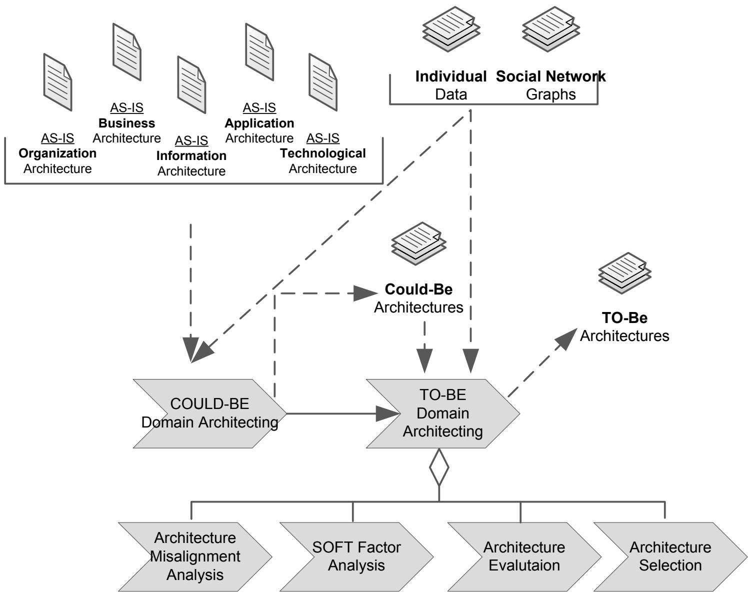


**Figure 61 TO-BE Architecture Design**

Following the definition of the TO-BE architecture follows the deployment of the models (business process reformulation) and possible of the technological and software systems that were deemed necessary to the operational excellence of the enterprise. The monitoring capabilities are in principle already deployed as they were used in the elicitation of both the AS-IS architecture and of the informal enterprise structures.

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[19] Note that when describing this process we are considering that the enterprise architecture models being used are the ones defined by the CEO99-2005 approach.

The deployment of the TO-BE architecture is of sensitive matter and should be accompanied but thorough and continuous analysis of the mutations of the organizational social networks. This is a fundamental step to understand the **link D** of Figure 46 (page 55) and to avoid possible resistance. The continuous action monitoring is also essential to guarantee that the employees are actually following the business processes as they were defined and in case this is not so, the earlier the deviations are identified and explained, the healthier the processes will remain. After this complex procedure, the ODE's loop should be up and running at all organizational level and being executed by every one of the organization employees.

## 11 Bridging the CEO2005-2007 and the ODE Loop

The connection of the ODE Loop with CEO2005-2007's research model (**Section 8**) is straightforward but still needs explanation regarding two different topics if it is to be completely understood: (1) the mapping of the Loop in terms of the agent architecture of **Section 8**; and (2) the definition action contexts that denounce the existence of the ODE Loop and that can be elicited through the mechanisms of **Section 7**.

### 11.1 Connecting With the Agent Architecture

Figure 62 (page 71) recapitulates CEO2005-2007's ***Agent Architecture Model*** (on the left) and instantiates the ***ODE Loop*** for a running organization (on the right). The agent architecture argues the need for a differentiated enterprise representational scheme at every complexity level of the organization (left side), and the ODE Loop starts proposing how this scheme might be achieved and implemented (the right side).

**Table 8 Models for Agent Understanding**

| Granularity Level | Representational Models | Technology Support |
|---|---|---|
| **Organization** | Enterprise Architecture + Inter Business Units Social Networks + Strategic Scenarios and Strategic Choices | Diagramming Tools + Work Flow Systems + Strategic Simulation Tools |
| **Group** | Enterprise Architecture Views + Intra Business Unit Social Networks + Individual Data | Diagramming & Visualization Tools + Group Network Simulations + Expertise Locators and Portals + Role Base Content Systems + Group Communication Tools |
| **Individual** | Enterprise Architecture Views (namely Role Models) + Intra Business Unit Social Networks + Individual Social Data + Action Context Models | Diagram Visualization Tools + Work Management Systems (Action Plans/Schedules) + Communication Tools + Multitasking Tool Support |

In practical terms, the ODE Loop is the projection of the **processes** that occur at each of the different architectural layers of the Agent's Architecture, at every particular granularity level.

The effective execution of tasks, activities and processes, which regarding the ODE Loop allow enterprise actors to control the environment, are in terms of the ***Agent Architecture Model*** processes of the ***Action Layer***. On the other hand, the analysis of the Task/Activity/Process data is mainly a projection of processes that occur at the ***Decision Layer***, while the Re-Design of the Enterprise Architecture/Work Teams & Choice of Architectural Views/Roles is mainly the concern of the ***Change/Learn Layer***.

The table above systematizes Figure 62 below and additionally contains a column where we suggest some technological tools that can be used to effectively support the ODE Loop process and that respect the division of complexity defined in the ***Agent Architecture Model***.

