Enterprise Information System, Agility and Complexity
What is the Relationship?

Hakima Mellah[1] and Habiba Drias[2]

[1]*Research Center in Scientific and Technical Information, CERIST, 03 Rue des Fréres Aissou, Ben Aknoun, Algiers, Algeria*

[2]*Houari Boumediene University of Sciences and Technology, USTHB, Algiers, Algeria*

Keywords: Complexity, Enterprise Information System, Agility.

Abstract: The term complexity is present everywhere. Complexity surrounds information, information system, organization as well as computing systems. In this work we present some challenges that deal with complexity. Why can enterprise organization be seen as complex? From what, complexity can arise within enterprise information system? What is relationship between complexity and agility? What are factors that may evolve complexity within enterprise information system? How computing system led information system towards complexity? To response to all this challenges, several dimensions dealing with complexity are displayed such as dynamics in enterprise information system components, while interacting, that can be tolerated by components autonomy; intelligibility that causes knowledge evolving; and inter-connectivity that is necessary with distribution. All these factors influence each others, within a three dimensional system. UML modeling of enterprise information system that includes complexity parameters is given.

1 INTRODUCTION

Technological advances means of information processing and dissemination encourage new uses emergence putting users at the center of the computing system. This leads us to more complex systems, whose evolution is guided by the use, which is in its turn modified. We can cite in this context, the evolution of the Internet and Web for example or Web1.0 to Web2.0. Future computing systems and their use are facing an increasing complexity due to the following changes:

- Emergence of new computing environments such as large-scale as well as mobile ad hoc networks
- Emergence of new uses and needs from this evolution, requiring sophisticated applications, using large complex data volumes
- A strong need for user-centered applications, where Information Technology (IT) system user is considered as a major component or as an important integral part entity of the system. The development of these applications and their evolution are driven by user-system interactions. We can consider the system as a set of IT components interacting with each other and with the environment
- The advent of service technology, the web, large-scale networks, etc., making the computing environments more open and distributed and components are no longer under the control of a single organization
- Computing environment is heterogeneous, thus, becoming difficult to configure, maintain and troubleshoot

In this context, thinking about IT system engineering requires the integration of its complexity as an essential characteristic. IT system complexity arises from its opening to its environment, itself complex, distributed and dynamic (Hassas, 2006), (Benatallah et al., 2003), (Hassas, 2003). These IT developments and their features have a strong impact when it comes to be deployed in environments like that of the enterprise. The enterprise, taking advantages of these evolutions, finds itself constraint to change its organization and its information system. These developments are also dictated by the enterprise business environment evolution, beyond its computer system, and rely on informational and structural entries made by the Enterprise Information System (EIS). The latter belongs to complex systems category because it interacts with other EIS, computer systems, resources and users. These information systems are distributed,

Mellah, H. and Drias, H.
Enterprise Information System, Agility and Complexity - What is the Relationship?.
In *Proceedings of the 1st International Conference on Complex Information Systems (COMPLEXIS 2016)*, pages 74-80
ISBN: 978-989-758-181-6

heterogeneous, decentralized, interdependent, and often operate in a dynamic and unpredictable environment (Mordinyi and Kuhn, 2011). EIS represents the mean used by the enterprise to protect its data, to have a memory, retrieve, store, process, disseminate, exchange information that is the foundation of business intelligibility and knowledge. According to (Peaucelle, 1997) it embodies the language used to represent the organization reliably and economically aspects, it is seen as as the organization. However, information is considered as one of the main resources of the enterprise's business, that is being evolved through interaction and communication.

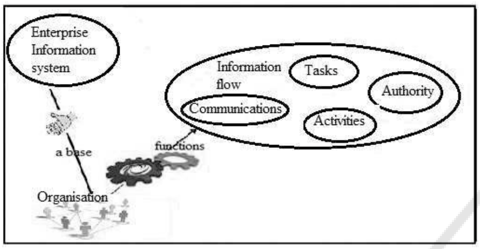

Figure 1: Information system, Organization, information flow: A complex framework.

