Organizational Engineering: An Overview of Current Perspectives

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Abstract: *The increasing development of communication and information technologies have catalyzed numerous organizational changes while our knowledge of organizations remains segmented and disperse throughout many disciplines and fields of study. The task of managing a particular enterprise at a particular point in time is getting increasingly difficult and while as a field, Organizational Engineering has tried to gather some of this organizational knowledge together, until now, many angles remain unaddressed.*

Keywords: *Organizational Engineering, Organizational Design and Engineering, Change, Process, Enterprise Architecture, Social Networks*

1 Introduction

(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 natural that we seek solutions for improving their way of addressing our needs. **Organizations** are socio-technical arrangements which pursue collective goals, control their own performance and have more or less defined boundaries which separate them from the environment. They act and are expected to produce specific results, but their performances depend on the individual agents within them (both human and artificial) [1] 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 [2]. Individuals are finding it increasingly difficult to control the enterprises of which they are part and it seems that every enterprise is facing uncertainty and change and being pushed to the limit in every aspect of its environment [3].

This paper describes the way of thinking of four different perspectives of ***Organizational Engineering,*** as well as their contributions to address the many challenges that enterprises face today (***section 2)***. It presents a list of problems that ***Organizational Engineering*** approaches have been ignoring, mostly due to the dispersion and segmentation of organizational knowledge among areas that are seldom considered together (**section 3**), and proposes a new discipline called ***Organizational Design and Engineering*** whose purpose and goals are established precisely to unify and extend this knowledge on organizations and their behavior (**section 4** and **5**).

The paper concludes with a brief reflection about the maturity of this field and with speculations about future possibilities (**section 6**).

2 Organizational Engineering (EO) Perspectives

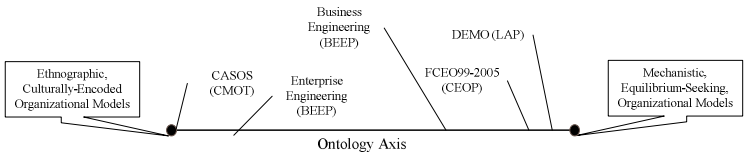

Figure 1 Positioning along the Ontological Axis

2.1 Language Action Perspective (LAP)

LAP is centered in the analysis of individual's communication patterns and the effects that they produce. Communication is considered rule governed behavior enabled by the performance of ***speech acts***, through which people in an enterprise can anticipate and coordinate each other's actions to produce changes in the world [4]. DEMO, which is one of the main approaches of LAP (that differ from one another mostly in terms of notation and ***speech act*** pattern organization [5; 6]) is a methodology for the elicitation of enterprise conversation patterns (***Transactions***) as well as the set of skills, authority and responsibility needed to execute them (***Actor Roles***) [7].

DEMO describes the organization as a state machine operating in a discrete linear time dimension whose state is determined by the set of commitments (***Coordination-Facts)*** and results that subjects achieve by performing tasks (***Production-Facts***) at a particular point in time. DEMO also structures ***Transactions*** and ***Actor Roles*** according to three different layers by describing the enterprise as (see Figure 2 below): (1) a ***documental systems*** where ***Actors*** (individuals performing actor roles) produce, store, copy, transport and destruct documents; (2) an ***intellectual system*** where ***Actors*** exchange information and perform computations; and (3) a ***business system*** where actors engage and comply into commitments to produce original new things.

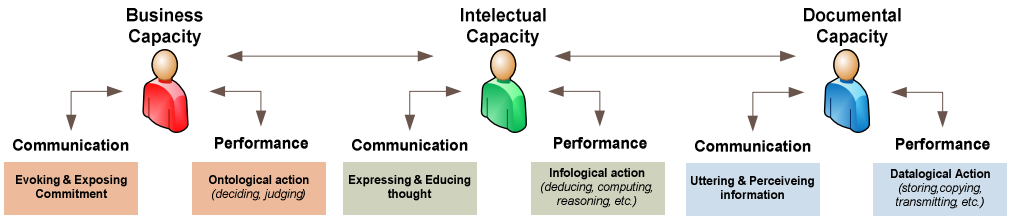

Figure 2 Business, Information, and Documental Systems of the Enterprise

DEMO assumes an ontological positioning that characterizes enterprises as systems of actors who interact through transactions and this approach serves as a mechanism for developing information systems to support these patterns as well as for thinking through and implementing the re-structuring of the patterns of discourse established between actor roles.