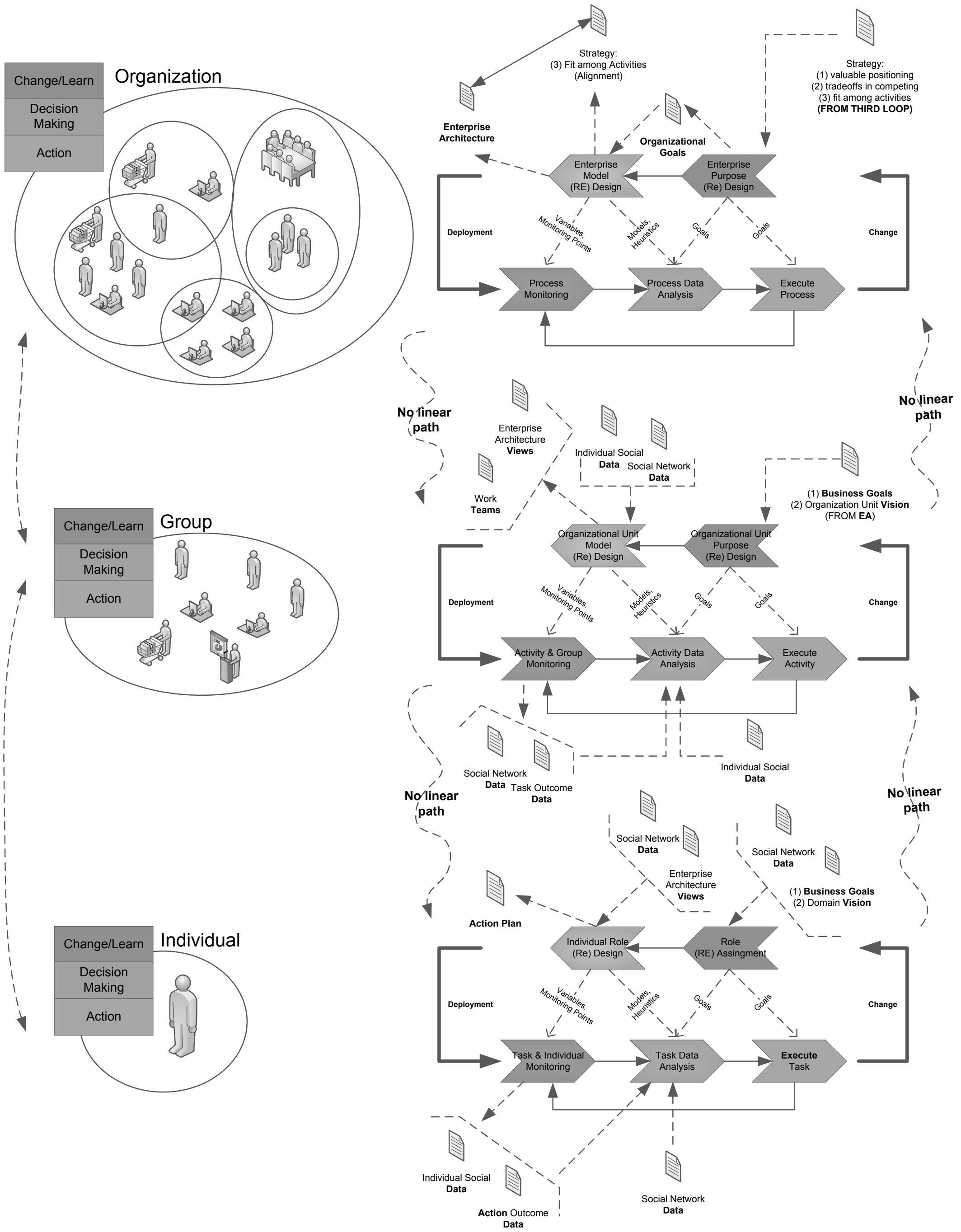


**Figure 62 the running organization**

The ODE Loop is also in concert with the differences of complexity and time scales that occur from granularity level to granularity level.

The **first loop** is related to real-time execution, the **second loop** with tactical (mid range) time execution and the **third loop** concerns strategic time, which unlike the others, only makes sense at the organizational granularity level (see Figure 63 below).

As in the Agent Architecture, the granularity level being considered influences the time-spans that are consider real, tactic or strategic: in a bank institution, for example, the time span for one execution of an instance of a `Loan Granting` business process is measured in terms of weeks. For the same business process, the Activities that constitute it might have time spans in the order of days, and at the level of the bank clerk the tasks that are executed regarding this process have outcomes within minutes or even seconds.

Although the Process/Activity/Task executions all happen at the **first loop** level of ODE (real time spans), they enjoy different time-scales associated with the level of granularity at which they are considered. So real time in terms of individual is different from real time at group level and the same is true for the organizational level.

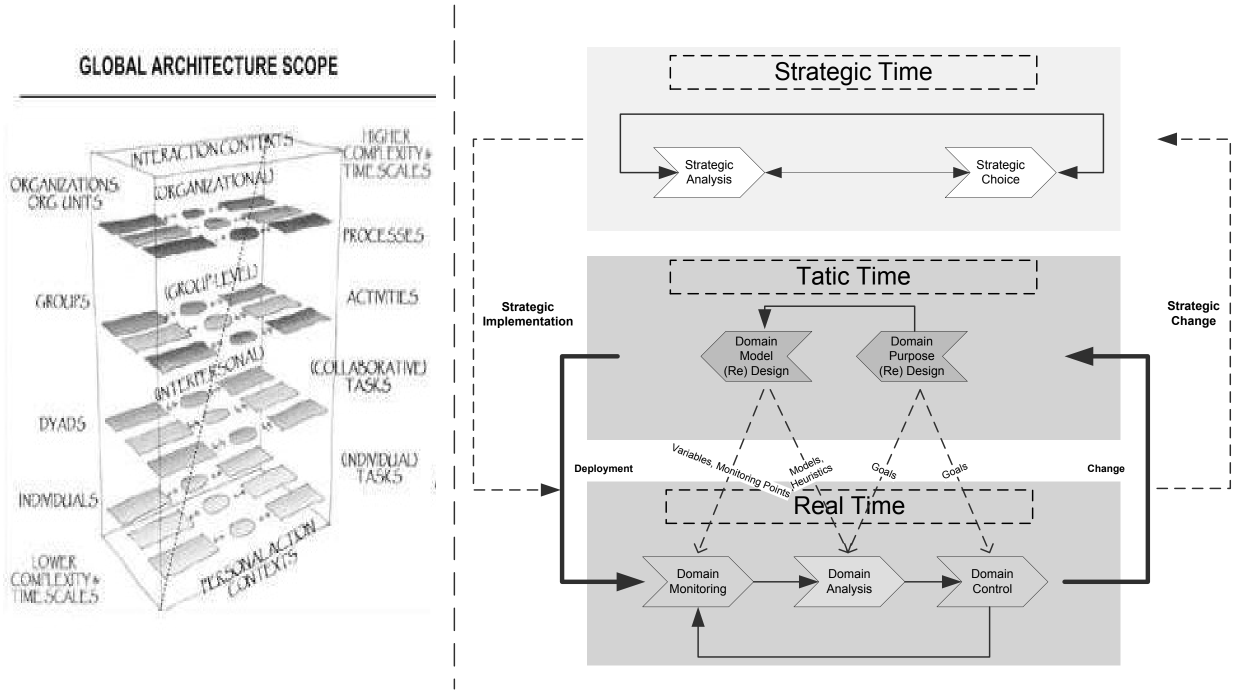


**Figure 63 Evolution of Time Spans and Complexity**

The left side of Figure 63 illustrates the complexity matrix of Figure 38 (in page 44) and its right side depicts the different stages of the ODE Loop.

Notice that the picture simplified the third Level of the ODE Loop. The `Strategy Implementation` sub-process was replaced by its true essence: the execution of the **first** and **second** stages of the ODE Loop.