What is noticed is that the activity in the enterprise generates information flows (figure 1), and for that some authors such as Hugues Angot (Angot, 2006) addressed the organization in information flows terms, and what is emphasized are structured relations between the different information sources components. This what explains the JJ Lambin (LAMBIN, 1990) vision, for the EIS, as structured relationships complex network, where are involved humans, machines and procedures, which aims to generate relevant information ordered flows from the enterprise internal and external sources, intended to serve as a basis for decisions and solutions presented to the user. EIS can be viewed through the dynamic organization (and even self-organization) of its flow. Information flow generated during the execution of an activity or task is susceptible to disturbances that may block its routing, thus making the system obsolete. In order to overcome the disturbance, one solution would be through other network topologies, thus generating new communication links, which did not exist a priori between different interacting entities. This explains our vision of flow management problem, as a self-organization problem. And consequently a solution to the problem mentioned above would be the induction of a self-organizing mechanism that is a key feature of complex systems. With the large scale processors networks evolution like Internet, considered as the most used mean for information exchange between enterprises, new practices are highlighted and new needs have emerged towards the computing environment. It is therefore necessary to think about computing systems development able to work intelligently with their environment systems. Tackle EIS in a holistic view considers it as a whole or "holism" without separating the user from the EIS contents and the environment in which this system interacts. This is especially true in a dynamic environment context where interactions between different parts of the computing system are constantly changing, requiring challenges of its structure, organization, interactions and its dynamics. Currently the information flow increasing systems' complexity is a characteristic of enterprises and manufacturers regarding products, services to offer, and all information exchange. This complexity also comes from changing environments that are disturbance surrounded, in which EIS operate. Difficulties arise and the system has to solve unforeseen problems on the basis of available information that is generally incomplete and imprecise.
A complex system is a system, characterized with self organization, adaptation, evolution, etc., it consists of plenty of constituents which interact in a hierarchical frame to function as a whole. Emergence, adaptation, evolution are the elementary properties of complex systems, where emergence is the most essential feature (Zundong et al., 2010).

2 COMPUTING SYSTEMS AND ENTERPRISE INFORMATION SYSTEMS

Computing systems evolution, evolved by fact and in the same direction EIS. Computing systems evolution and the emergence of new technologies, reveals evolution needs in the same direction of information systems, which is seen at the same time as an opportunity for EIS to benefit from these evolution. Further, EISs as complex systems are systems whose components interact to accomplish goals. The developers of such systems must, in addition to the application logic expressing the reaching goal, to include a management and supervision logic in order to overcome the environmental problems for which the organizational goal cannot be reached. The management logic is important, for example, in case of EIS components non functioning (Mordinyi and Kuhn, 2011).

2.1 Enterprise Organization

Evolution in enterprises organizations was clearly noticed in the last decade (Mintzberg, 1994). It took into account the networks, knowledge and skills management, cooperation, enterprise organizational structure, for the following reasons:

- The economic transformation that requires responsiveness
- The competitive nature that is a factor of organizational requirement
- The costumers/users growing power pushing enterprises to reshape their organization to better respond
- The facility offered by the IT for information exchange internally and externally

The reasons cited above showed that the organizational implementation of strategies is a key performance factor and the organization became a part of the enterprises competitiveness. These organizational changes result in two heavy and common trends to many enterprises that are exploding the organization boundaries and the transversal management. The basic elements constituting an organization (Mellah et al., 2007) are connected by a variety of complex flows that are all important and explain how an organization operates (considering all of these flows). (figure2)shows the environment in which EIS evolves considering different dimensions that make the system complex. The characteristics of this flow are:

- The massive character. Given the important need of customers/users that is increasing and the flows variety and their complexity. These flows connect all the basic elements of an organization and may involve authorities, materials, or simply communications and all these parameters need control to assure their connectivity and survive. Information uses increase its intelligibility that is a key for knowledge management.
- Dynamic and autonomy. Tolerated by the advent of communication IT (eg intranet), in the sense that IT break formal organization barriers to form working groups that are non formal organizations. ITs endow EIS of autonomy.
- Distribution and inter-connectivity. ITs provide a growing organization, the means to be split into different parts distributed on the network that can communicate later with each other. Maintaining this distribution, inside or outside the enterprise, must be assured by means like self organizing protocols (Mellah et al., 2007). Interaction networks link organizational positions to form organizational structures. In the context of cooperative distributed problem solving (CDPS), an organizational structure can be seen as a way to specify the coordination strategy (pa S. Young and Edmund, 1993).