2.2 Organizational Engineering Center Perspective (CEOP)

CEOP started as a study of modeling languages and notations to address the gap that existed between manager's talk and the information system requirements of organizations. Its research core was the concept of business process and to graphically represent the enterprise CEO99-2005 relied on three basic modeling primitives: (1) the ***Entity*** as

anything existing in organizations and relevant to business; (2) the **Activity** as the unit of work performed in the organization; and (3) the ***Role*** as a skill, set of skills or special properties that entities have to hold when they engage in some ***Activities***.

Through the use of these three basic primitives, CEO99-2005 approach was able to represent five primitive ***Architecture Models*** that compose the whole ***Enterprise Architecture*** [8]: (1) Organizational Architecture, (2) Business Architecture, (3) Information Architecture, (4) Application Architecture and (5) Technological Architecture.

Until 2005, CEOP assumed an ontological positioning which characterized the enterprise as a system of ***Entities*** who played ***Roles*** when engaging in ***Activities*** and by capturing the **nouns** and **verbs** of the business environment it used ***Enterprise Architecture Models*** to think through the possible changes in the processes and information systems to better align the information, technology and processes with the enterprise's business goals. (Nowadays CEOP is looking for synergies with social sciences, among other fields of study, but this is addressed in **section 4**).

2.3 Business Engineering & Enterprise Perspective (BEEP)

BEEP is a study of multiple disciplines, methods and techniques to attempt changing the enterprises to better accommodate the many technological developments and opportunities that the ***information age*** is creating. It is a school of thought initiated by the research of James Martin that was then formalized and further developed by St. Gallen's IIM research group.

Enterprise Engineering (EE) (James Martin's Research) is a prescription of form for the structure and operation of the enterprise as well as the set of change methods needed to accomplish it. According to this approach the enterprise of the *information age* should be ***Value-Stream***[1] oriented, supported by proper information technology (workflow automation), its employees should be split across process oriented teams and the corporate culture should constantly take efforts of improvement [9].

Business Engineering (BE) (St. Gallen's Research) extends *EE* by defining an ***Enterprise Architecture Model*** to accommodate the results of all the methods of the approach [10] and besides defining a processes and meta-models for the capture of the organizational concepts considered worth modeling, BE envisions future industries structures (of which companies will be part) that will catalyze even more the need for enterprise transformations [11; 12].

BEEP takes the ontological positioning of describing the enterprise as a complex system, and besides the concerns with system properties such as speed, accuracy, robustness, etc., it considers emergent organizational properties such as trust, motivation, power relations and conflicts, etc., to describe the enterprise. Although being concerned with these ***soft***[2] organizational properties it is not clear how these approaches take care of them in practical cases.

2.4 Computational and Mathematical Organizational Theory (CMOT)

The CMOT is a study of the non-linear dynamics that affect **individual** and **organizational** behavior through the use of computer simulation models [13] and the CASOS group, one of the influential teams on this field, focuses its

[1] **Value-Streams** are end to end sequence of activities which add value to the operation of the enterprise.
[2] **Hard** expression usually refers to engineering related system properties while **Soft** expression refers to social and human system properties.

simulations on **Social Network Analysis** mechanisms in order to understand how individuals in the organization relate and work with one another outside the formal organizational chart.

The group's work models enterprises considering basic domains of analysis that map onto each other through the concept of network [14] (see Table 1 below).

