The influence of software emerging technologies on organizational systems. An example from pharma industry

Mihai Liviu Gherman, *FAIMA Doctoral School, University "Politehnica" of Bucharest, Romania, mihai.liviu1964@yahoo.com*

Cezar Scarlat, FAIMA *Doctoral School, University "Politehnica" of Bucharest, Romania, cezarscarlat@yahoo.com*

Dan Andrei Panduru, *FAIMA Doctoral School, University "Politehnica" of Bucharest, Romania, andrei_panduru91@yahoo.com*

Abstract

The scope of this paper is to describe some of the benefits by using Information and Communication Technologies (ICT) and, more specifically, the emerging technologies, within the organizations. For the beginning, the Organizational Systems and Organization Modeling are shortly described as the main domains affected by emerging technologies, then are mentioned the main advantages of ICT, closing with a more detailed discussion about emerging technologies and their potential use. The main findings of the study are: the potential use of blockchain technology in defining and evaluating the decision making system, the relative similarity between the mechanisms on which Artificial Intelligence (AI) is based and the ones used in organizational design and, finally, the evolution of AI applications from support to mean of production. The implications of the above-mentioned aspects are significant for the organizational systems (evolution of the structures to virtual ones) as well as for management and value creation system. If the hardware emerging technologies are generally changing only the value creation, the software ones will completely change, in an uncertain, but defined way, the existence of the companies and the global market.

Keywords: Organization, Organizational systems, Organizational modeling, Emerging technologies, Information and Communication Technologies (ICT), Artificial Intelligence (AI), Blockchain technology

Introduction

Since 80s, the world is under the impact of the fast-growing technologies. Personal computers, mobile communication, Internet, fiber-optic, social networks, Artificial Intelligence (AI), blockchain, Virtual Reality (VR), nano-robots changed the humans' lives and behaviour. All of these could be named *emerging technologies* at their time. No doubt they changed the functional status of the organizations, both as scope and as structure. Within the scope of this research, the emerging technologies are split in hardware and software even though there are many combined. The paper intends to study how the three subsystems of an Organizational System, mainly Value Creation, are evolving under the influence of software emerging technologies. More specifically, how the evolution of AI from products related to system facilitators to means of production change the organizations and their activities. In subsidiary, other aspects of software emerging technologies influences on Organizational Systems are presented.

The remaining of this paper is as follows: organizational systems, organizational modeling, Information and Communications Technologies (ICT) and Emerging Technologies Influence on Organizations, examples of the use of Artificial Intelligence (AI) as a means of production, conclusions and managerial implications, limitations and future research.

Methodology

The methodology used in this paper is a qualitative one. The research is on going, in initial qualitative research phase. Starting from the observation that a large series of companies belonging to important industries have begun to use Software Emerging Technologies as mean of production, a significant study of books and articles has been done in order to identify the changes in organizations due this phenomenon, some specific cases, similarities between the mechanisms on which AI is based and the principles of Organizational Modeling, or how other technologies (blockchain) could be used.

Thus, the paper is structured in three parts: first one containing the introduction and the methodology, the second one being the in fact research and the third one - conclusions and limitations. In the first two chapters of the research are described the aspects of Organizational Modeling on which research questions reffers to. Then, some characteristics of emerging technologies are presented as well as their potential use, concluding with an example of AI use as mean of production.