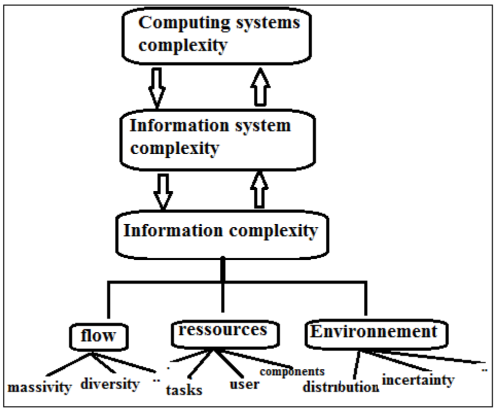

Figure 2: Complexity parameters surrounding information.

2.2 System-environment Coupling

The vision adopted by (Hassas, 2003) considers the computing system as a set of components in interrelational and retroactive interactions, evolving in a shared, dynamic and uncertain environment that correspond to that of a complex system, is inspired from autopoetism/Enactivism characteristics. But we must not be confused by autopoetism abstract conceptualization and by complexity theory which treats systems as entities that we see outside ourselves. We are part of the problem and of the solution (Cachon, 1999). The challenge of this type of system is to find an effective organization of its components (by self-organization), in organizational structures implementing or highlighting a coherent behavior towards the environment complexity. However, living systems have managed such a challenge for millions of years. As supported by the Enactivism (Hassas, 2006), we believe that this ability to living systems is due to their coupling with the environment. Natural phenomena are an inspiration source in different computer systems areas (Bonabeau et al., 1999)(Drias et al., 2005). This phenomenon is due to the fact that living systems have properties that allow them to adapt to a complex environment. Systems such as cell organisms, insect colonies or societies of individuals exhibit complex global behavior that self organizes their components into robust and flexible structures. These systems are characterized by a high reactivity, robustness to individual failures, and a great capacity to adapt to environmental changes. Several computing areas have referred (Hassas, 2006) to bio-inspired approaches. Rats, spiders, ants, fish, birds, bacteria, etc., are all natural living systems that attracted researchers attention, for differentiation, information dissemination, aggregation, optimization,...etc. All these works mainly refer to the Stigmergy mechanism (Grasse, 1959) which was discovered by P.P Grasse, and is used by insect colonies to coordinate their behavior. Coordination is assured through the persistent effects left in the environment by previous actions on the future actions of agents. The environment is considered as a space fit these traces of actions and interactions. Structures and processes emerge in a autopoetic vision (ie the permanent co- evolution of the process and structure as a result and process support (Hassas, 2003).

To overcome the deadlock situations that may encounter a distributed system and that will disturb its inter-connectivity, IT designers (or sellers) recognize that it is necessary, even essential to think about designing systems that assume themselves, their management. This is recognized in academic and industrial settings by Oriented Autonomic Computing, recognized in 2001 by ”Paul Horn” (senior vice president of IBM Research) as analogous to the human’s nervous system (Markus and Julie, 2008). The Distributed Autonomic Computing or DAC is accomplished mainly through the implementation of self * properties which can be classified according to a taxonomy of criteria and in this taxonomy we find the resource allocation, which is characterized by the fact that a system needs to allocate limited services or allocate tasks to resources,etc. (Frei and Giovanna, 2011). Information delivered by an EIS is captured in a complex way. It can be framed in a three-dimensional system with content, use and structure dimensions (Mellah et al., 2008), as it is considered that information content must be related to other content, and is nothing without external factors (environment), to this information, without the value given by the user and without context raised pertinence (Mellah et al., 2013b).

3 COMPLEXITY AND AGILITY

The first changes, in perspective, known by organizational theory, is the transition from a closed to the perspectives of an opened system (Mellah et al., 2008) taking into account organization’s external factors. To evolve, an EIS must be opened to its environment. We find this openness and evolution in the characteristics of agile information systems. Agility is defined by Gartner as ”the ability of an organization to sense environmental change and responds efficiently to that change”(Mellah et al., 2013b). Agile information system is a system able to adapt to the functional and technical developments, it is often more open to absorb management process with third parties, and allow organization evolution without challenging business applications. In practice, agility is materialized by ”services” orientation [wikipedia].

