Towards A General Systems Theory Approach for Developing Concurrent Engineering Science

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Abstract. Information, as a specific commodity, sustains our knowledge production in every domain of human activities. But the Knowledge-based Economy (KbE), requires intensive information and Knowledge Management. The KM is the key-factor of enterprises competitiveness (LS- large scale enterprises; SME- small and medium size Enterprise ;μE- micro size enterprises). Even the e-workers, immersed in Professional Virtual Communities must use efectively both basic concepts, methodology, methods and techniques from concurent engineering science. To design the Complex Adaptive Systems, is our our long-term research target. The present paper is an ambitious attempt to initiate a global collaborative project for the DCCE scientifically foundation based on General Systems Theory holistic approach.

Keywords. General System Theory, Interoperability, Distributed Smart concurent Engineering, Concurent Science.

1 Introduction

The Concurrent Engineering is a quite "young" (25 years) multidisciplinary domain of interest, but the time has come to convert it from "best practices" – oriented methodology engineering - to a smart Distributed Concurrent & Collaborative Engineering Science (DCCE)

Web science and Internet Technology provide enterprises (Large Size, SMEs, μSMEs) with better and more flexible ways to fully satisfy their customers on the global e-market. Enterprises are increasing their efforts, even more in order to improve their (intra and inter) business processes, in order to reach a more

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competitive level, as well as become more agile actors [Loss, Rabelo, Perreira-Klen 2005a].

Available estimates indicate that SME 's are the main employers in Europe, representing 60% of the Job market [5]. It is also estimated that industrial subcontractors represent roughly 20% of al industrial jobs.

1st of January 2007 marked the beginning of the 'new wave' to enlarge the European Union (27 countries) after Romania and Bulgaria, both joined in. In the newly integrated 'members' economy, the real ratio of SMEs contribution is more spectacular (e.g. 92% in Romanian economy). The challenges to develop a sustainable digital and global economy by using the advanced ICT-platforms are the key-drivers of Knowledge based Economy. The academic research community has received this 'message' since the '80s. In a huge effort to fill the gap between remarkable scientific achievements and the real socioeconomic needs, a "new requirements list" has been developed during the last three decades.

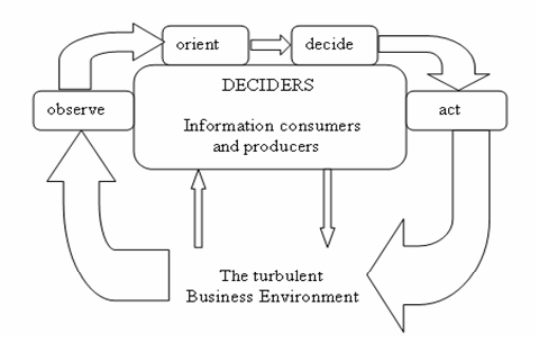
Altough many Reference Models, Standards, Frameworks and IC-Technologies have been created, 'Enterprise Interoperability' (IST-FP6-successful projects: ATHENA, ECOLEAD, INTEROP, [9, 10, 11] a.s.o), still represents a key-problem to be fully solved in the years to come**.** The main paradigm that concerns many authors with in their present research is 'Virtual Organization'/Collaborative Networks [1]. Taking into consideration the international research context, one could notice that the "concurrent engineering "(CE) paradigm, that has been rapidly developed since 1982, has to be re-balanced from an advanced methodology useful in engineering science including methods, tools, techniques into a collaborative sciences foundation.

The paper is structured in the following sections: Section #2 is concerned with the GST (General systems theory oriented framework); Section #3 deals with a new approach for the ICT- Infrastructures Architecture of collaborative platforms supporting the nowadays geographically-distributed Concurrent Engineering (DCE);Section, Section #4 provides a case-study (REMEDIA- project).

