Towards A General Systems-Theory-focused Approach to Design the Future of Concurrent Engineering Science

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Abstract. Information, as a specific commodity, from the sunset of our civilization until nowadays, is sustaining our knowledge production in every domain of human activities. But the Knowledge-based Economy (KbE), which is to be consolidated in the next decades, requires for information and Knowledge Management due to the ICT-based Information Systems availability and capabilities. The KM is the key-factor of enterprises competitiveness (LS- large scale enterprises; SMEs- small and medium size Enterprise ;µE- micro size enterprises). Even the e-workers, immersed in a Professional Virtual Communities (PVC) are included in VBE (Virtual Breeding Environment) according to Camarinha-Matos and H. Afsharmanesh basic concepts. To design the Complex Adaptive Systems, with either Systems of System or Federation of Systems topology, in our long-term research target The Concurrent Engineering is quite "young" (20 years) of multidisciplinary domain of interest, but it is the time to aiming at conversion from "best practices" – oriented methodology (including specific methods and and techniques) engineering to a smart Distributed Concurrent & Collaborative Engineering Science (DCCE). 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 to emerge from different views in concurrent engineering.

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

1 Introduction

Web science and the Internet technology provide enterprises (Large Size, SMEs, μSMEs) better and more flexible ways to fully satisfy their customers on the global e-market.
Enterprises are increasing even more their efforts in order to improve their (intra and inter) business processes, so that they can become more competitive, as well as more agile actors [Loss, Rabelo, Perreira-Klen 2005a, Santa Catarina University].

Available estimates indicate that SMEs are the main generators of employment in Europe, representing 60% of all jobs [Pouly 2005]. It is also estimated that industrial subcontractors represent roughly 20% of al industrial jobs [Lúkanen 200].

The 1st of January 2007 marked a 'new wave' to enlarge the European Union (27 countries) after Romania and Bulgaria, both joined in. In the new 'members' economy, the real ratio of SMEs contribution is more spectacular [e.g. 92% in Romanian economy].

The challenge to develop the new digital and global economy by using the advanced ICT- platforms are the key-drivers of Kb Economy. The academic research has received this 'message' since the '80s. A huge effort to fulfill the gap between remarkable scientific achievements and the real socioeconomic needs to fulfill the "new requirements list" has been done during the last three decades. [ESPRIT program, IST - Framework 4,5,6] www.cordis.org.

Many Reference Models, Standards, Frameworks and IC-Technologies are supporting the 'enterprise interoperability' [IST-FP6-successful projects: ATHENA, ECOLEAD, INTEROP, a.s.o], but the interoperability is a key-problem to be fully solved in the years to come **[**Stănescu, Infoday 9th –IST 2007**]**