Organizational Systems

"An organizational system is formed by the flow of activities, sources and energies within an organization" (Latham, 2016). It includes more subsystems which can be grouped in three levels: value creation, facilitators and orientation, as shown in *Figure 1*. Value creation system includes the whole chain, starting from the understanding of the customer requirements, continuing with the design and development of the products and services to be done, ending with their delivery.
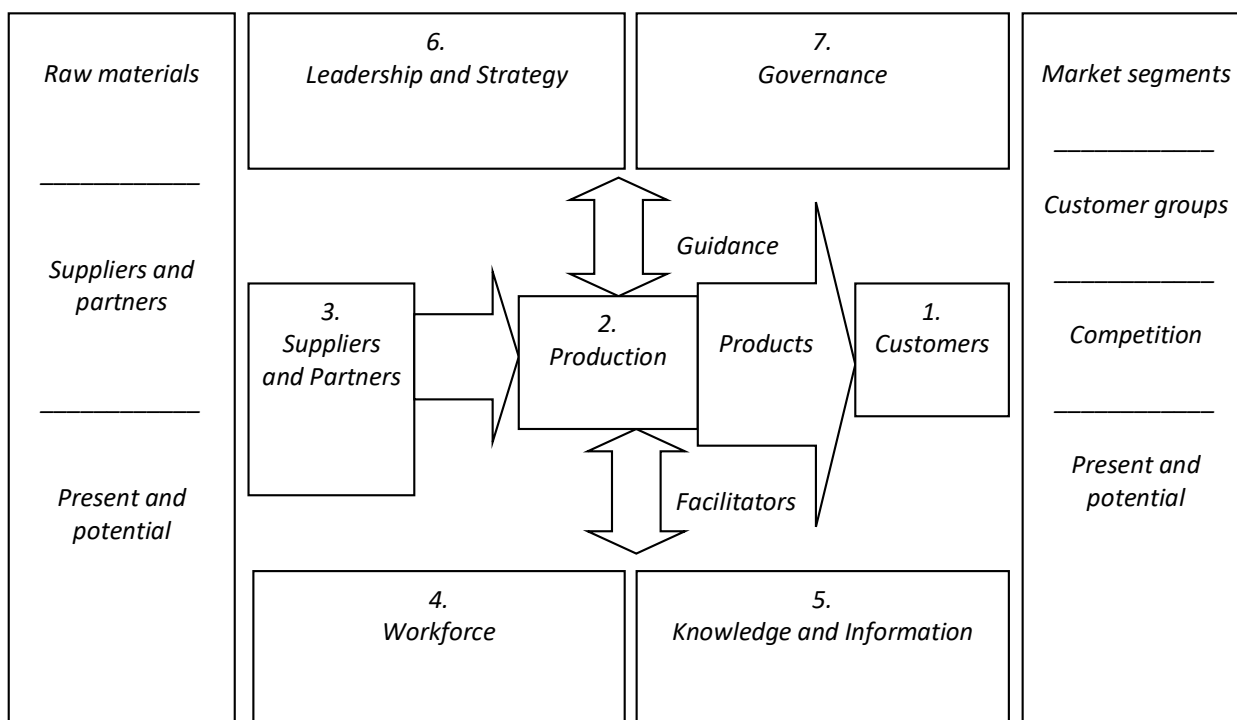

Figure 1. The general organizational system of an enterprise (after: Latham, 2016)

Facilitator's system contributes to the improvement of all the other systems. It includes the support for the knowledge development of the employees, their improvement capacity to learn and innovate. Also, it provides the performance measurement means of the organization.

The orientation (guidance) system provides the directions and the resources for the value creation and facilitators system. It includes leadership actions, strategic development decisions, governance rules, *etc.*

Any organizational system needs permanent evaluation based on results. An example of such an evaluation is presented in *Figure 2.*
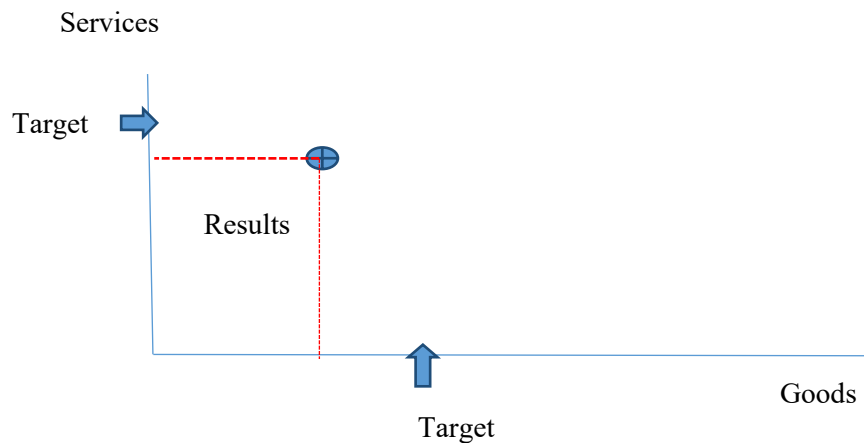