2 General System Theory-oriented Framework

2.1 Paradigm Shift

The companies are overheated by ICT- technologies. The well-known MONITOR/ANALYSE/PLAN/EXECUTE (MAPE) has been provided by the Department of Defense-USA some time ago, but we also stress on another J.R. Boyd FEEDBACK PARADIGM O.O.D.A .(OBSERVE /ORIENT /DECIDE /ACT) addressing the decision-makers for every domain of real economy.



1. The OBSERVE-ORIENT-DECIDE-ACT (OODA) loop

The 'classical behaviorist' (psychology) uses to explicitly deal with uncertainties the 'S.H.O.R.- STIMULATION-HYPOTHESIS-OPINION-RESPONSE' paradigm is useful for [8].

In the following we must consider the meaning of these general features:

- Extending and enhancing scientific knowledge and truth about our existence.
- Using management of existing knowledge and truth about existence.
- Producing new technological knowledge through innovation.
- Unprecedented dissemination of knowledge to address citizens through new channels of modern communication.

The five 'pillars' of knowledge-focused education as described by UNESCO bring into attention the 'step like-staircase' of 'Lifelong Learning' paradigm: Learn to know / Learn to do / Learn to live together / Learn to be / Learn to choose

Jussi T. Koski, professor at Helsinki Technical University compares the idea of learning to be to the future wish of various organizations and working life by Charles Mandy, that an increasing number of people would stop working increasingly earlier in life in order to become what they really are. This means that the transparency of values is essential. J.T. Koski was the one who completed the UNESCO four-dimension LEARNING space with the fifth: LEARNING to CHOOSE . This is highlighted as part of personal, skilful competence. Choosing presumes 'mastery of values, without which people may lose their ability to act. Mastery of values is the individual's capability to prioritize matters based on a personal life experience on his or her capacity to learn'. Skilful competence consists of developing 5D-Learning in a stable, harmonious fashion.

Taking into consideration this trendy 'societal positive tsunami' that involves every citizen of the Planet in the future (Knowledge-based economy that is sustained by lifelong learning), several research projects have studied the 'Virtual Organization' area. Usually the focus was on issues supporting creation rather than on management actions (e.g. IST-FP6-ECOLEAD, 2005 [10]). The 'Learning Organization' remains a challenge for our Information Society! [6]

A paradigm shift is required to dynamically meet the needs of 21st Century experts' for exploiting information as well as to speed up the decision making processes! [6].

2.2 Von Bertalanffy's General Systems Theory reloaded

Keeping in mind such turbulent "Research Eco-Systems", an "ad-hoc" buzzword with respect to Business Eco Systems [1], the authors have just made an attempt to find which could be the 'CENTRIPETIC' force to reduce the 'entropy' of our days scientific life. Our response focuses on re-evaluating the key-role of General System Theory (for Collaborative Concurrent Engineering), but is not limited to this.

From 1930 until 1976, the famous "parent" Ludwig von Bertalanffy has provided a solid-ground scientific foundation for General System Theory. Von Bertalanffy wondered: Is cultural change and evolution essentially expression of an inherent and auto continuous dynamics or is it brought about by cultural diffusion? Is history a sequence of individual, unrepeatable and therefore merely describable events, or does it show recurrences and regularities as, respectively, the opposing "idiographic" and "homothetic" views of history contend? However, by changing the structure of organization, perhaps culture, and the business environment in which it exists can progress. Bela Banathy's concept of a "Human Activity System" offers great promise. Banathy describes a Human Activity System as 'an assembly of people an other resources organized into a whole in order to accomplish a purpose. The people in the system are affected by being in the system, and by their participation in the system they affect the system. People in the system select and carry out activities- individually and collectively- activities that will enable them to attain a collectively identified purpose'.

"The behaviour of complex, adaptive systems cannot be captured by constrained optimization models. This is a fundamental departure from the presumptions inherent in conventional economics. Such systems have to be analyzed 'in' time and this limits the way in which mathematics can be used. The historical trajectory is that the value of an economic network in a complex adaptive system can be represented mathematically, e.g. as a logistic equation, but it is not derivable from a set of axioms set in a timeless context". However, conventional deduction can still be used to specify adjunct hypotheses concerning the factors that shift historical trajectories around. It follows that, in complex adaptive systems, the stationary states such trajectories attain are not analytical equilibriums but, rather, end states of cumulative historical processes.