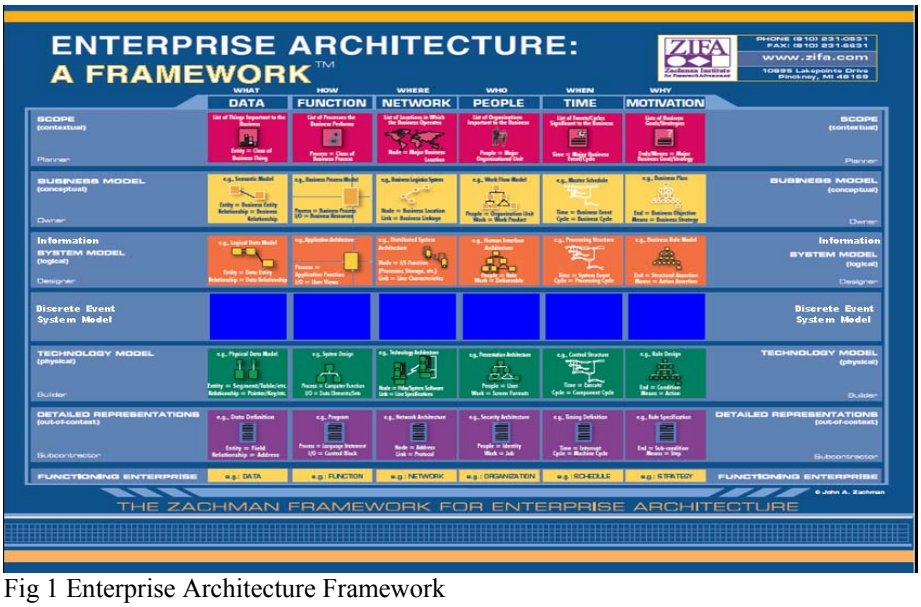

Fig 1 Enterprise Architecture Framework

The main paradigm the authors are concerned with in their present research is 'Virtual Organization'/Collaborative Networks [Camarinha_Matos, Afsarmanesh, 2005] Taking into consideration the international research context, one could notice that the "concurrent engineering "(CE) paradigm, that has been developed rapidly since 1982, has to be re-balanced. From an advanced methodology useful in engineering science (including methods, tools, techniques- IST-CE.net.project phase 2 1999-2004- http://www.ce-net.org) into a collaborative sciences foundation.

The recent published document 'Enterprise Interoperability: a concerted research roadmap for shaping business networking in the knowledge-based economy'- European Commission- 'Information, society and media' ISBN-92-79-02437-x (http://publications.europa.en) coordinated by Man-Tze-Li, whilst one of the authors of the present paper (Aurelian Stanescu) was one of many contributors, provides the following list of indicating scientific disciplines, and whose ideas, propositions and findings could provide a starting point for the proposed science base.

1. Systems/Complexity Science
2. Information Science
3. Network Science
4. Web Science
5. Services Science
6. Economic Science
7. Social Science

Table1. Science Base for Enterprise Interoperability Indicative research areas

The present paper is aiming at a scientific foundation of Distributed Concurrent (Collaborative) Engineering Science, which proves that the 'best practices' era of the CE has just passed and our community is going to develop a more general systems theory-based 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).

Finally, concluding remarks, further work and a constrained list of reference are also included.

2 General System Theory-oriented Framework

2.1 Paradigm Shift

The companies is overheated by ICT- technologies. The well-known MONITOR/ANALYSE/PLAN/EXECUTE (MAPE) has been provided by the Department of Defense-USA (Air force Doctrine Center 1998) 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.

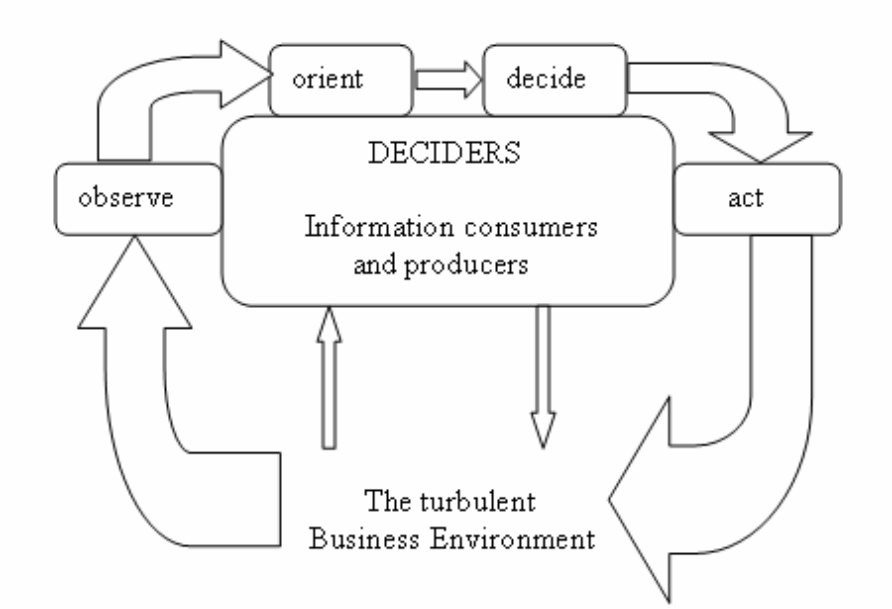

Fig 2 The OBSERVE-ORIENT-DECIDE-ACT (OODA) loop

The 'S.H.O.R.- STIMULATION-HYPOTHESIS-OPINION-RESPONSE' paradigm is useful for the 'classical behaviourist' (psychology) to explicitly deal with uncertainties (Whol 1981).