The picture above also highlights that at all levels of granularity agents are regulated by at least two different time scales: (1) the real-time which concern their daily execution of actions; and (2) the tactic time which respects their activities at the ***Change/Learn & Decision*** Layers.

At the level of the organization there is an additional time scale: the strategic time, which of course influences all the remaining organizational time scales.

## 11.2 Connecting the ODE Loop with the Action Context primitive

To finalize the connection between the architecture and the ODE loop, the only detail left mentioning is the fact that the loop will itself represent one or a set of action contexts as defined in **Section 7.**

Recalling what was mentioned in that section, **contexts** are clusters of actions, resources and people which are identified through clustering techniques (automated or manual).

What this means is that in a particular enterprise, it is possible to know that an employee is executing the **management report context**, because his/her actions are mainly described by verbs like ***analyze***, ***print, elaborate*** which predominantly refer to information items such as ***status reports***, ***project budgets*** and ***project plans***, and the involved actors are (1) someone who makes the reports and (2) someone else who analyzes them. Another example would be an employee engaged in a **team meeting context,** which can be identified because his/her predominant observed actions are of the types ***propose***, ***accept/reject***, ***assist*** and the set of involved actors in those actions is more or less coincident with the all the team members.

Thus it is possible to establish the analogy with what will happen in the case of the ODE Loop: (1) the ODE Loop will implicate the use of information items such as social networks, individual action and personal information, enterprise architecture views, among others; (2) it will also require the use of specific diagramming and visualization tools; and (3) it will be linked with specific verbs like ***capture*** (actions), ***group*** (actions)***,*** ***identify*** (contexts)***,*** ***find*** (patterns of action in contexts), ***analyze*** (contexts)***,*** ***redesign*** (tasks/activities/processes/resources). This means that it will also be possible to cluster these elements into particular actions contexts that specifically identify the continuous execution of the ODE Loop.

Because the ODE Loop is still a concept that has not been tested in practice, it is impossible to say how easy/difficult it will be to effectively elicit the action contexts associated to it. We can infer that this will not be as easy as it would initially seem: (1) ODE Loop will involve every member of the organization and most of the real time phases of the loop will blend with the standard work routines; and (2) the design phases of the Loop at higher organizational levels such as the Enterprise or Group Level which are more visible because of their obvious repercussions in the organization, occur rarely and because of this these contexts will be dormant most of the time.

# 12 Conclusion

In this thesis we have addressed a series of research objectives concerning the explanation of the discipline of Organizational Design and Engineering. These goals were targeted trough the clarification of this discipline objectives, through the refinement of its ontological positioning, and finally through the proposal of an implementation method and tools for actual deployment in practical enterprise environments. The research was based on a wide bibliographic review of contemporary perspectives of Organizational Engineering as well as the study of other authors from fields of systems engineering, control theory, social, organizational and management sciences.

## 12.1 Answers to the research goals

Remember the list of research goals established in the Part I Section 1.3 of this document:

(1) produce an overview of the current known approaches of Organizational Engineering;

(2) produce an overview of CEO's research through time in order to justify its future lines of research;

(3) identify the main shortcomings of current Organizational Engineering approaches;

(4) refine the definition of ODE and suggest how the identified shortcomings can be overcome;

(5) position the contributions of the different OE approaches in the context of ODE;

(6) link the development of ODE's concepts with the current research of the CEO's group.

Revising **section 1,** the first two goals to be addressed were concerned with the review of the main schools of thought on Organizational/Enterprise Engineering. The study of the perspectives and their corresponding approaches was done in ***Parts II*** and ***III*** of this thesis from **sections 2** to **8**.

**Section 2** described the *Business & Enterprise Engineering* perspective, **section 3** described the *Language Action Perspective,* **section 4** described the *Computational and Mathematical Organization Theory,* and **sections 5** through **8** reviewed the *Center Of Organizational Engineering* perspective and summarized its key developments through time.

***Part IV*** addressed the remaining four objectives namely the third research goal, which was the identification of the fundamental issues of the different approaches in the context of engineering and social sciences integration. This was approached in **Section 9** through the exposition of the approaches' different ontological positions and application methods and by assuming the human factor as one of the central inhibitors or enablers of organizational change and adaptation.

**Section 10** addressed the fourth and fifth research goals through the proposition of a circular process for aiding the implementation of ODE's tools in organizational environment. It also explored the hard-soft integration problem of Organizational Engineering, especially through the proposition of interaction between enterprise architectures and social network analysis tools.

Finally, **section 11** linked the process of **section 10.3 with** CEO2005-2007 agent's architecture and with the Action/Interaction Context modeling primitives of human behavior. This addressed the sixth and last research goal.

## 12.2 The maturity level of Organizational Engineering research and the role of ODE

The evolution of a systems engineering field goes through numerous maturity levels of evaluation, starting with the simple ability to observe and monitor, ending with the full capacity of prediction [94].

As with the case of aerodynamics, which is equipped with a complete set of tools from observation to prediction mechanisms, we seem to have found our universal observation unit in organizations through the monitoring of actions performed by machines and individuals, but unlike physical forces, things like emotions, motivations, imagination, innovation, creativity, and human processing of information are not concepts/realities for which, until now, we have been able to write mathematical equations.

***Enterprise Architectures*** **and Models**, which are the main tool of today's Organizational Engineering, are the set of construction artifacts that allow for managing the enterprise system through times of change. They select models to address different perspectives and abstractions. The problem with this is that the tradeoffs that are accounted in the design choices of the ***Enterprise Architecture*** model perspectives, are concerned with the ***hard properties of the system,*** this is, restrictions in matters of business rules, costs, availability, theoretical performance, etc, and the emergent enterprise properties, which are inevitable due to its social nature, are not fully accounted and controlled in the design.

It is in this spirit that ***Organizational Design and Engineering*** is proposing higher **hard-soft** integration. It recognizes Enterprise Architecture as the core representational element for the **hard enterprise system properties**, but it is starting to consider the emerging field of Social Network representation and analysis as its representation mechanism of **soft enterprise system properties** which currently allows for the observation of informal structures and, depending on the question being answered by the social network graph diagram, even for the inference of political issues and conflicts.