The state of the art in "Enterprise Interoperability & Integration" domain proves the Information Systems axe integrated successfully with Business & Management Layer [7]

“An Information System can be any organized combination of people hardware, software, communication networks and data resources that COLLECTS, TRANSFORMS&DISSEMINATES INFORMATION in an ORGANIZATION” [4]. People have relied on IS to communicate with each other using a variety of physical devices (hardware), information processing instructions and procedures (software), communication channels (networks) and stored data (resources) since the dawn of civilization.

Considering the difficulties noted above, they also require capabilities to initiate and lead transformation as well as understanding the wider social, economical and cultural implications of proposed transformations. The

interdisciplinary character will increase as claims that IT is no longer a source of strategic advantage have generated a growing concern over the loss of pure technology-oriented jobs and increased the demand for business-oriented IT jobs. It is expected that demand will increase for integration, enterprise architecture, information management and business process management. The integration between Business Process Systems and Information System in progress of being consolidated by the interoperability research issues.

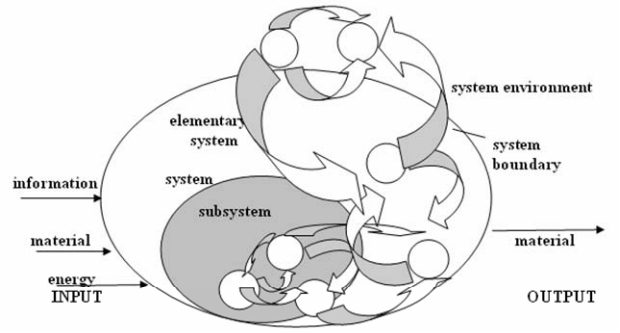
The researchers will establish numerous knowledge links to other enterprises or co-workers with which they combine rapidly and flexibly to respond to market changes or to create new markets. The size of an enterprise will matter less than its ability to collaborate, its ability to adapt, and its ability to interoperate [3].

The most important challenge raised by the new focus on the interoperability is to determine a way to represent the complex system specification semantics according to sustain collaborative work.

4 Interoperability - focused Distributed Collaborative Concurrent Engineering Framework

Coming back to the CE - focused domain, a distinction can also be made between meta-system / hyper-system / functional system / subsystem / aspect system / application module (API) / granular micro-system. A distinction can also be made between subsystems and aspect systems in order to gain a better insight into complex adaptive systems. A subsystem is a subset of elements in a system, in which all original relationships between these elements remain unchanged. An aspect system is a subset of relationships in the system, in which all elements remain unchanged. Furthermore, a distinction is made between *static systems* and *dynamic systems*. Contrary to dynamic systems, in static systems no events occor. This behaviour is the manner in which the system reacts to certain internal and external changes. A process is defined as a series of transformations in the course of the throughput, as a result of which the input elements undergo a change in regard to their place, position, size, shape, function, property, or any other characteristic.

In regard to the presence of the process, permanent and temporary elements can be distinguished in the system. The permanent elements are the subsystems or components of the assembly system, such as feeding systems, robots and sensors. These subsystems fulfil functions in the assembly process, and form, through mutual relationships, the structure of the system. The temporary elements are continuously imported into the assembly system and transformed into an output desired by the environment (market). These elements entail a flow of material (product parts), an energy flow and an information flow. The emphasis lies on the flow of material. Hence, only the flow of material is considered in regard to the output .



