Project

Socio-Cognitive Modelling for Complex Socio-Technological Networks

CRESCO - S.P.III.4

A major ambition of the CRESCO multi-discipline project was to allow an inter-disciplinary flow of methods and ideas related to the network-based modeling and simulation of complex systems and their aggregates. In the above context, CRESCO-SOC-COG research has been focused on human factors, their vulnerabilities and human errors, in the frame of networked structures of high-risk decisions in large human organizations. Socio-cognitive and technological aggregates are complex from their nature and their computational models are not sufficiently known. They include humans and organizations, they are intelligence-based systems. Their study is a new domain of systemics and requires an interdisciplinary effort, advanced AI technologies and a meta-systemic approach [http://erg4146.casaccia.enea.it/SC-CRESCO/index00.html].

OBJECTIVES

The sub-project has been aimed at: recognition, modelling and experimental simulation of main critical aspects of socio-cognitive decision-making in human organizations involved in the management of large complex critical infrastructure (LCCI) networks (such as electrical and telecommunication).

METHOD

For the reason of the heterogeneity and complexity of the problem, the research approach were based on the TOGA (Top-down Object-based Goal-oriented Approach) meta-theory [ ]. It enabled to incorporate top-down different specific methods and to maintain the systemic integrated view on the global problem.

The work has been divided into three innovative research activities: methodological, socio-cognitive and socio-technological (see the sub-project STRATEGY table 1).

Tab.1. STRATEGY of CRESCO-SOC-COG

A	SYSTEMIC SOCIO-COGNITIVE MODELLING METHODOLOGY **A1.** The **global computational methodology** framework for the identification of goal-oriented decisional network has been developed. It is based on the top-down application of the generic IPK (information, preferences, knowledge) model and four modelling paradigms of the TOGA meta-theory. **A2. Normative criteria** development and real-time decision-making under **risk uncertainty**: analysis and application. of the Precautionary Principle.	Contribution **ENEA** A. M.Gadomsk T. A. Zimny
B	COGNITIVE MODELLING Cognitive analysis (one node) of human and artificial decision makers on subsymbolic and symbolic levels independent on social and organizational roles. **B1. symbolic:** recognition of the role of main emotional and psychic factors under risk using an experiment (questionnaires) **B2. sub-symbolic:** recognition of the contribution of non-conscious genetic-neural processes in decision-making (basic computer simulation) based on neural Darvinism (G.M. Edelman).	Contribution **ECONA** A. D'Ausilio A. Londei
C	SOCIO-TECHNOLOGICAL MODELLING Recognition of organizational and technological constrains of socio-tech. Network (role dependent) from the viewpoint of the **communication manager-supervisor** and possible **organization errors** in decision-making.	Contribution **Tor Vergata DII** M. Caramia
The developed models should serve as the basic "roadmap" for the computational identification of: cognitive, organizational and social vulnerabilities, and, at a consequence, for the prevention and response design.		

Some References:

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A. SYSTEMIC SOCIO-COGNITIVE MODELLING METHODOLOGY

Four principal paradigms of CRESCO-SOC-COG (TOGA meta-theory) were applied and validated. They were the following:

P0. Top-down and bottom-up decision-making modelling paradigm.
P1. Universal Reasoning Paradigm (URP - based on the IPK model)
P2. Universal Management Paradigm(UMP)
P3. The Precautionary Principle model, when the risk is plausible but not possible to assess (Gadomski, Zimny,2008)