Figure 2. Evaluation model of the sales depending on market types and value creation

Supposing a company with value creation system formed by production of goods and providing services (*Figure 2*), some conclusions about the activity and organizational system could be reached. In this case, both sales targets were not reached, but the services sales are higher, so one or more of the following conclusions could be taken into consideration:

- the market asks for more services than goods in the specific field – external factor;
- the sales force should be improved – facilitator factor;
- both targets were too high – orientation system factor, *etc.*
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In any case, some *organizational changes are needed*.

Organizational modeling

The organizational modeling is the process of designing and implementing an organizational system. It has three distinct, but interrelating phases: discovery, design and implementation as shown in *Figure 3*.

The first two phases are mainly inductive and creative, the last one being more deductive, including iterative tests and development processes. During the design phase, is recommended to work on three models: ideal, feasible and detailed (Latham, 2016).
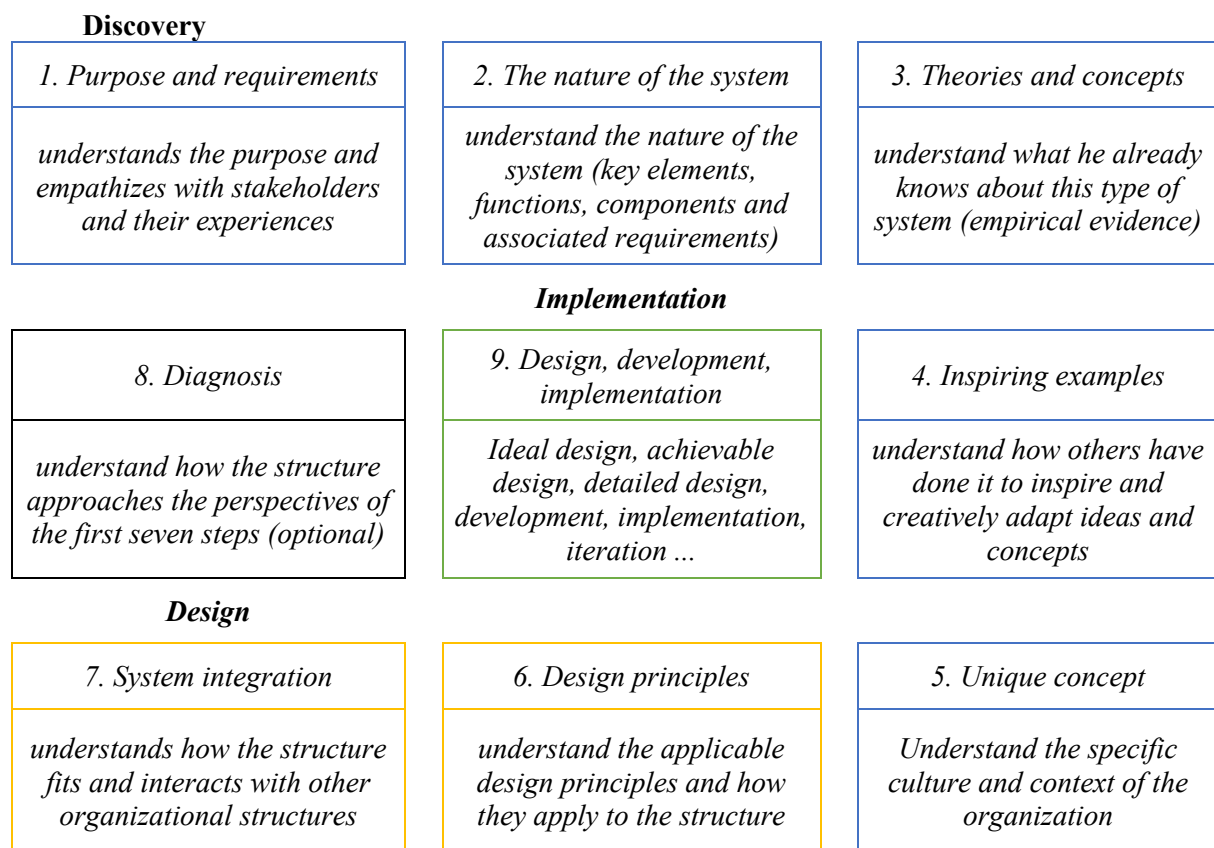
Discovery