2. Graphical representation of dynamical system

A e-Collaborative Enterprise as a geographically dispersed meta-system is a meta-system with a SoS or FoS topology supported by the following mathematical model [Stanescu 2002]

$$S^{e-CE}(.) = \{ \text{MVIEWS}, \text{MPLATF}, A, R, G \}$$

MVIEWS is a N views modelling framework of the meta-system

MPLATF is a tool cases set based subsystem defining a software environment (e.g. model-driven meta-modelling. object oriented tools, a.s.o) (RFID oriented)

A is a multi-agent system

R is 3-Dimensions resources set (human, financial technology)

G is a shared goal for set of actors of enactment of a reference scenario)

The most important challenge raises by new scientifically achievements on the interoperability "problem-solution".

"Numerous Knowledge links between various "actors" with a Collaborative Network enactment (enterprise, e-workers, a.s.o) have to rapidly and flexible be combined to respond efficiently to market rapid changes. The size of an "enterprise" will matter for less than it's ability to collaborate its ability to adapt or its ability to interoperate [3]"

A new very important challenge is generated by new" trendy" research on operability.

The problem is concerned with the representation of the complex System Specifications addressing technical, semantic and pragmatic interoperability. [2].

5 Interoperability-based "REMEDIA" Case Study.

One of the entities of the project coordinator, the “Center for Human Resources Training” of the University POLITEHNICA of Bucharest (UPB-CPRU) was a partner (1 out of 39) in the project UE-IST Framework FP5 (2001-project-38379) whose main objective was to elaborate the vision and roadmap for virtual organizations in EU countries.

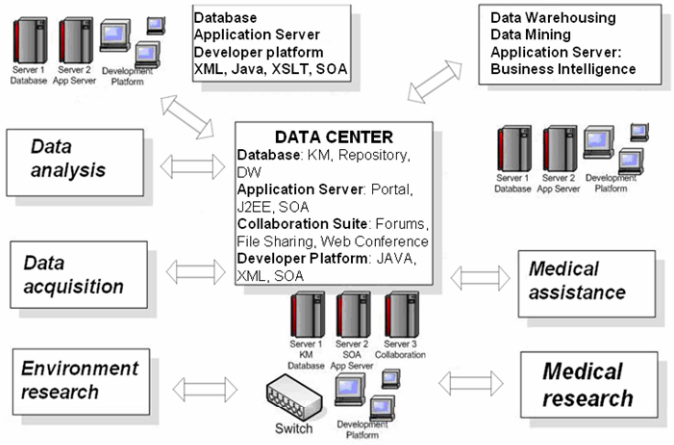
The main conclusion of the final report was:

"In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part of some SUSTAINABLE COLLABORATIVE networks that will act as breeding environments for the formation of DYNAMIC VIRTUALORGANIZATIONS." [12]

The activity of identification of a high priority problem for research in common Europe has had the following results:

The necessity to create and consolidate a Profesional Community capable to use information and virtual GROUPWARE communication technologies to do research into the relation of great social impact Environment – Chemistry – Biochemistry – Pathology – Medicine – Information Systems – Automation.

The share of technological, human and financial resources by different organizations involved in a collaborative network in common Europe including academic research, industry, governmental and non-governmental organizations.



3. Solution Architecture

6 Conclusions

The paper is focused on reporting the synthetical results of a seven years "long term" research, including the "FABRICATOR" ISP_FP6, Vision & Roadmap for Virtual Organization, Education & Research Ministry founded project "Interoperability Based "REMEDIA" Environment-Health (2006-2008).

The present paper supports the following key conclusion:

The General System Theory could play the role of "centrifugal force" for the D.CC.E.

The following issues are to be debated during conference :

- information System development solves the problem to integrate (Collaborative P2P Co-Research platform) Business Process Monitoring

and Management System (BPMMS) and Information System (e-decision Support System).

- Dual Embedded system (Supervisory Control Data Acquisition lower layer & Service Oriented Architecture upper layer) is the final target.
- The UPB / Faculty of Automation & Computer Science, Department of Automation & Informatics has already installed the IC5 Infrastructure System Integration (Operability Oriented) Oracle 10g full application environment (upper layer), wireless Java based module application middle (layer) and respectively, SCADA lower layer.

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