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 (UNESCO report 1996) 'Learning: the treasure within' 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 report list of four-dimension LEARNING space by the fifth: LEARNING to CHOOSE . This is highlighted a s a 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 good 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). The 'Learning Organization' remains a challenge for our Information Society!(Stanescu 2006)

A paradigm shift is required to dynamically meet the 21st Century experts' needs for exploiting information as well as to speed up the decision making processes! (Stanescu 2007)

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 (Camarinha-Matos, 2005), 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 at 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- 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 [Stanescu INCOM'06]

"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" [O'Brien, 2004]. (Fig.2) 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 demand for graduates capable of coordinating complex information and supply chain networks and project managers coordinating global IT projects is expected to increase. The integration between Business Process Systems & Information System in progress to be consolidated by the interoperability research issues.

They 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 for less than its ability to collaborate, its ability to adapt, and its ability to interoperate [Man She Li,2006].

The most important challenge raised by new focus on the interoperability is concerned with the problem how to represent the complex system specification semantics according to sustain collaborative work.

3 Interoperability - focused Distributed Collaborative Concurrent Engineering Framework

Coming back to the CE - focused domain, a distinction can be also 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*. In static systems, contrary to dynamic systems, no events take place. 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*.

Owing 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 .

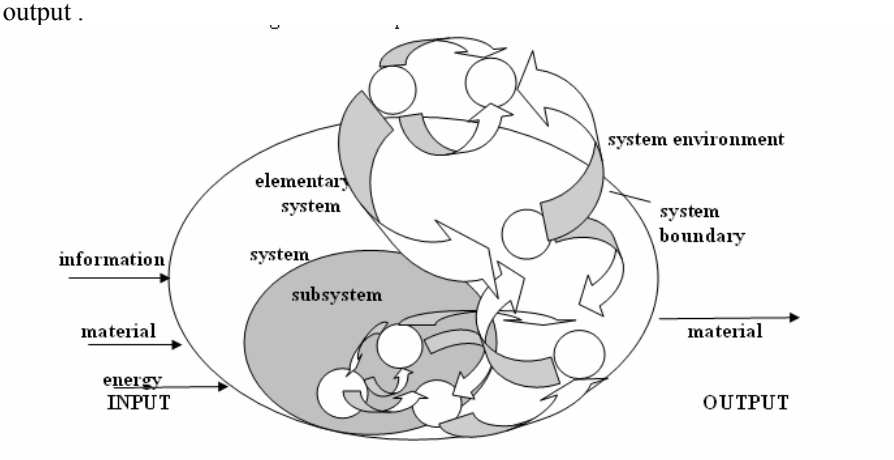

FIG3: Graphical representation of dynamical system

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]

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

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)
Recently, the public available document "Enterprise Interoperability : A Concerted Research Roadmap for Shapping Business Networking in the Knowledge_Based

Economy " (http://cordis.europa.eu/ist/ict-ent-net/ei-roadmap_en.htm) coordinated by Man-Tze-Li provides the conceptual view of the ISU.

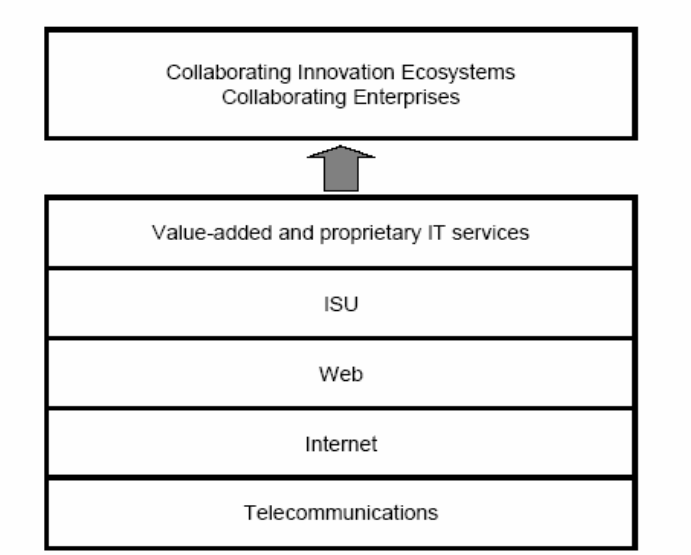

Fig 4. Conceptual View of the ISU

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 [Man Tze Li, 2006]"

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

The problem is concerned with how to represent the complex System Specifications addressing technical, semantic and pragmatic interoperability. [Dumitrache 2007].