1. Purpose and requirements	2. The nature of the system	3. Theories and concepts
understands the purpose and empathizes with stakeholders and their experiences	*understand the nature of the system (key elements, functions, components and associated requirements)*	*understand what he already knows about this type of system (empirical evidence)*

Implementation

8. Diagnosis	9. Design, development, implementation	4. Inspiring examples
understand how the structure approaches the perspectives of the first seven steps (optional)	*Ideal design, achievable design, detailed design, development, implementation, iteration ...*	*understand how others have done it to inspire and creatively adapt ideas and concepts*

Design

7. System integration	6. Design principles	5. Unique concept
understands how the structure fits and interacts with other organizational structures	*understand the applicable design principles and how they apply to the structure*	*Understand the specific culture and context of the organization*

Figure 3. The general framework for designing an organizational structure (adapted after Latham, 2016)

Information and Communication Technologies (ICT) and the influence of emerging technologies on organizations

The classical definition of ICT is that it is the complete hardware, software and telecommunications set which provides the support for the activities of an organization by point of view of decision making, communications system and performance measuring.

The main advantages which ICT brings into organizations are:

- **time reduction** in any decision making, value creation and facilitators system,
- increased volume of **knowledge** for all employees,
- better potential for **human resources evaluation**.

Time reduction is a historical goal of any organization. Initially, the introduction of technology in production process, happened during the Industrial Revolutions, brought high time reduction, diminishing the total cost of the products. Through innovation and new discoveries, automation and robotization, the process of lowering the production time continued, reaching very high levels in our days. If, for example, the production cost of a car in 1960s and 2010s are compared at actual cost of money, big differences are remarked. A factor which, together with the technology progress, contributed to the time reduction process is the knowledge accumulation at the employee's level.

In time, together with the increase complexity of the organizations, another element began to have more and more importance: decision making. Simon (1955) defined rational decision making as the process of

selecting the alternative that is expected to result in the most preferred outcome. If the organization is seen as a "network of decisions" (Langley *et al.*, 1995), that has to be structured in such a way as to best attain its goals.

Currently, the blockchain technology could be applied in system modeling, decision being considered as transaction, seller as decision provider and buyer as decision receiver. A similar logic is used for the feedbacks. In the same time, the recent rise of decisions making by artificial intelligence brings a new set of challenges. In particular, machine learning algorithms generate continuously new predictions and information that may have significant importance for the organization processes, especially decision making processes.

The accumulation of knowledge has an important role in the process of human resources evaluation. On the other side, the stochastic character of emerging technologies in organizational design is provided by the human factor. Both elements are influencing each other, so the link between the two is bidirectional.