Through the ODE Loop, ***Organizational Design and Engineering*** explicates that Enterprise Architecture + Social Network Analysis + Simulation are essential for monitoring, controlling and auditing the organization behavior, and also extremely useful to support hypotheses generation, inductive reasoning, innovation, conception and design and engineering of the organization, and due to the possibility of representing the ODE Loop as one action context (or a set of them), it also becomes possible to assert whether or not this process is taken serious and effectively executed in the organization. It is an effort for pushing forward the maturity level of this discipline.

### 12.3 Future Research Lines and Questions

In many aspects this research was incomplete especially because of the topic difficulty and also because of the inexistence of formal comparison frameworks for approaches of Organizational Engineering. I would like to conclude this thesis with a set of research proposals and questions that might point to future research agendas that would, in my opinion, solve many of the questions that this work left unanswered:

- Although there are frameworks that compare modeling techniques which share the same purpose (namely regarding business process modeling notations), there are no approaches that I know of that compare the efficiency and efficacy of complete processes of Organizational Engineering (all the observation, modeling, delineation of solutions, deployment steps). Metrics that measure the effectiveness of these processes should be developed; this would better explain the relative success of the different approaches taking into account their specific objectives.
- In the line of integration of Enterprise Architecture with Social Network tools, case studies should be planned in order to determine which of the elements of the enterprise architecture most influence the informal organizational structures (**link D** of Figure 46 page 55):
    - How changes in enterprise business processes influence the Social Networks being monitored?

    - How changes in the way business processes are automated (workflows/applications/manual procedures) influence the Social Networks being monitored?
    - How changes in the availability of the enterprise information entities influence the ***Access, Needs*** and ***Advice*** type Social Networks?
    - To what extent, can the existing social networks overcome the failure of a certain application of the business environment during a certain period of time?
- Also in the same line of the above suggestion, case studies for the reverse direction (**link C** of Figure 46 page 55) should also be planned for:
    - With this set of individuals what information systems can the enterprise live without?
    - With this set of individuals and their relations, what information systems does the enterprise absolutely depend on?
- In the particular context of the CEO's research on action contexts, it would also be valuable to explore to what extent the personal scheduling rules that context elicitation process allows identifying differ or match the inferences that can be drawn by soft individual properties monitoring and analysis:
    - What rules are inferred by context elicitation that social network analysis cannot infer?
    - What rules are inferred by social network analysis that action context elicitation has missed?
    - To what extent people with similar action context have different scheduling rules and can these rules be inferred by social network analysis?
- Finally, case studies would have to be defined in order to plan the implementation of the ODE Loop's (according to **section 10.5**) and then, through the elicitation of action contexts, verify whether or not the Loop follows the steps that we have defined, if there are some steps that were not accounted for in the definition, and in the case it is actually verified whether or not the enterprise is more responsive to its challenges.

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## Appendix A: Process Models of the Organizational Engineering Approaches