Domain/ Domain	Agent	Task	Resources / Knowledge	Definition
Agent	Agent Access Communications Friend's & Enemy's	Assignment	Resource Access	**Agents:** Groups and individuals whom in turn can be either human or artificial.
Task		Precedence	Resource Needs	**Tasks:** Elementary units of work in which individual agents engage.
Resources/ Knowledge			Dependence	**Resources/Knowledge:** Can be alternatively characterized as individual's special skills, their access to particular machinery or some combination of both.

Table 1 CASOS Domains & Network Type Examples

The **agent, task, resource** and **network** data are extracted through manual or automated means (surveys, interviews, e-mail mining, etc.) and the simulations are probabilistic mechanisms to infer emergent patterns that occur in the organization's daily operation. They try to reflect the real world (not mimic it) and to do that, they assume premises from the fields of social sciences [15; 16; 17]: **agent bounded rationality, homophily** (higher probability of interaction among individuals which share common characteristics: background, culture, etc.)**, agent need to communicate, task orientation**, etc., as well as common sense observations: **task uncertainty**, **information distribution constraints**, etc.

CASOS assumes an ontological positioning that characterizes enterprises as complex adaptive systems and its approach serves as mechanism for analysis and hypothesis generation about organizational and individual behavior.

3 Some Problems with Organizational Engineering Approaches

As tools for controlling and improving organizations, their behavior, services and capacity to change, the different perspectives of *Organizational Engineering* can be accused of at least three important faults that are certainly holding back their true potential effect: (1) they do not provide formal means of integrating *soft* and *hard* knowledge about enterprises; (2) they forget that the organization's employees are an integral part of the system who are shaped and shape the system themselves; and (3) they rely on punctual intervention methods for the implementation of their solutions rather than on continuous processes through time.

These issues are of the most importance because it has been shown that people factors (not addressed by current ***Enterprise Architectures***) are central in enabling or frustrating the enterprise's possibilities of improvement through controlled change and adaptation [18; 19], and that these same factors can be molded to some extent by changing structures (reporting, processes, etc.), systems, technologies and leadership skills [20; 21; 22] which are, as we have seen, the objects of the interventions of *Organizational Engineering* approaches.

The *Organizational Design and Engineering* discipline, that we present next, is being developed to address these and other issues such as real-time organizational analysis and control, and although a long path has yet to be covered its tracks are already being built.

4 Organizational Design and Engineering (ODE)

According to what has been said so far, we define the ideal objective of *Organizational Design and Engineering* as the development of the body of knowledge needed to model the enterprise in such a way that will allow understand, predict (to some degree of certainty) and control the possible outcomes of the different organizational design and operation activities. In ODE, enterprises are seen as ***complex adaptive system*** whose elementary components are networks of people, machines and other organizations. This has numerous implications namely that: (1) it is possible to apply principles of decomposition to organizations; (2) enterprises have mechanism to potentiate change and self-management; and (3) enterprises share both: (3.1) ***Hard-System Properties*** such as *scalability*, *flexibility*, *stability*, *accuracy*, *robustness*, etc., which may be selectively targeted and usually imply favoring certain aspects over others (tradeoffs); and (3.2) ***Soft-System Properties*** which are related to the social nature of the enterprise and are things such as *trust*, *motivation*, *loyalty*, *dedication*, etc., that emerge throughout the organization's life cycle.

Unlike the reviewed approaches of OE, in ODE we define a continuous circular process that is not to be executed only by consultants (or *Organizational Design Engineers*) but by all agents (human and artificial) in the organization, this way guaranteeing that ODE is continuously in use, to support and improve organizational outcomes (see Figure 3 below).