Definition. We define an agile information system as a self organizing system or a system endowed with a self organizing mechanism. We consider the agility of an EIS as a new class in the taxonomy of self * properties criteria.
This definition underlines that an agile information system as it is characterized by self organizing property is a complex system. The computing resources offered by an agile information system are expressed in terms of services. They have the following features(Mellah et al., 2013a):

- May extend beyond the enterprise boundaries through transit interfaces such as Internet.
- Are requested by the mean of interfaces used to interact with a variety of enterprises (other organizations).

Conversely an organization providing any service is often called upon to interact with a set of service requesters (Benatallah et al., 2003) the service can have the following characteristics:

- changing and evolving over time(Thompson, 1967).
- appearing in a new version instead of the old one.
- new version of services with advanced features can be offered by organizations integrating interaction process.

”Computer services” create the technological foundations and management required to support enterprise agility (McCoy, 2007) and complexity. To ensure this agility and enabling services use in order to meet the business process and the user, it is important to have a software service-oriented architecture (SOA) (McCoy, 2007)(Mecella and Pernici, 2006). System-environment coupling, that characterizes agile information system, is among the arguments justifying the consideration of the above issues in terms of EIS modeling through information flows, their inter-dependencies, their dynamics. Within MAS paradigm, this coupling can be assured by a self organizing protocol (Mellah et al., 2007) and can be projected within SOC (Service Oriented Computing) as an SOA solution for agility (Mellah et al., 2013a) that leads systematically an SOA to an ASOA (Agile SOA). Consequently an ASOA is defined as being a SOA whose components self organize while encountering disturbance within environment. Agility as it is matched to complexity considers EIS in two levels: (i) a core centered data, users, and connectivity between them, (ii) a shell evolving in

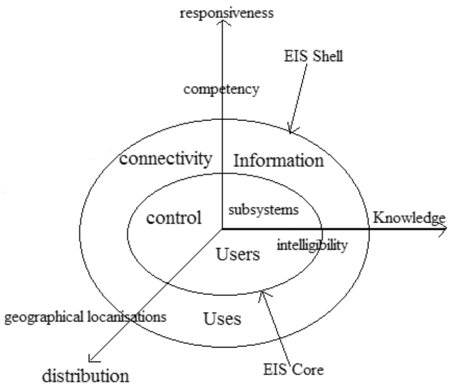

Figure 3: Agility parameters within EIS.

three dimensions, which axis are supported by intelligibility, dynamics and inter-connectivity. The three parameters are involved and represent the support of knowledge, autonomy and distribution intra and extra enterprise (figure3).

4 ENTERPRISE INFORMATION SYSTEM MODELING

Organization theory deals with complexity as a structural variable that characterizes organizations and their environments (Zaho et al., 2007). Draft (Syntec, 2007) matches complexity to the number of activities or subsystems, which basically composes the organization. This implies that a complex system is a system of systems. More the system has subsystems and more it is complex. Complexity can be decomposed into three dimensions: vertical, horizontal and spatial, corresponding respectively to the number of levels in the organizational hierarchy, the number of posts or departments within an organization, and the number of geographical locations. We can identify the following understandings (Zaho et al., 2007):

- Activities/subsystems. Each subsystem can be composed by other subsystems
- Activities/subsystems have a geographical location (network's node) that may change well. Therefore, they do not have a persistent physical location
- Activities/subsystems can be decomposed to highlight features that are invisible at first sight. That is an important characteristic of complexity. The decomposition can be done based on relative uses that characterize subsystems. While they are decomposed, a structure or a pattern is generated (figure 4).

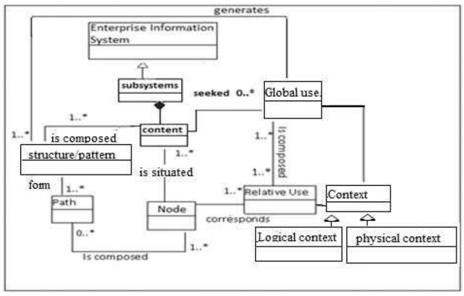

Figure 4: EIS classes diagram in relation with entities implied in information flow.