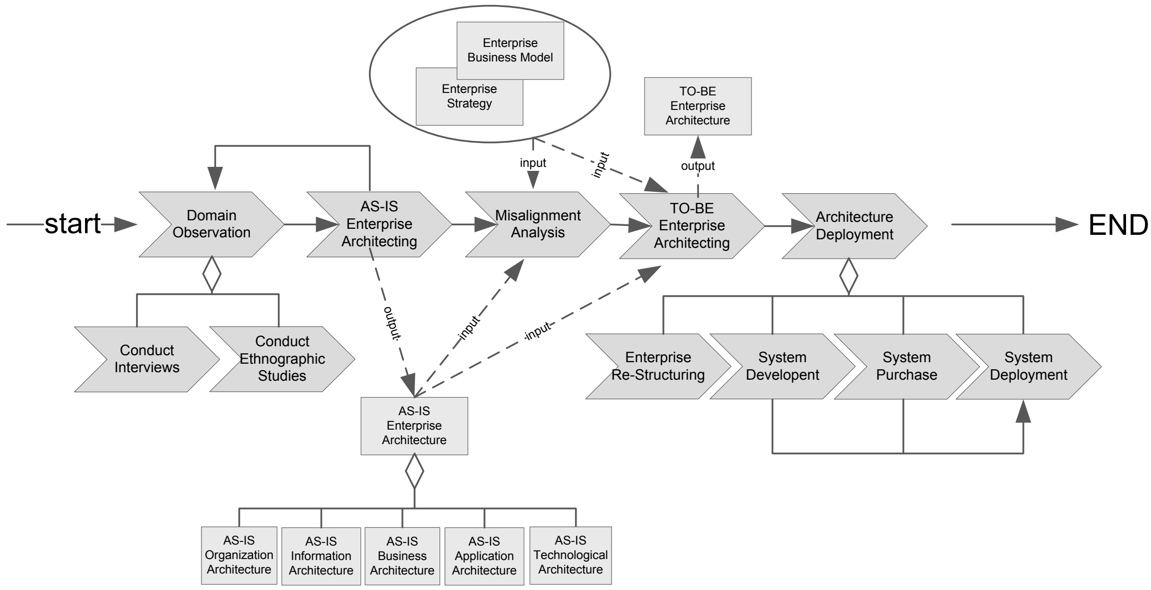


**Figure 64 CEO99-2005 Process (CEO)**

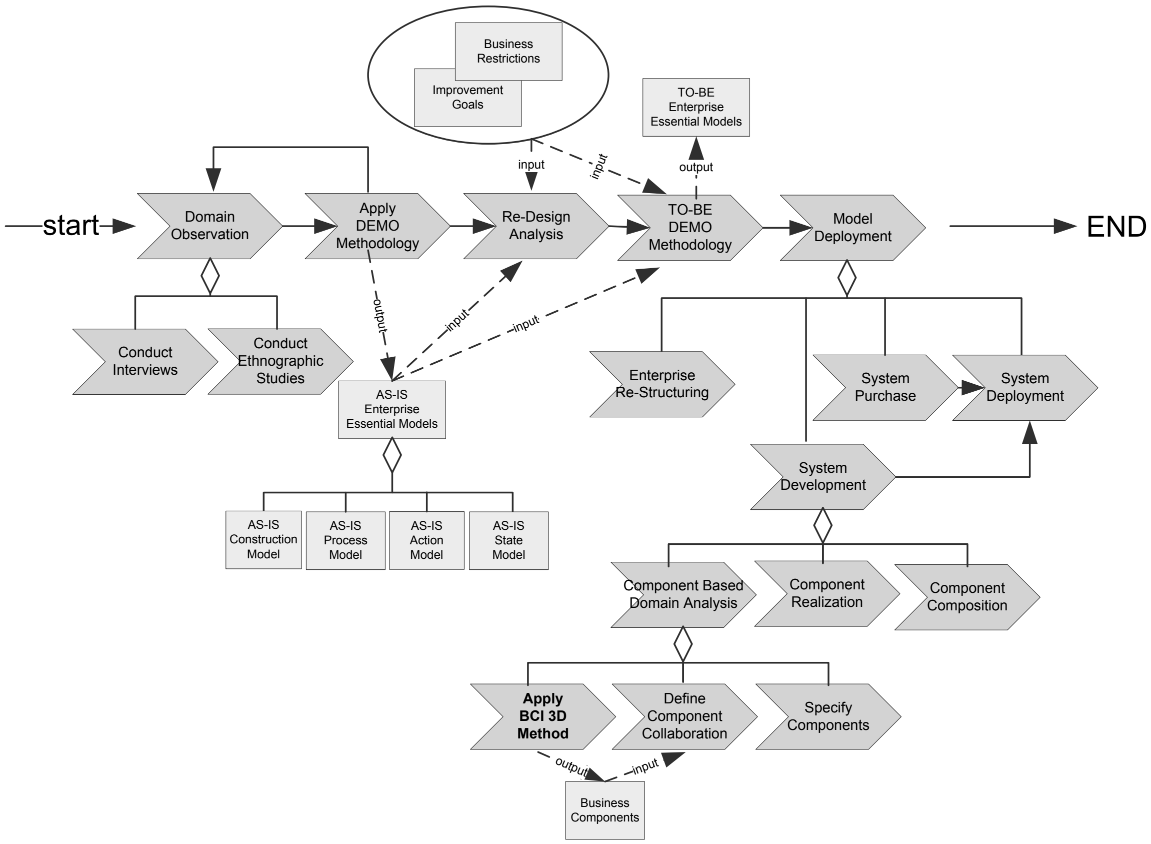


**Figure 65 DEMO Process + Suggested Component Development Process (LAP)**

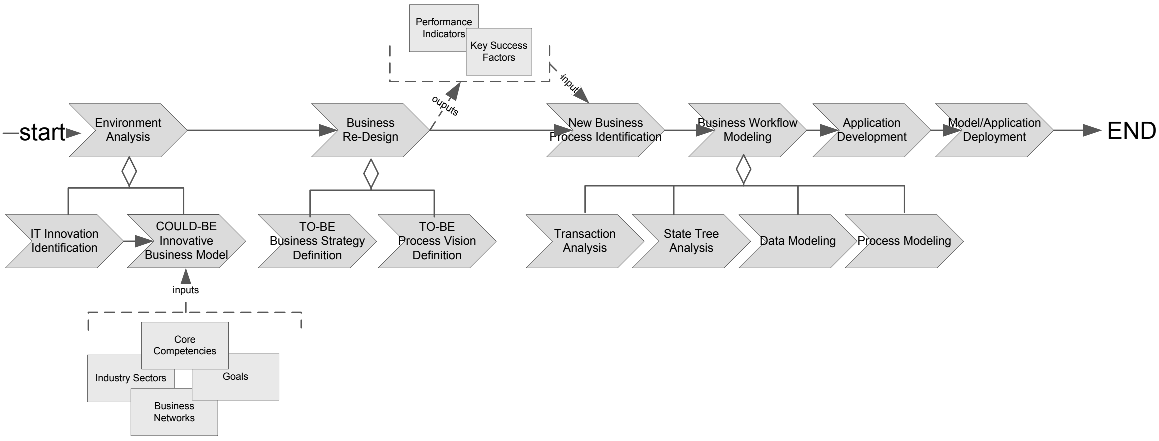


**Figure 66 Business Engineering Process (BEEP)**

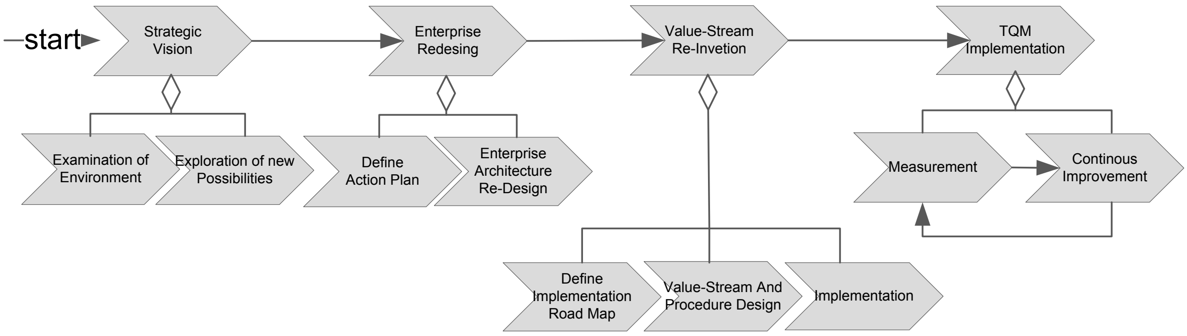


**Figure 67 Enterprise Engineering (BEEP)**

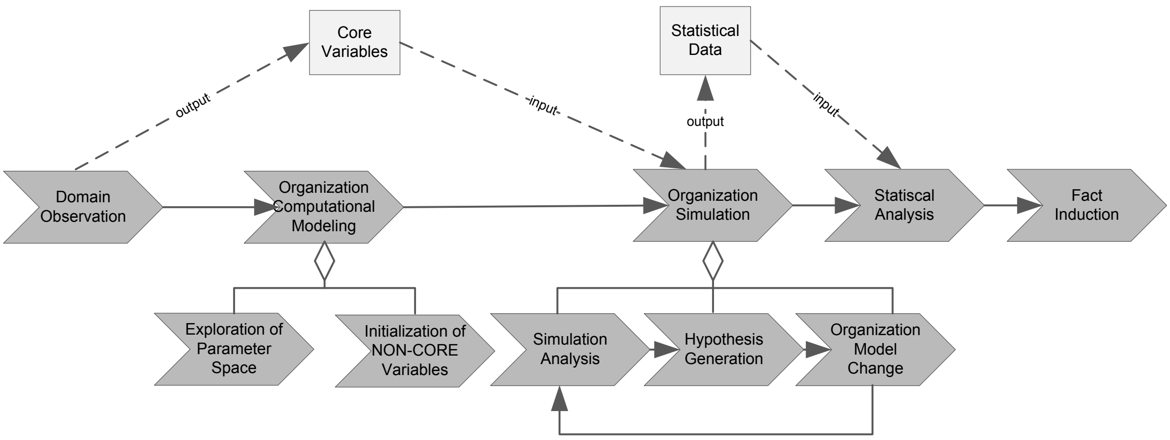


**Figure 68 CASOS Process (CMOT)**

## Appendix B: Examples from the World of Social Networks

### 1 Case Study: The Consulting Firm (illustrative real life case study take from [102])

*A certain consulting firm was composed of people with either advanced degrees or extensive industry experience in the fields of strategy and organization design or technical areas such as data warehousing or information architecture. By having these experts the firm thought that it could integrate the different types of knowledge in such a way to differentiate from its competitors that were solely focusing on organizational or technical solutions. After some indications that the consulting firm's goals were not being achieved it ordered a social network analysis which resulted in the graphs o Figure 69.*