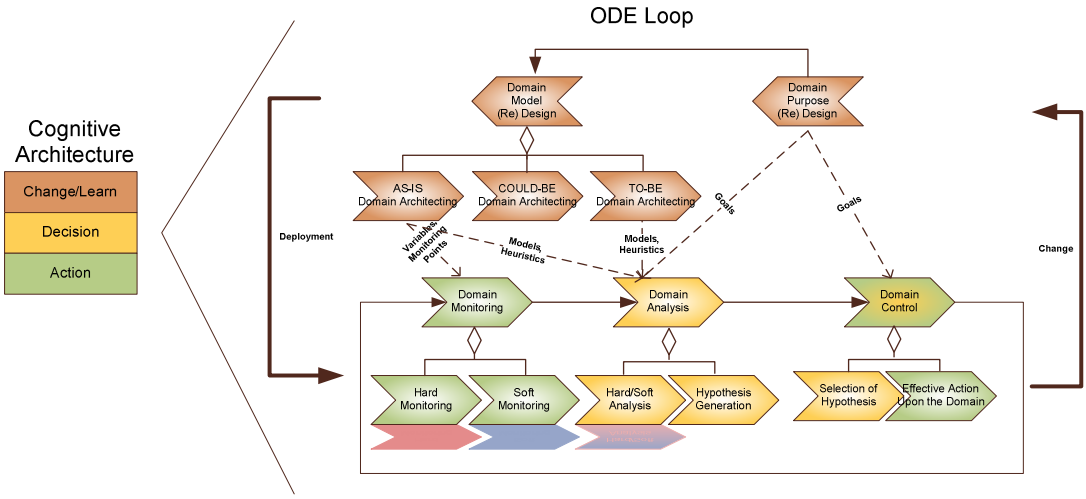

Figure 3 Agent Cognitive Architecture and ODE Loop Meta-Process

The idea of the loop is to establish a sustainable structure to explain how ODE's tools can be used in the management of routine/change/strategic activities of enterprises. The **first loop** (bottom of Figure 3) continuously monitors its own action and takes additional actions based on its monitoring while the **second loop** (top of Figure 3) is responsible for establishing the frameworks for the monitoring, analysis and action. The self correcting mechanisms of this process can only work as time passes and the system acts and responds to changes coming from its past actions and/or random disturbances that might occur.

Providing the right tools for supporting agents in implementing this loop is forcing them to think through their actions, thus giving them the opportunity to decide whether or not to modify their behavior in subsequent performances.

5 Explaining the Loop in a Running Organization[3]

The previous section introduced the idea of ODE as a discipline for designing and implementing **minimum cockpits of operability** which are the buttons and pictures that will enable organizational agents to perform their tasks in concert with organizational expectations (and needs), and also to change and redesign the enterprise in a predictable and accountable fashion. To explain how we believe that the different approaches of OE contribute to this end and how they fit in the ODE Loop, we will try to answer the following three non trivial questions: (1) **what buttons and pictures do individual agents need to improve their capacity to perform?**, (2) **what buttons and pictures should individual agents be granted, because they are part of groups?**, and (3) **what buttons and pictures are needed by individual agents when trying to change and drive the organization as a whole?**

5.1 Answering the first question

The first question seems the easiest to answer because we can actually observe individual agents in action: they perform ***actions*** of either *performative* or *communicative* nature which can be grouped in **tasks** and are always related to specific ***times***, ***locations*** and **resources** such as information items, technological items, people, etc.

Ideally, the list of tasks that an agent is assigned to perform will be connected to the set of skills that he disposes as well as the set of personality traits (in the human case) that pre-dispose him to use his skills properly in the assigned job. On the other hand, being able to perform well also means choosing to execute the tasks in a proper order and following proper patterns of actions to the specific situations at hand.