The data is the central element which stays at the base of any software emergent technology. Together with Google revolution, all organizations are evolving in a completely new world.
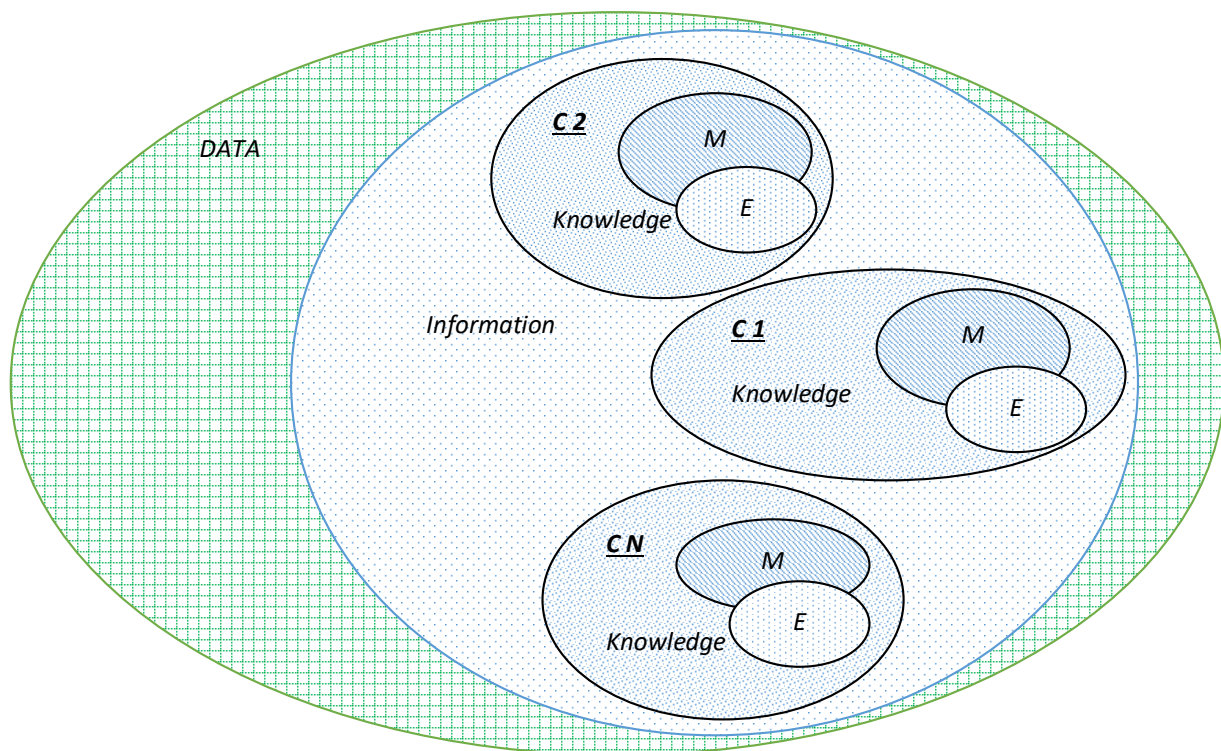A schematic representation of this situation is shown in *Figure 4*.

Figure 4. Companies in the world of data: M - Management, E - Employees, C - Company

The unstructured data are transformed by structuring in information, and then, at the company level, by processing, in knowledge for management and employees.

Coming back to the definition of emerging technologies, we may observe that there are five attributes associated to the concept.

The first one is radical novelty: "novelty" (Small, Boyack and Klavans, 2014) may take the form of "discontinuous innovations derived from radical innovations" (Day and Schoemaker, 2000) and may

appear either in the method or the function of the technology. Novelty is not only that, but it may also be generated by putting an existing technology to a new use or, in other words, applying an existing technology from one domain to another domain or 'niche' (Adner and Levinthal, 2002). This implies that 'evolutionary' technology (those not characterized by revolutionary technical developments) can also be radically novel in domains of application different from those where the technology was initially developed (Rotolo, Hicks and Martin, 2015).

The second defining attribute of emerging technologies is "clock speed nature" (Srinivasan, 2008) or "fast growth" (Cozzens *et al*., 2010), or at least "growth" (Small, Boyack and Klavans, 2014). Growth may be observed across a number of dimensions such as the number of actors involved (*e.g.* scientists, universities, firms, users), public and private funding, knowledge outputs produced (*e.g.* publications, patents), prototypes, products and services, *etc.* (Rotolo, Hicks and Martin, 2015). It refers also to the areas of application, from industry to agriculture, from finance to politics.

The third attribute of emerging technologies is coherence that persists over time.

This attribute could be described as "convergence of previously separated research streams" (Day and Schoemaker, 2000). Srinivasan (2008) mentions "convergence in technologies" and Stahl (2011) argues that technologies "have already moved beyond the purely conceptual stage".

Coherence brings the right balance between technology performance and technology diversification. Getting some elements of certain technologies and smartly putting them together, creating in this way a "new" technology named "emerging", means coherence. The older ones remain with their benefits; meanwhile the emerging ones bring new and sometimes, unexpected results. In this way, the emerging technologies detach themselves form their "parents", getting their separate identity. Furthermore, they must stay detached for some period of time to be seen as self-sustaining (Glänzel and Thijs, 2012). Coherence refers also to some characteristics of the organizations seen as groups of people, such as "working together using logical interconnection", "being united" or "congruity" (Rotolo, Hicks and Martin, 2015).