These points highlight the key features of agile information systems, well supported by a SOA (McKelvey, 1999). The key features appear to be compatible with Drafts proposal. In order to tackle information system complexity, it is required to harmonize the quality of service offered to users internally and externally. A new version for the design of complex systems is called organic computing (Mellah et al., 2013a). The latter satisfies conventional requirements for trustworthy systems, which autonomously adapt to dynamic changes of the environment, and have self-x (self-organizing, self-healing, etc.) properties (McKelvey, 1999) as postulated for autonomic computing (Markus and Julie, 2008). From our perspective, we recognize the information complexity, issued from a set of interacting EIS or from a SOA, in a three-dimensional system, handling service, context and service discovery structure (Draft, 1992).

Each EIS represents one or more organizations, one or more subsystem. We can note a mapping between our work and that of Draft, interpreted in the following points:

- Each level of an organizational hierarchy corresponds to the existence of services, and the number of departments in an organizational level may correspond to the number of contexts that we ascribe to services.
- The geographical locations constitute the service discovery structures generated by the various service discoveries, to meet the needs of the user and achieve the desired goals.

Considering these technicalities, we confirm that complexity theory is easily supported by a SOA, in the sense that SOA offers issues to integrate self-organization within a SOA as it is a key feature of complex systems(figure 5). Self organization can be handled on the basis of layered architecture(Mellah et al., 2013b) and a Self Organizing (SO) protocol (Mellah et al., 2009; Mellah et al., 2010). The SO protocol controls interaction between nodes supporting EIS contents, by the mean of checking and routing

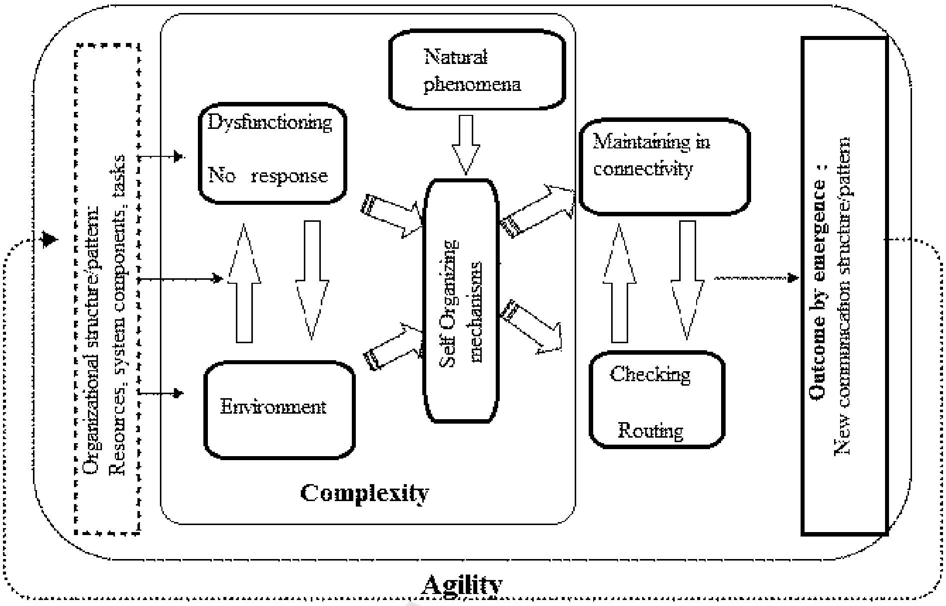

Figure 5: Illustrative schema on agility, complexity and system-environment coupling.

process to maintain connectivity of the hole system (Mellah et al., 2009; Mellah et al., 2010).

5 CONCLUSION

In this work we have presented some challenging situations that deal with complexity and that turn around information, EIS, computing system. The complexity parameters that surround information, and that make complex EIS, are presented. A self organizing view to agility (that is matched to complexity) is given. While discovering contents, offered by a EIS or its subsystems, a structure is generated. Without considering the use context which can be either relative use characterizing the content itself (can varied), or global use, characterizing the system in its hole, the structure represents itself a complexity support(Mellah et al., 2013b), because it is this structure that gives robustness to the system, by self organization, recognized as a feature of complex systems and of agile information systems.

REFERENCES

Angot, H. (2006). *Systeme d'information de l'entreprise: Analyse theorique des flux d'information et cas pratiques*. Editions de Boeck universit. Bruxelles.