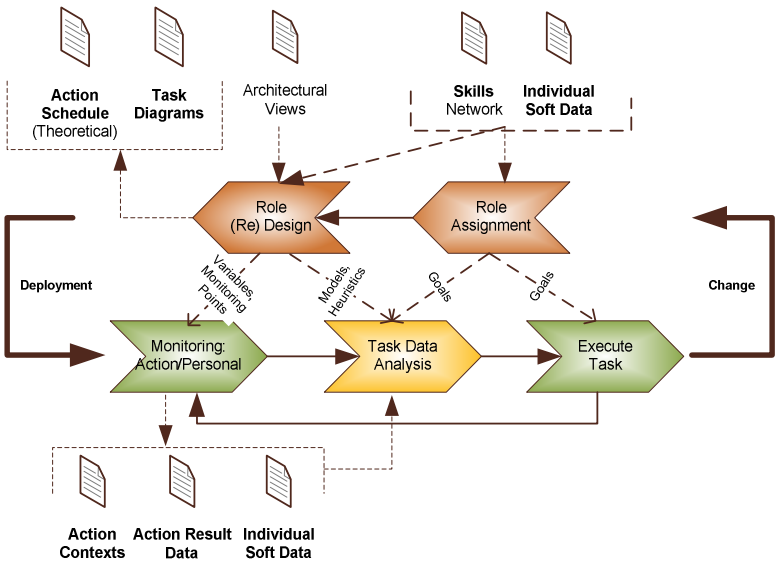

Figure 4 ODE Loop for individual buttons and pictures

For potentiating improved behavior of agents in their job, we have instantiated the ODE Loop respecting the ideas of the above paragraph (see Figure 4 above).

[3] The explanation of the ODE Loop instantiation uses the terminology of CEO2005-2007 **Agent Architecture**.

A***gents*** are assigned to ***roles*** (Role (Re)-Assignment) based on ***Skills Networks*** and ***Individual Soft Data*** (if applicable) to establish a match between their competencies, personality traits and specific ***role*** requirements. Additionally, the ***roles*** are designed (Role (Re)-Design) taking into account specific aspects inherited from ***Enterprise Architecture Model*** (that relate with the organizational level) such as the ***activities*** in each ***business process,*** but also the specificities of the available human/technological resources. This means that in two distinct enterprises, the same **activity** might be achieved by different role sets and collaborations according to the restrictions of the organization's reality.

Implementing the **first loop** should be about providing agents with the analogous of today car's *Global Positioning Systems* (something to guide them through their tasks, provide them alternative paths, and recalculate those as needed). The tonic is on providing tools for re-schedule/re-design plans of actions, and to support the multitasking nature of corporate work.

In this spirit, Monitoring Action/Personnel is the capture of ***verbs*** and ***nouns***, the sequences in which they are used, and the observable outcomes of their execution. This information is clustered in ***contexts*** which represent the different scenarios between which agents might shift during their performances. ***Contexts*** are the central tool for multitasking support through which it is possible to explain to the agents **the how** (actions and task order) and **the why** (task scheduling rules) of their executions.

Individual monitoring should also be about soft agent data (personality traits, trust, motivation, etc.) because even if this data cannot be directly linked to ***contexts*** and ***scheduling-rules*** it will be precious for the activities of ***re-design*** described above.

5.2 Answering the second question

According to our definition, a ***group*** is an aggregate of individuals who consciously identify themselves as being of part of a **commonly** conceptualized set (each individual identifies himself as a member of the group). ***Groups*** exist to serve purposes and they can be formal structures such as organizational units and work teams, or informal setups such as practice communities, etc. The concept of group surpasses that of a network or that of an aggregate of people who punctually cooperate in some task, a group (as ***entity***) implies stability.

The purpose of the group, the type of ***activities*** it performs (***productivity***, ***coordination, accuracy*** or ***quality tasks***), the members available, etc., are all variables in the group design equation. Furthermore, rather than multitasking groups allow parallel processing, which raises even more the complexity bar when comparing with individual agents.

There are entire books dedicated to the subject of ***groups*** [23] and we cannot be expected to address all the issues here, but from our study of the organizational engineering perspectives we have come to conclude that regardless of the complexity of groups, once people associate with each other relations, which may be crucial units of performance and behavioral analysis, emerge. These relations can nowadays be mapped in network diagrams [14; 24; 25] which answer numerous questions and help understanding how groups really work: *who are the group brokers?* (Individuals which connect a group to other distinct groups)***,*** *who are the group central connectors?* (Individuals whom others frequently consult for information)***,*** *who knows what?* (Information network), *who has access to what knowledge/resource?* (Access network), *who is friends with whom?* (Friends network), etc.