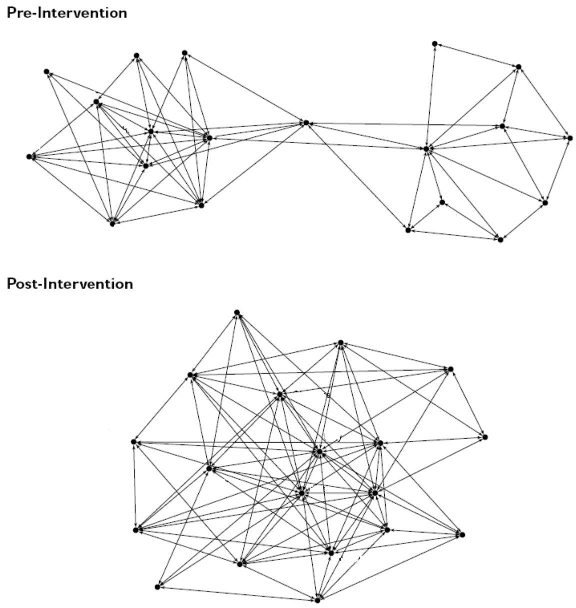


**Figure 69 Case Study of Social Network Analysis Implementation [102]**

*The social network analysis confirmed that the group expertise had been split in mainly two teams: (1) which was concerned with strategy and organizational projects, and (2) focused on technological solutions (Top of Figure 69). This led to the firm delivering the exact type of service that their competitors were doing.*

*After acknowledging this fact, the firm took action to correct the situation: (1) it assigned mix teams to subsequent projects; (2) the partner implemented mixed revenue sales goals; (3) communications forums for sharing information were introduced (weekly status calls, a short weekly e-mail update, and a project-tracking database).The result of the intervention was significant and after a period of six months the team worked much more as a united team (bottom of Figure 69).*

***"In this case, the underlying problem was that each subgroup had grown to a point of not knowing what the other group knew."*** [102]

**2 Types of Social Networks**

| Type of Network | Rationale | Possible Question to Ask (building the network) |
|---|---|---|
| Access Network *who has access to what information or resource* | Even if we know that some has relevant information it does not mean that he/she will be willing to share it in a helpful way [102]. | (1) When I need information or advice, this person is accessible to me with enough time and content. |
| Communicative Network *who interacts with whom and about what* | Very useful when trying to understand enterprise's informal groups. Helps to identify sub-groups or cliques which might concern enterprise political issues and the roles of people among these groups [102]. | (1) How often do you with the following peoples regarding topic Y? (2) How much do you communicate with each person relative to the others? |
| Information Network *who goes to whom for advice* | Helps to identify the efficiency with which the group traffics in information [102]. | (1) From whom do you typically seek work related information? (2) Who do you often give work related information to? |

**Table 9 Examples of social network types and the analysis they allow for**

**3 Practical Implementation Proposal of Action Contexts + Social Network Analysis + EA**

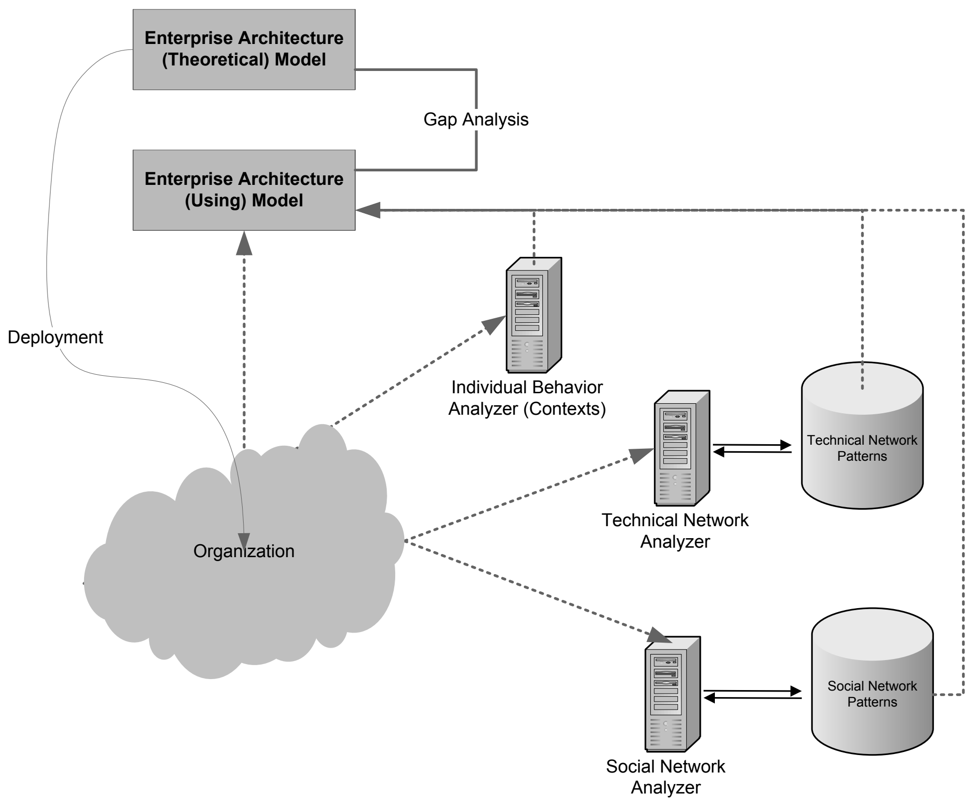


**Figure 70 Practical Validation Model**

## Appendix C: Integration work at the Domain Design Phase of the ODE's loop

The idea behind the integration of DEMO [15] and ARIS [78] comes in the ODE's spirit of trying to blend the best characteristics of multiple modeling approaches.