The fourth defining attribute of emerging technologies is to bring "benefits for a wide range of sectors" (Martin, 1995), "create new industry or transform existing ones" (Day and Schoemaker, 2000), "exert much enhanced economic influence" (Porter *et al*., 2002), or change "the basis of competition" (Hung and Chu, 2006); in other words, changing the paradigm of the socio-economic world.

The final defining attribute of emerging technologies is the uncertainty. The non-linear and multi-factor nature of emergence provides it with a certain degree of autonomy, which in turn makes the prediction a difficult task (de Haan, 2006; Mitchell, 2007).

Another important characteristic of emerging technologies is ambiguity which arises because proposed applications are still malleable, fluid and in some cases contradictory, *i.e.* even the knowledge of possible outcomes of emergence is incomplete. It looks like a logical and flexible game, based on some uncertain rules, without a predicted end and winner. Uncertainty and ambiguity are key starting concepts for a wide variety of science and technology studies (STS) focusing on the role of the expectations in technological emergence (van Lente and Rip, 1998).

By using emerging technologies, the organizations evolved to boundless or virtual ones. The formal links became more and more informal, the flexibility and the goals focus increased, the evaluation being easier.

Example of AI used as a means of production

Focusing on the Artificial Intelligence (AI) as typical example of emerging technology, we may observe that mechanism on which the AI applications are based is similar in some aspects with the one used in

organizational system design. Thus, the algorithms based on machine learning consists in providing information and an objective to the machine, giving positive or negative feedback depending if the he way proposed is closed or not to the right one, leaving to discover itself the correct one (Fry, 2018).

The design of an organizational system starts with the goal (final result), continues with a series of rules concerning groups, communication or policies – to obtain a structure able to fulfill the goal. Rapid change of the business environment enriches the management with fresh information that involves structural changes, while the goal remains the same. However, there always is a certain degree of uncertainty, transforming the industry, and allowing discontinuous innovations.

The border between ICT people and general users of applications is more fluid, their roles in the companies being closer. If the hardware emerging technologies, like robots, are already used in production, AI and blockchain evolve from an IT product used as system facilitator to a mean of production, becoming in this way the most "complete" emerging technology. This tendency can already be observed in some industries, such as the financial (the blockchain technology, using complicated encryption algorithms and based on deregulation principle, created the cryptocurrencies and their transactions), banking or pharmaceutical.

Use case, Pharma Industry

On the pharmaceutical market, specifically, in January 2020, Bayer AG has announced the beginning of its collaboration with Exscientia Ltd., a UK-based drug-discovery startup (Bayer, 2020).

Like most companies of its size, Bayer was already using AI products that help them process the data they have (*e.g.* operational or medical). An example is an AI-based product that supports Bayer to find the right treatment for the different patients suffering of cardiovascular disease (Derix, 2020). The idea behind this product is to use the data collected during everyday healthcare to segment patients based on their symptoms and characteristics. This would help understand which patients are more likely to develop a cardiovascular condition, and which is the best way to treat them. In this case, AI is used as support means for the company, being part of the facilitators system.

However, through the collaboration with Exscientia, the company is moving one step further, using AI to develop new drugs (*i.e.* a new product). Exscientia is a start-up based in Scotland that has built a platform that is using AI to the discovery of small molecule drugs. The company has announced that they developed a compound that has entered a phase 1 clinical trial after less than 12 months from the initial screening (Burki, 2020) – which is remarkable, because the average duration for this stage of drug development is 4-6 years.

Actually, the AI-driven design of drug combinations has already marked a paradigm shift in the drug development (Rashid, 2021). Rashid and Chow (2018) have reported that AI was used to develop pharmaceuticals to *personalized medicine*.