To answer the second question of **section 5** we say that organizational agents who relate to groups (in any way) need at least the same set of "buttons and pictures" that were highlighted in the answer of the first question and also ***social network related information.***

Figure 5 below illustrates the instantiation of the ODE Loop focusing on the processes that occur at group level.

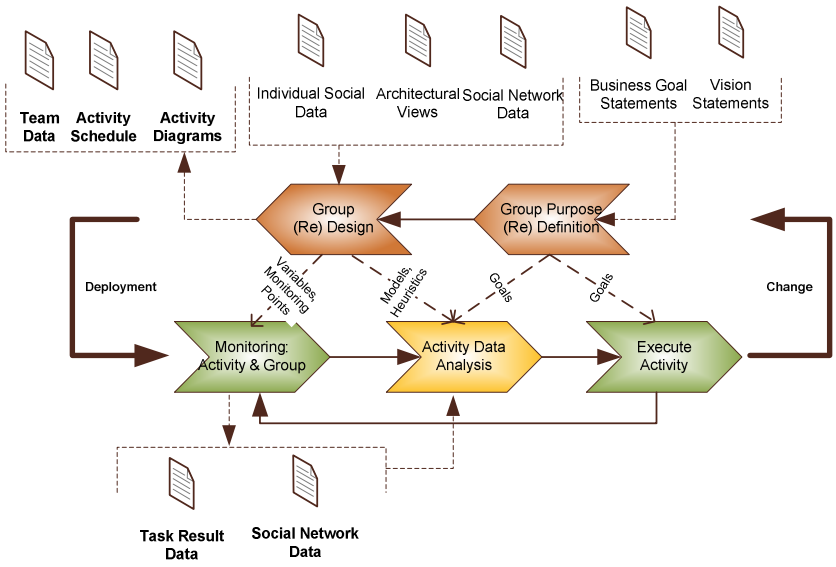

Figure 5 ODE Loop for Group Related Buttons and Pictures

The focus was given to the use of ***social network data*** as well as ***process*** and ***activity*** data (inherited from the ***Enterprise Architecture Models*** that relate to the organizational level) in all the activities of the ODE Loop.

Different agents will interact with groups from different angles, and this will influence the type of ***network data*** that they will need: if a an agent is member of a group, he will need to know how to effectively challenge authority in that group, what agents should he address when facing specific problems, how to reconcile organization-specific goals with the group's specific strategic priorities, etc, while agents interacting with groups from an external perspective might find it more useful to know about its brokers, how to channel information in effectively, etc.

It is an open issue whether there are other primitives that should be used to model and explain the interactions of people in groups and we could not identify them in our study of *Organizational Engineering* perspectives. Our opinion today is that the concept of ***networks*** (only considered in ***CMOT)*** is one that should clearly pervade all the approaches of organizational change and control.

5.3 Answering the third question

To answer the third question we have to remember that enterprises exist to produce something. They deliver services or in other words, fulfill a purpose, but they **do not exist alone**! Enterprises are part of industries where they face competition from other organizations whose success might implicate their own failure.

It is important to understand this, because talking about organizational change means both: (1) punctual structured interventions to increase operational efficiency, or (2) more radical alterations that have effects in the general organizational behavior[4].

In the first case, agents require all the representation and control schemes that individual agents need to perform their job and deal with the groups with which they interact, but they also need some elements capable of relating all organizational components to manage and study the consequences of the modifications. In the latter case they need all of the above tools but also a discipline called **strategy** which is about: (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's activities (doing many things well) [26].