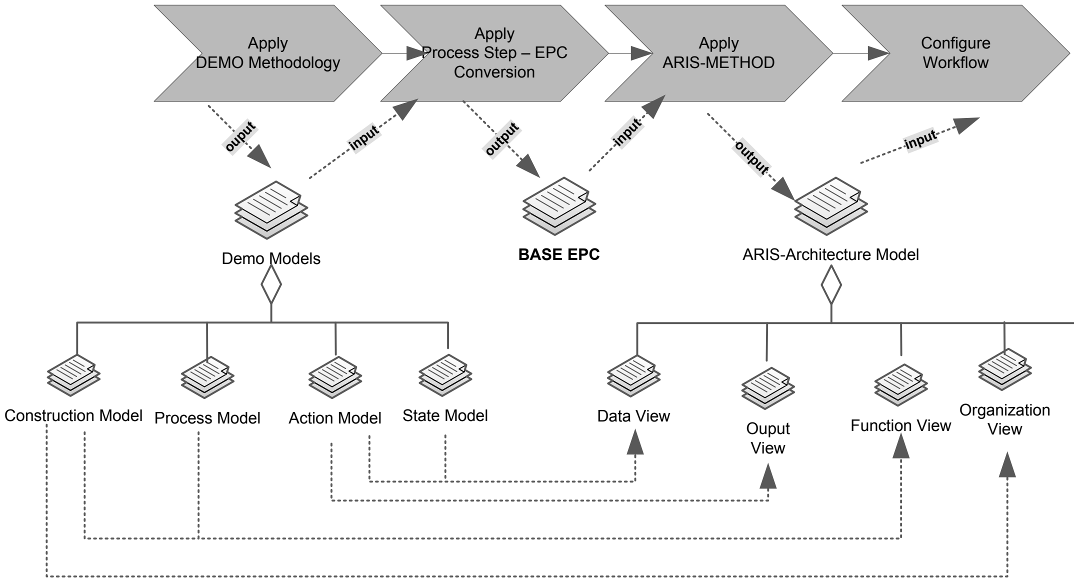


**Figure 71 The for combining DEMO with ARIS**

DEMO and ARIS both address the problematic of organizational modeling from a workflow perspective, but while the first is mainly suitable for requirements engineering and discussions regarding the design of enterprise coordination the latter, due to its enormous support in the information technology industry, is currently most adequate for actual deployment and implementation.

Figure 71 illustrates the process that we have delineated to achieve the outcome of being able to program ARIS-configurable workflow systems while preserving the numerous benefits (transaction pattern structure of business interaction) of using the DEMO.

The process starts with the application of DEMO to build the set of models that will then be used as basis for producing the initial EPC (ARIS process model). This EPC will be used to guide the definition of the multiple architectural views of the ARIS Method that once produced will serve to configure the actual workflow systems such as SAP/R3 for example.

The production of the initial ARIS's EPC is achieved using DEMO's ***Construction*** and ***Process Step*** Models. Table 10 below describes the correspondence between the basic DEMO constructs and ARIS's ones. Notice that other DEMO constructs exist, but it is always possible to define an EPC that is equivalent to the DEMO's *Process Step Diagram* (this is so because of the common background of Petri Net theory).

All the other DEMO models contribute as initial points for the construction of the ARIS business object models, there is a tight connection between DEMO's ***State Model*** and ARIS's Data model, and the Output Model uses the Action & Process Step Models as reference, etc (see Figure 71).