The cutting-edge technology of Organ-on-a-Chip is what the pharma industry is searching for, as it "can emulate the physiological environment and functionality of human organs on a chip for disease modeling and drug testing" (Ma *et al.,* 2021:119). This technology "can have critical roles in different preclinical stages of drug development and highlight the current challenges in translation and commercialization of this technology for the pharmacological and medical end-users" and future Organ-on-a-Chip platform is going to "bridge the gap between animal studies and clinical trials for the pharmaceutical industry" (*Ibidem*).

Other scientists have also shown how deep learning (a branch of AI) can be used for antibiotic discovery (Stokes *et al*., 2020). In this instance, the AI algorithm was able to identify a molecule that was not previously known to have antibacterial properties. The use of AI is associated with significant changes in

the profiles of qualifications and job descriptions, technology and management processes, and in organizational structures entirely.

All these examples demonstrate that the pharmaceuticals industry is moving towards including AI technology as a means of production.

Conclusions and managerial implications

In the new world, the management is facing huge challenges in its efforts to adapt the organizational system to the rapid growth of emerging technologies. The study's findings shows the significant changes within the organizations by using Emerging Technologies, like appearance of new departments with new roles, the redefining of some others, new organizational structures, etc.

If the *Figure 3* shows the static form of a general structure of the Organizational Systems, *Figure 5* shows the dynamism of the organizations due to Software Emerging Technologies. The way presented is not only irreversible, but has a much higher speed compared with the former evolution/s. This rapid evolution involves changes in the structures of the organizations, making them much more flexible, increasing the volume of the informal communications, but keeping a clear chain of command.
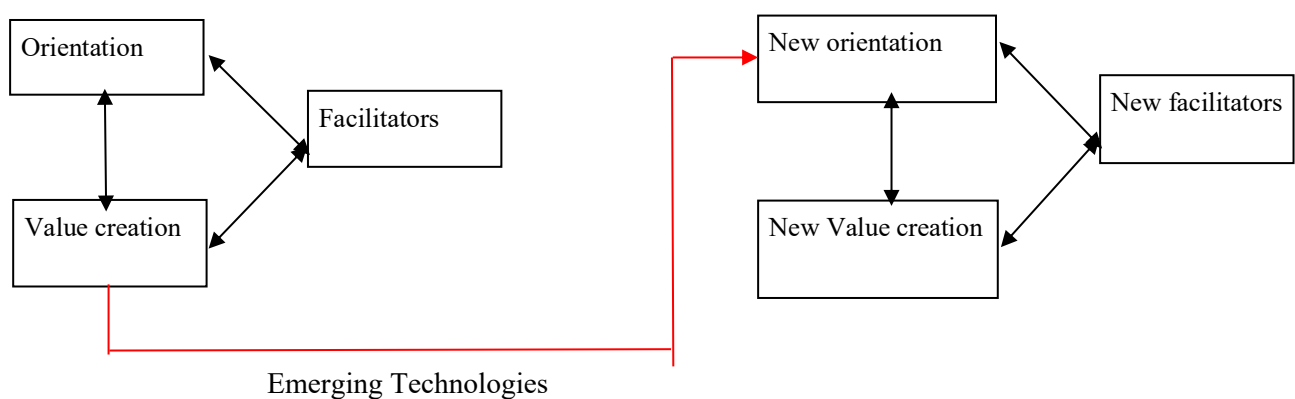

Figure 5. The evolution of the companies under emerging technologies influence

The role of the small and medium-sized companies increased, new occupations appeared as well as freelancers; some "old" ones becoming obsolete, while new type of entrepreneurs came on the market.

The change became more observable since the software emerging technologies overpassed the classical role of support means, becoming production means. New types of products have been defined, reaching the moment when "human beings are the products" (Tim Cook, Apple CEO).

The examples from pharma industry demonstrate that *use of AI is associated with significant changes in the profiles of qualifications and job descriptions, technology and management processes, and in organizational structures entirely.*

Limitation and future research

The paper is limited to the study of influence of emerging technologies (mainly software) in the organizational systems, seen as being composed by three subsystems: value creation, facilitators and orientation. There also are some considerations about how the organizational design is affected.

This paper is considered as starting point for further research on how the structures are changing and how an organization can be modeled under the impact of the software emerging technologies.

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