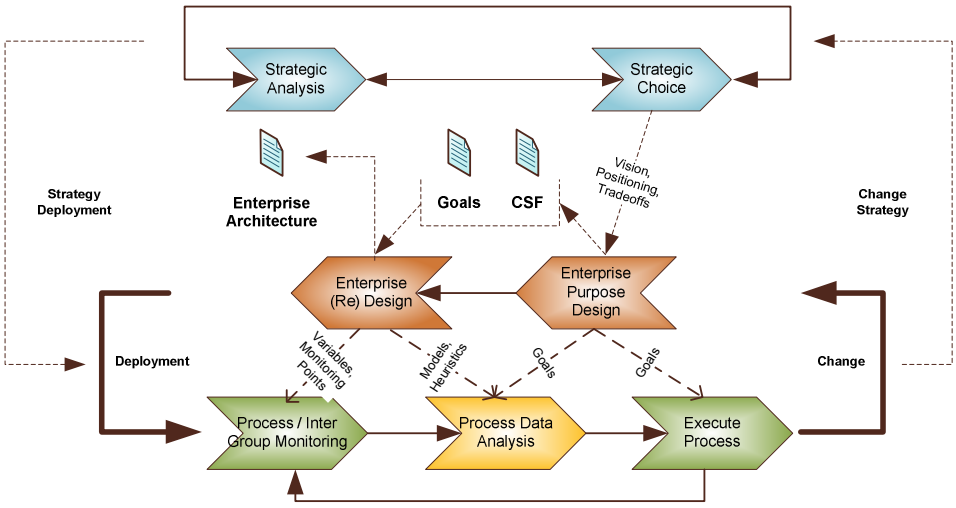

Figure 6 ODE Loop for Organization Related Buttons and Pictures

Figure 6 above instantiates the ODE Loop to help answering the third and last question of this section and besides the standard Design, Monitoring, Analysis and Control processes, we add a third level loop where the ***strategy*** discipline is included.

Strategy establishes the highest level framework (the first set of constraints) that will influence all the other activities of change design and implementation, while the element that connects the *"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"* [27] is the ***Enterprise Architecture*** representation: the ***entities*** (business nouns) and the ***activities*** (business verbs) (which can all be enriched by the concept of ***role***).

Strategy will constrain the enterprise's purpose, which will constrain the definition of the ***Enterprise Architecture*** which would ideally determine the purpose of groups and people within the organization. But as we have seen in **sections 5.1** and **5.2**, the networks that people establish and the mutual influential bonds that influence people and technology in the organization, teach us that there is no such linear relation among all these levels. In fact, the

[4] Punctual interventions might lead to unexpected emergent behaviors which also affect overall organizational behavior, but we expect that the continuous monitoring and analysis of all aspects of the organization to be able to correct this.

description should not even be top down, because people and group factors may limit the available strategies, and the possible architectural solutions. It is all a loop, and we expect that only through the continuous execution of ODE will it be possible to identify and dampen the emergent organizational behaviors (the unwanted ones, because some of them might be positive).

To end this discussion it is important to highlight that when planning organizational change, there is a type of social network (besides those that were considered for the interactions of individuals with groups) that is of great relevance. We are referring to the inter-group and iter-organizational networks that denounce the cooperation and coordination among organizational groups and between organizations, as well as the speed of information sharing, etc. These should also be included as a repertoire tool of ODE.

6 Conclusion

The evolution of a system's 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 [28]. It is to no one's surprise that today we can guarantee that planes fly (Aeronautics discipline) although not so long ago we were only observing the flight of birds.

In ***Organizational Design and Engineering*** we seem to have found our universal observation unit 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.

The repertoire of *Organizational Engineering* approaches and tools is diverse: some approaches use ***Enterprise Architectures*** (BEEP, CEO99-2005) to address organizational change; others rely on narrower models (LAP) and focus on organizational work optimization; and still some, use network and simulation concepts to describe and study the organization (CMOT).

With such different approaches and scopes it is not easy to understand what is OE's purpose and how it should progress. Departing from such diversity, we have defined the discipline of ODE which has ambitious targets regarding the prediction, control and optimization of organizational behavior.

This demands a higher level of **hard** and **soft** disciplines integration. Drawing from OE disciplines, ODE uses ***Enterprise Architecture*** for representing and planning **hard enterprise system properties** but it considers this insufficient and adds a circular process of application (ODE Loop) as well as tools of social network analysis (also drawn from OE) as its representation mechanism of **soft enterprise system properties.**

ODE is open to the development of both engineering and social sciences and it is especially concerned with tools and methods that will take both of these fields into account.

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