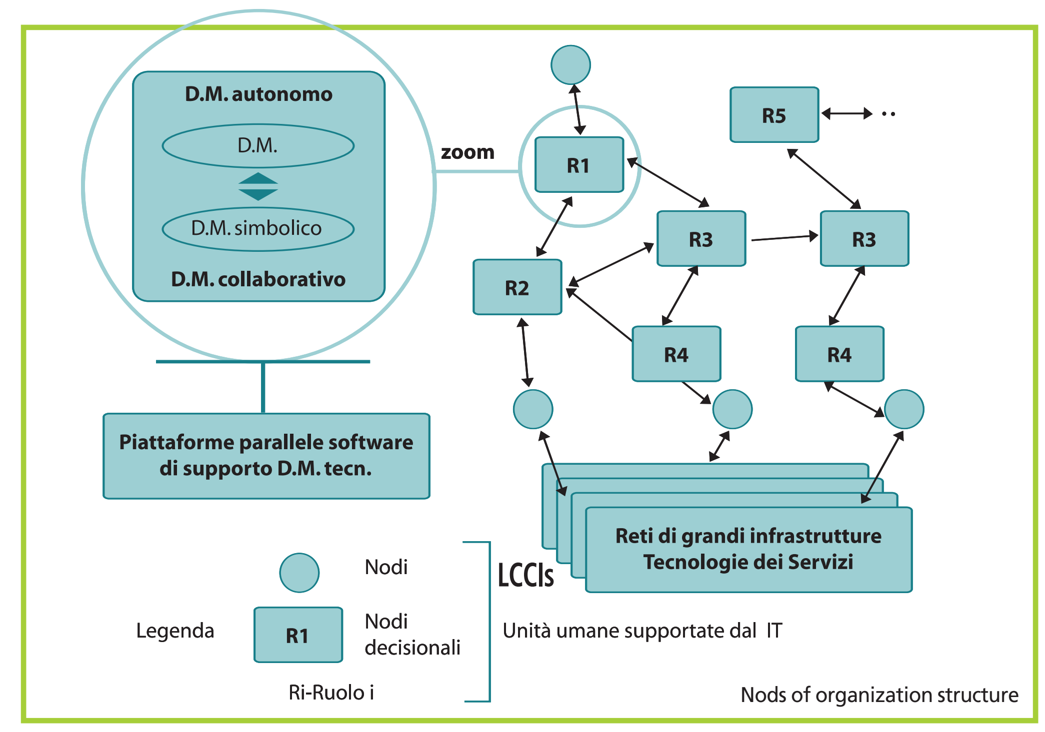

Figure 1 CRESCO-SOC-COG decision-making modeling paradigm. (Gadomski, 2005)

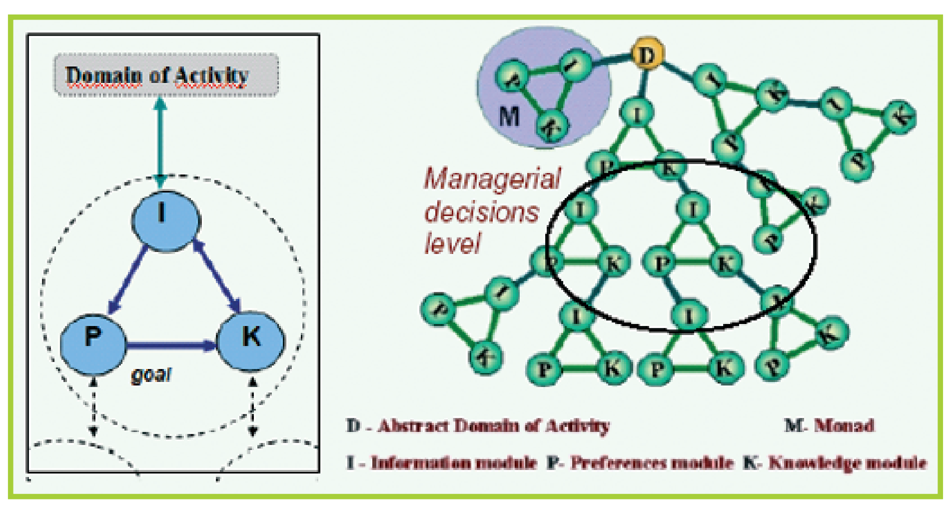

Figure 2 Universal Reasoning paradigm (IPK, Gadomski, 1993)