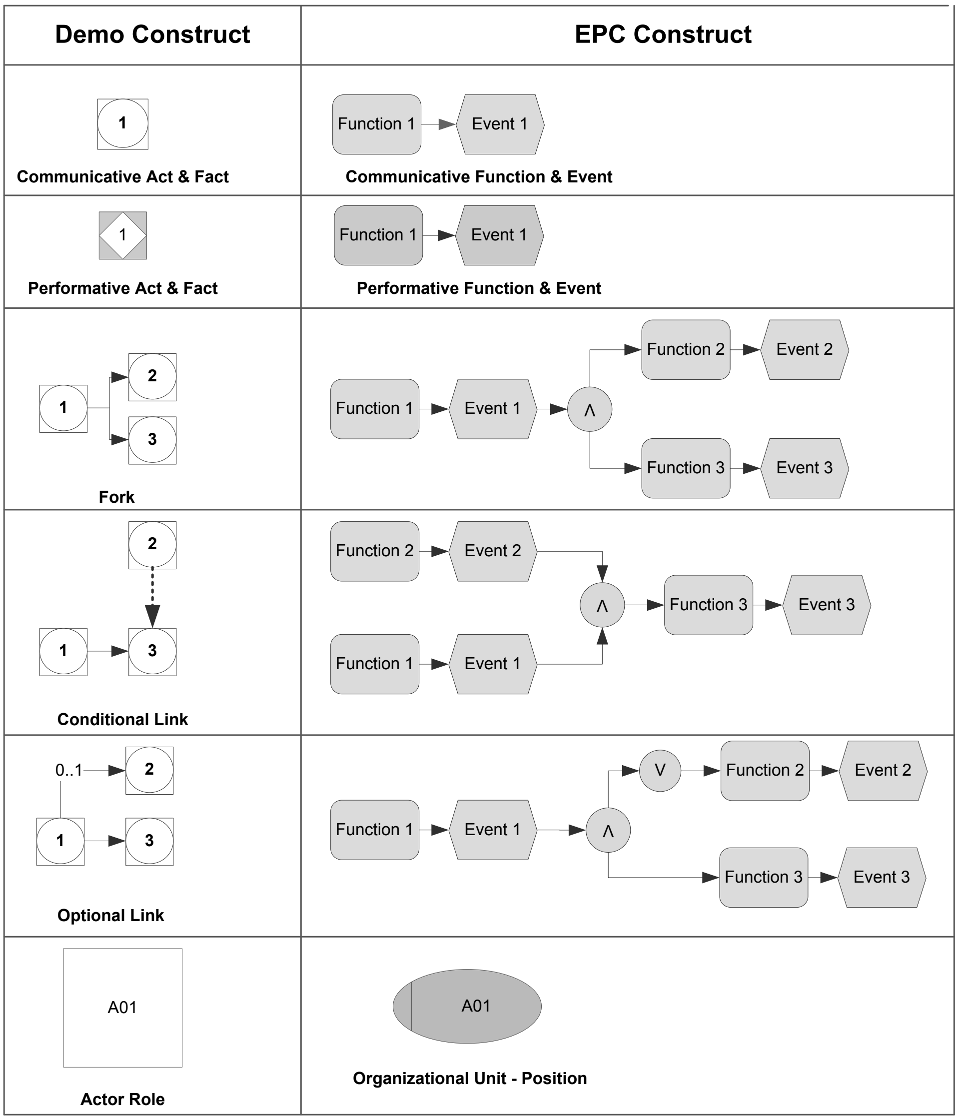


**Table 10 DEMO - EPC conversion table**

The benefits of using DEMO to guide the construction of ARIS's models come from many angles being the most important: (1) DEMO models are consistent, coherent and complete which will reflect in better ARIS's object modes; (2) DEMO models are stable and facilitate the separation of concerns between design (the general business protocol in terms of transactions) and implementation (the actual systems that the workflow has to call in order to put the transaction scheme into practice), this will of course be reflected on the design of ARIS's EPC; (3) DEMO separates the *Essential (business level), Informational (rational level), Datalogical (Document Level)* of the enterprise which helps in distinguish effective business rules (those that constrains state transitions at the *Essential Level)* from other rules that concern the information and data architecture of the system. Because it is possible to identify the communicative acts in the EPC this distinction also becomes obvious in ARIS; (4) the completeness of the *transaction pattern* regarding the interactions between people will be guaranteed that the workflow configuration will not forget important steps of business interactions such as cancelations, rejections, etc.

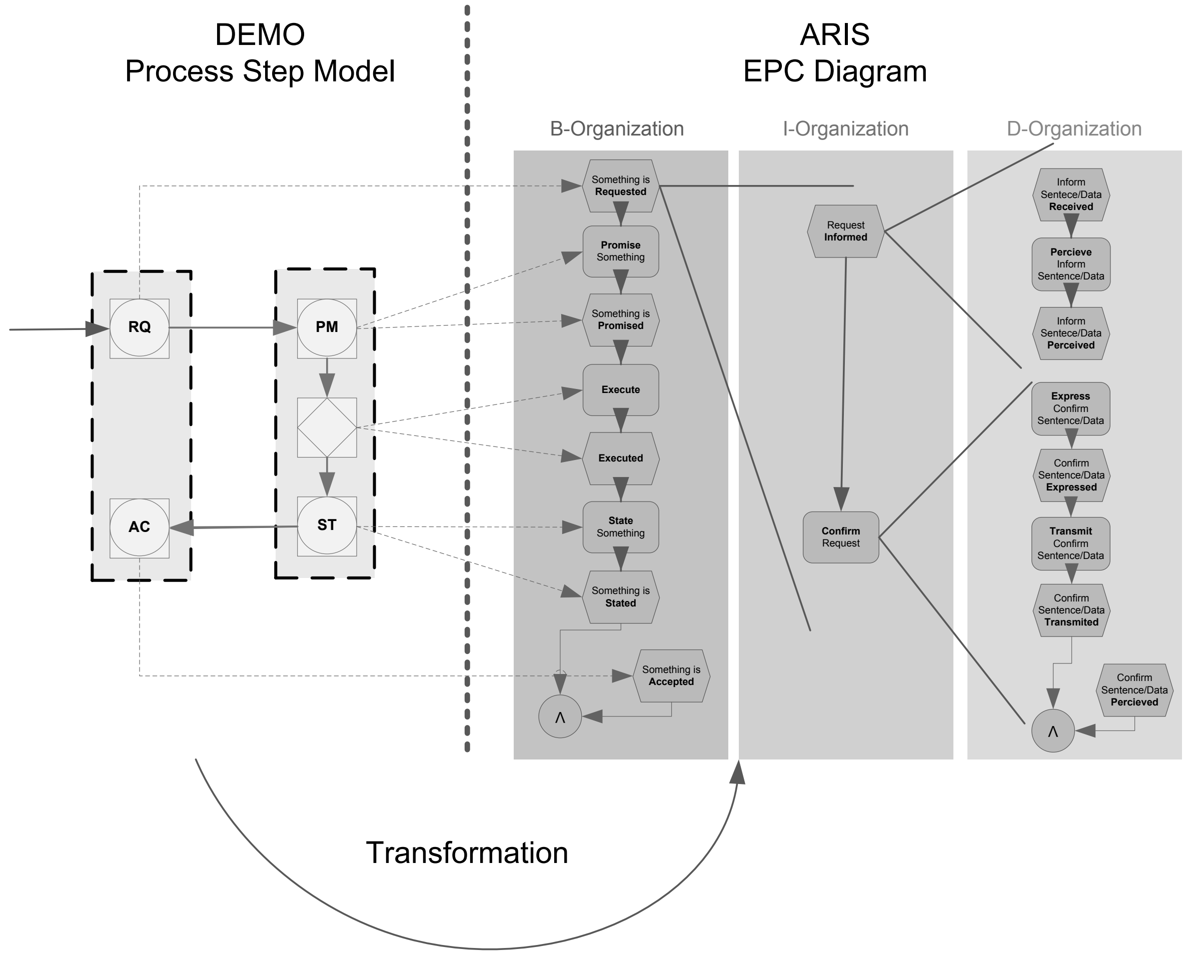


**Figure 72 From DEMO's Process Step Diagram to ARIS's EPC**

Figure 72 helps to justify the above list of benefits. On the left, it describes DEMO's Standard Transaction Pattern (where cancelation and rejection paths are being ignored), while on the right establishes the EPC conversion in terms of the *Essential*, *Informational* and *Data* levels.

As the picture shows, a single event at the *Essential* level involves at least two events and one function at the informational level and a set of events and functions at the data level.

What this construction means in terms of real life business communication is that when the workflow system registers the event that **something was requested** there is the absolute guarantee that the organization actor responsible for dealing with this information has been informed and that he confirmed his acknowledgement of the request to the customer.

Notice that the ARIS EPC is described in terms of high level events and functions so it is possible to associate each of them with specific modules and technologies, etc.

A last fact regarding DEMO's transaction pattern is that it also establishes what types of coordination acts belong to enterprise and which ones are property of the environment. This helps defining the enterprise boundary which is usually difficult to task.