Benatallah, B., Muas, M., Fauvet, M.-C., and Rabhi, A. (2003). Towards pattern of web services composition. In *Patterns and skeletons for parallel and distributed computing*.

Bonabeau, E., Dorigo, M., and Theraulaz, G. (1999). *Swarm Intelligence: From Natural to Artificial Systems*. Oxford University Press.USA.

Cachon, G. (1999). Complexity theory and organization science. *organization science*.

Draft, R. L. (1992). *Organization theory and design*. Saint Paul Minnesota: 4th west publishing company.

Drias, H., Sadeg, S., and Yahi, S. (2005). Cooperative bees swarm for solving the maximum weighted satisfiabity problem. In *IWANN*.

Frei, R. and Giovanna, D. M. S. (2011). Advances in complexity engineering. *International Journal of Bio-Inspired Computation*.

Grasse, P. (1959). La reconstruction du nid et les coordinations interindividuelles chez bellicositermes natalensis et cubitermes sp. la theorie de la stigmergie: Essai dinterpretation du comportement des termites constructeurs. *insectes sociaux*.

Hassas, S. (2003). Complex systems based on situated multi-agent systems, in french:systemes complexes a base de multi-agents situe. hdr. In *Liris Lyon*.

Hassas, S. (2006). Engineering complex adaptive systems using situated multi-agents: Some selected works and contributions. In *ESAW 2005*.

LAMBIN, J. (1990). *La recherche Marketing*. Hill, Mc Graw.

Markus, C. H. and Julie, Q. M. (2008). A survey of autonomic computing-degrees, models and applications. *ACM computing surveys*.

McCoy, D. (2007). *Defining cultivating and measuring enterprise agility*. Gartner Research.

McKelvey, B. (1999). Complexity theory in organization science: seizing the promise or becoming a fad? *Emergence*.

Mecella, P. and Pernici, M. (2006). Cooperative information systems based on a service oriented approach. *Inter-*

national journal of interoperability in Business Information Systems.IJBIS.

Mellah, H., Hassas, S., and Drias, H. (2007). Towards a self organizing protocol for a multi agents system. In *The sixth International IEEE Conference on Networking (ICN'07)*, pages 60–66.

Mellah, H., Hassas, S., and Drias, H. (2008). Modeling information in a three dimensional system to contribute to the agility of an enterprise system. *System and Information Sciences Notes, CoSIWn*.

Mellah, H., Hassas, S., and Drias, H. (2009). Massop : A self organizing protocol for multi agents systems inspired by bacteria colonies. *International Transactions on Systems Science and Applications*.

Mellah, H., Hassas, S., and Drias, H. (2010). *A Formal Approach for a Self Organizing Protocol Inspired by Bacteria Colonies: Production System Application. Book Chapter. In Bio-inspired Models of Network, Information, and Computing Systems*. LNICST. E. Altman et al. (Eds.).

Mellah, H., Hassas, S., and Drias, H. (2013a). A fault tolerant service discovery by self organization: a mas approach. *International journal of Business Information System.IJBIS*.

Mellah, H., Hassas, S., and Drias, H. (2013b). Service computing and agents paradigm for managing distributed information sources. *International journal of Business Information System*.

Mintzberg, H. (1994). *Structure et dynamique des organisations*. Les editions dorganisation.

Mordinyi, R. and Kuhn, E. (2011). Coordination mechanisms in complex systems. *Next generation Data technologies*.

pa S. Young and Edmund, D. H. (1993). An organizational self design model for organizational change. In *Workshop on AI and Theories of Groups and Organizations*.

Peaucelle, J. (1997). *Systemes dinformation. Encyclopedie de gestion*. Economica.

Syntec, I. (2007). *Les architectures orientes services. Livre Blanc*. collection thematique.

Thompson, J. D. (1967). *Organizations in Action:Social Science Bases of Administrative Theory*. McGraw-Hill.

Zaho, J. L., Mohan, T., and Liliang, L. (2007). Services computing as the foundation of enterprise agility:overview of recent advances and introduction to the special issue. *information systems Front*.

Zundong, Z., Limin, J., and Yuanyuan, C. (2010). A new kind methodology for controlling complex systems. *World Academy of Science, Engineering & Technology*, 68(44):146–159.