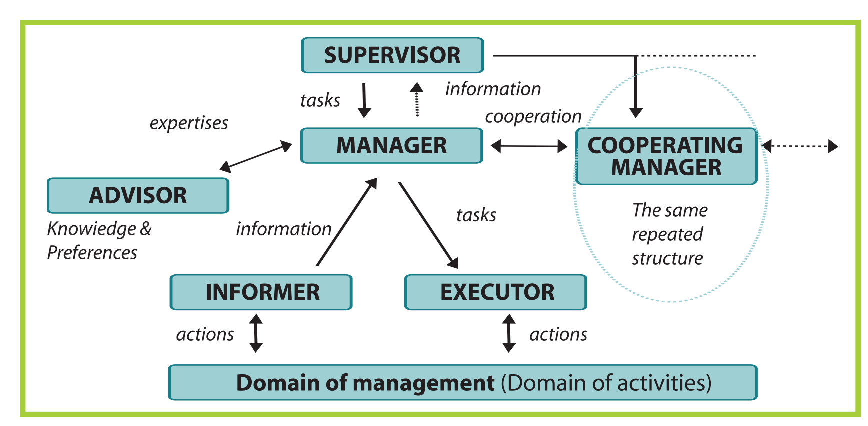

Figure 3 Universal Management Paradigm - UMP (Gadomski, 1997)

B. COGNITIVE MODELLING

Non conscious decisional factors (Sub-symbolic study). Decisional dynamics have been studied by means of the analysis of cognitive mechanisms emerging in neural architectures defined by an evolutionistic approach. Each artificial agent is described by a neural network whose neural organization is defined by a genetic coding. The genotype brings the complete information about the connectionist model of any organism (decision-maker) and, by means of an environmental pressure, a suitable population of agent's architectures may be selected. The numerical simulations of the artificial agents evidenced a strong correlation between dynamical complexity (Lyapunov exponent) and decisional efficacy (goal achieving). Moreover, several spontaneous (not goal-oriented) behaviors, and their dependence on the relation between the degree of stress and the decisional mechanism, have been evidenced.

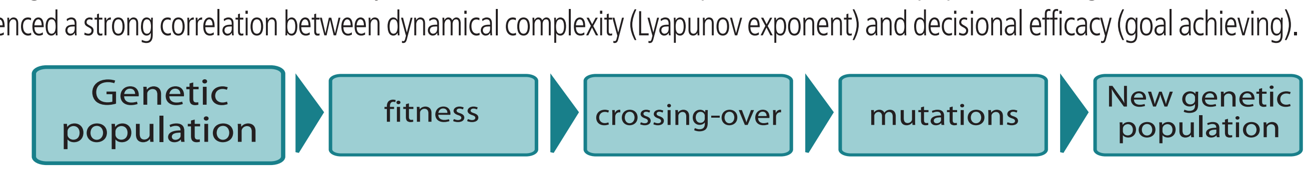

Figura 4 Decision-based sub-symbolic selection process applied in the simulation experiments

Conscious decisional factors (Symbolic neuropsychology study).
The influence of short temporal and long term emotional factors on rational decision making has been analyzed in the risk context. Results have been obtained by means of the analysis of a standardized behavioral test and personality questionnaires. The both obtained results are congruent and interpretable in the theoretical frame of the Information Preferences Knowledge (IPK) generic socio-cognitive model.

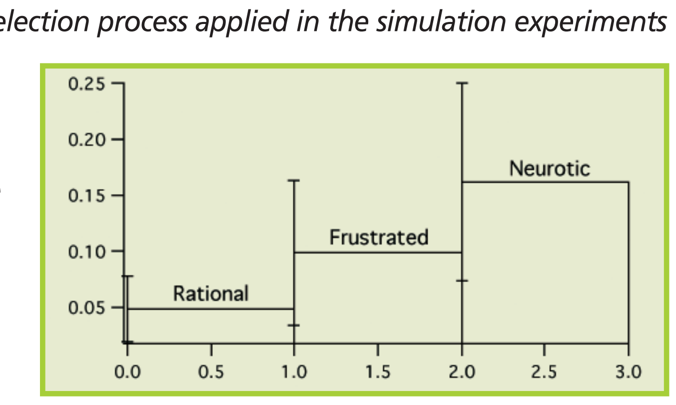

Figura 5 Influence on decision-making. Mean and standard deviation of Lyapunov exponents associated to the three behavioral groups (personalities). The ANOVA test confirms the difference significance.