4. 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."*

http://www.uninova.pt/~vomap

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 PROFESSIONAL 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 – COMPUTER SCIENCES

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 .

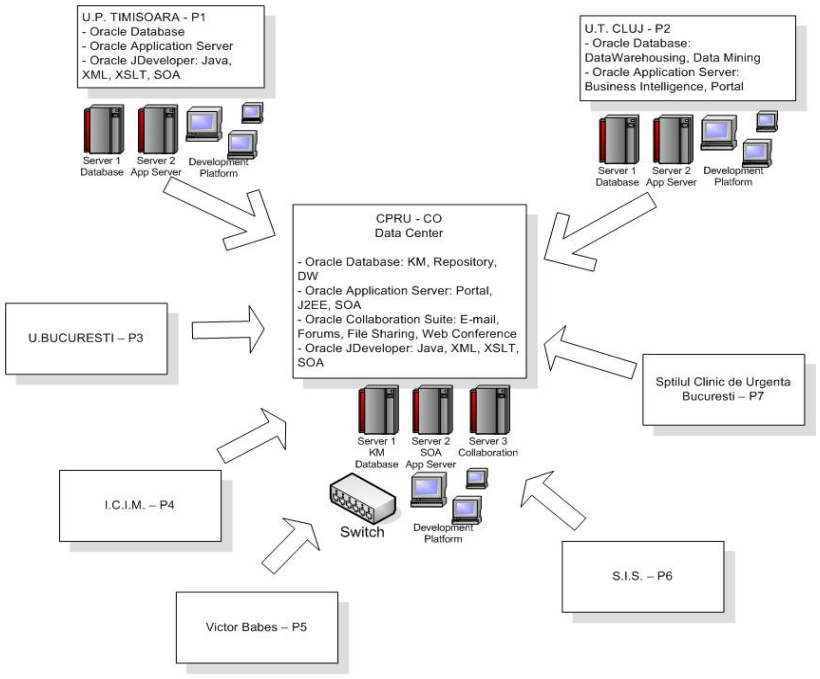

Fig 4 Solution Architecture

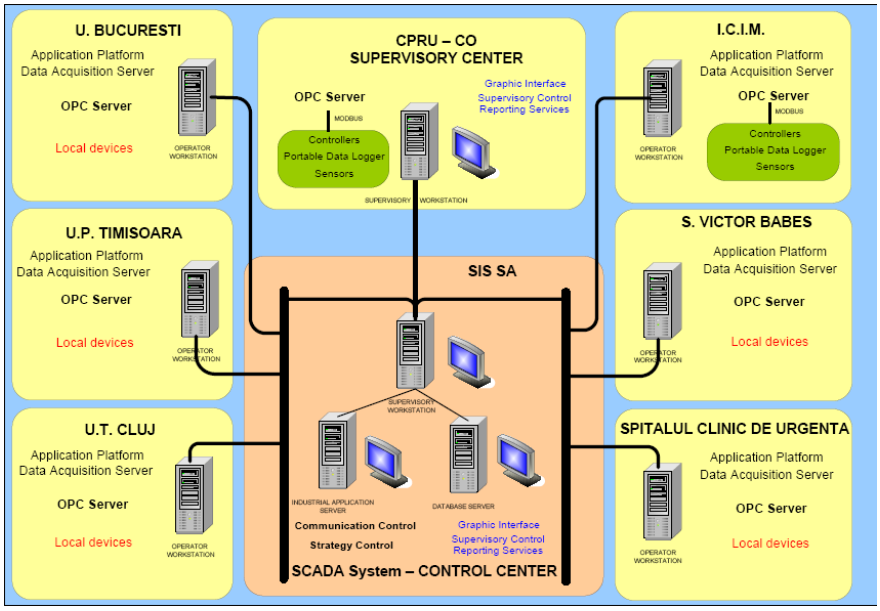

Fig 5. SCADA system

5. Conclusions

The paper is concerned with 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 aims at supporting the key conclusions:
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 developement solves the problem to integrate (Collaborative P2P Co-Research platform) Business Process Monitoring and Management System (BPMMS) and Information System (e-decision Support System) integration
- 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, Departament of Automation & Informatics has already installed the IC5 Infrastructure System Integration (Operability Oriented) Oracle 10g full aplication environment (upper layer), wireless Java based module application middle (layer) and respectively, SCADA lower layer.

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