C. SOCIO-TECHNOLOGICAL MODELLING

For the socio-technological modelling a simulation model extending the TOGA paradigms to the model of complex organizational system as a distributed computing network, has been applied. The developed Grid model has been presented at an international conference (see, Caramia and Giordani, 2007) and accepted for publication in an international journal (see, Caramia and Giordani, 2008). The adopted detailed approach is based on the modelling framework of Ranganathan e Foster (2002) where a hierarchical model to manage information and task flows from the user to the Local Scheduler in the Grid network area were proposed. The principal actors in this model are: the users, the External Scheduler (ES) and the Local Scheduler (LS). Users (see Fig. 6) are associated with tasks that represent the activity domain in the UMP (Universal Management Paradigm) -TOGA according to manager-supervisor communication framework. In order to let ES and LS negotiate an economic model was introduced. The simplified test d-m (decision-making) scheme was applied for the negotiating agents.

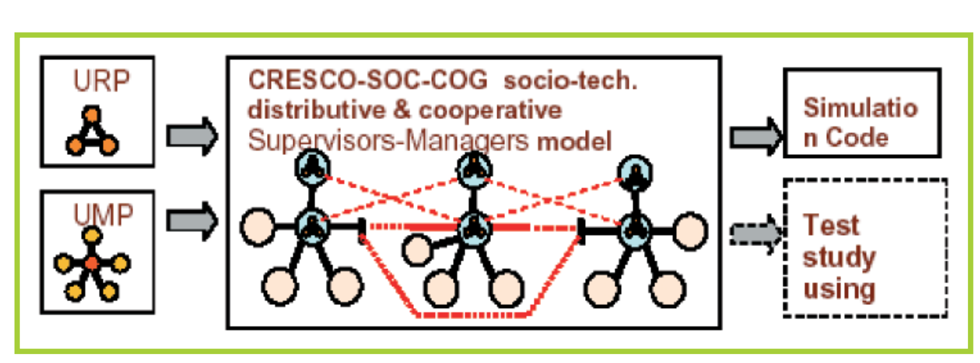

Figure 6 The TOGA object-based representation of the Ranganathan e Foster model.

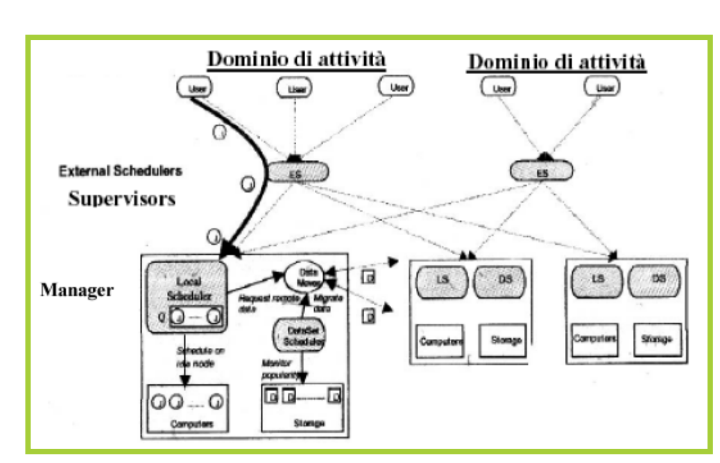

Figure 7 The adopted Ranganathan e Foster model.

CONCLUDING RESULTS

Tab. 2 Summary

Partner	Theme	Results form	Next tasks
ENEA	Systemic Methodology, coordination and synthesis - Global socio-cognitive modelling of organization d-m network vulnerability - Role of socio-cognitive networked decisional interdependences - Precautionary Principle in d-m	5 CRESCO- ENEA seminars 2 international conference papers	Concluding validation of the final results.
ECONA	Cognitive d-m modelling: Sub-symbolic genetic-neural modeling Symbolic neuropsychological	3 seminars 2 international conference papers accepted	Research completed Possible extension and specialization of the obtained models.
TOR VERGATA DII	Socio-technological modelling and decisional vulnerability: - Communication and negotiation oriented simulation - Integration of the top-down and bottom-up strategy	2 seminars 1 international conference paper 1 journal publication Calculation code.in C++	In preparation: the concluding seminar with the analysis of the possibility of application of the ENEA-GRID for an integrated simulation.

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