Memory Evolutive Systems,

a category-based dynamic model, on the way to a comprehensive approach to multi-level complex systems

by

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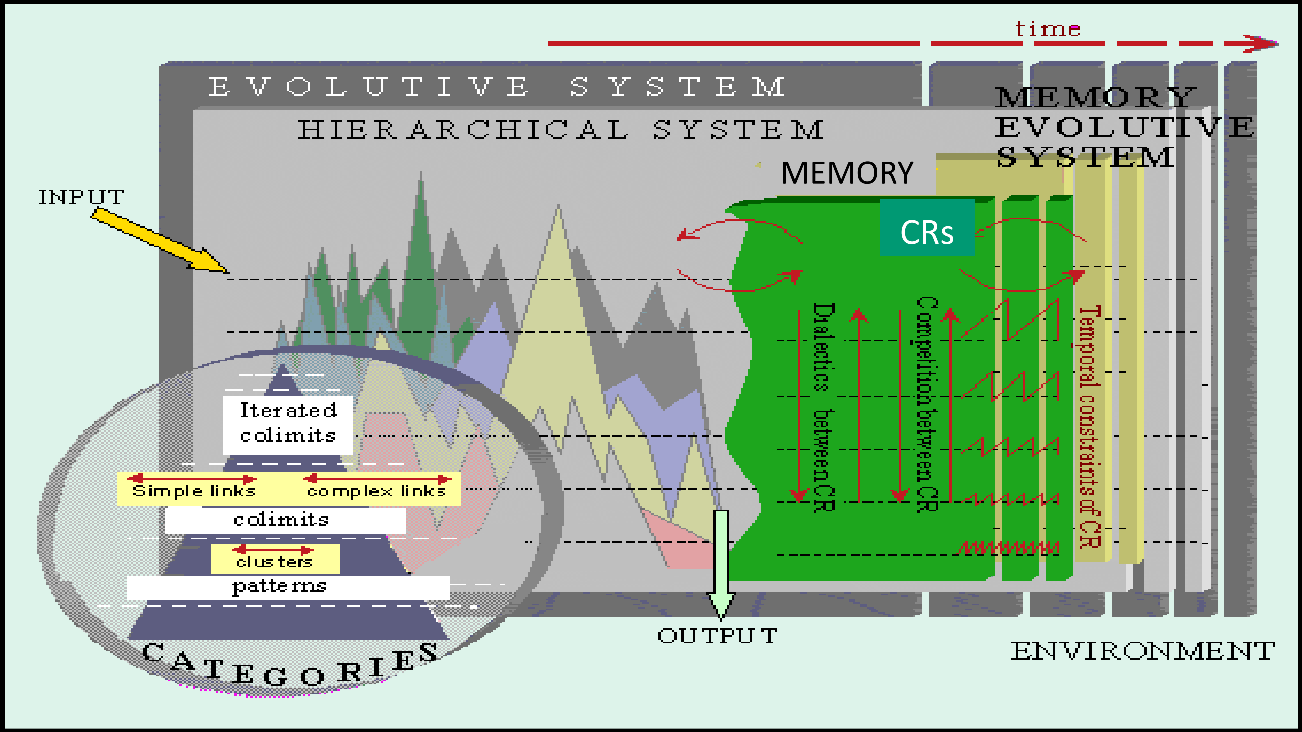
MES: A MODEL FOR MULTI-SCALE COMPLEX SYSTEMS



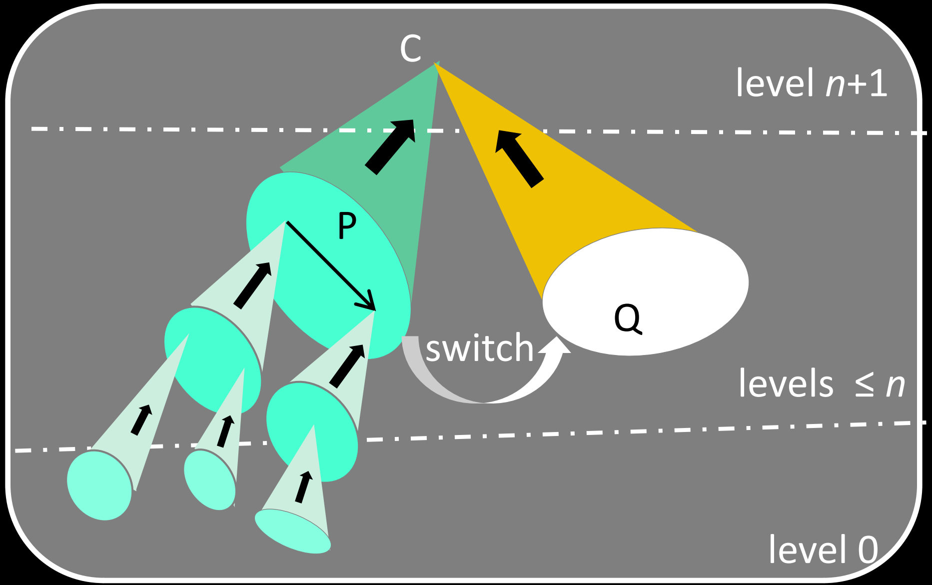
Memory Evolutive Systems (Ehresmann & Vanbremeersch) give an integrative model, based on a dynamical ***category theory***, accounting for:

(i) a dynamic hierarchy of complexity levels with *multiform components*;

(ii) a multi-agent multi-temporal self-organization, relying on

(iii) a flexible memory allowing for self-repair and adaptation to changes.

HIERARCHY. MULTIPLICITY PRINCIPLE (MP)



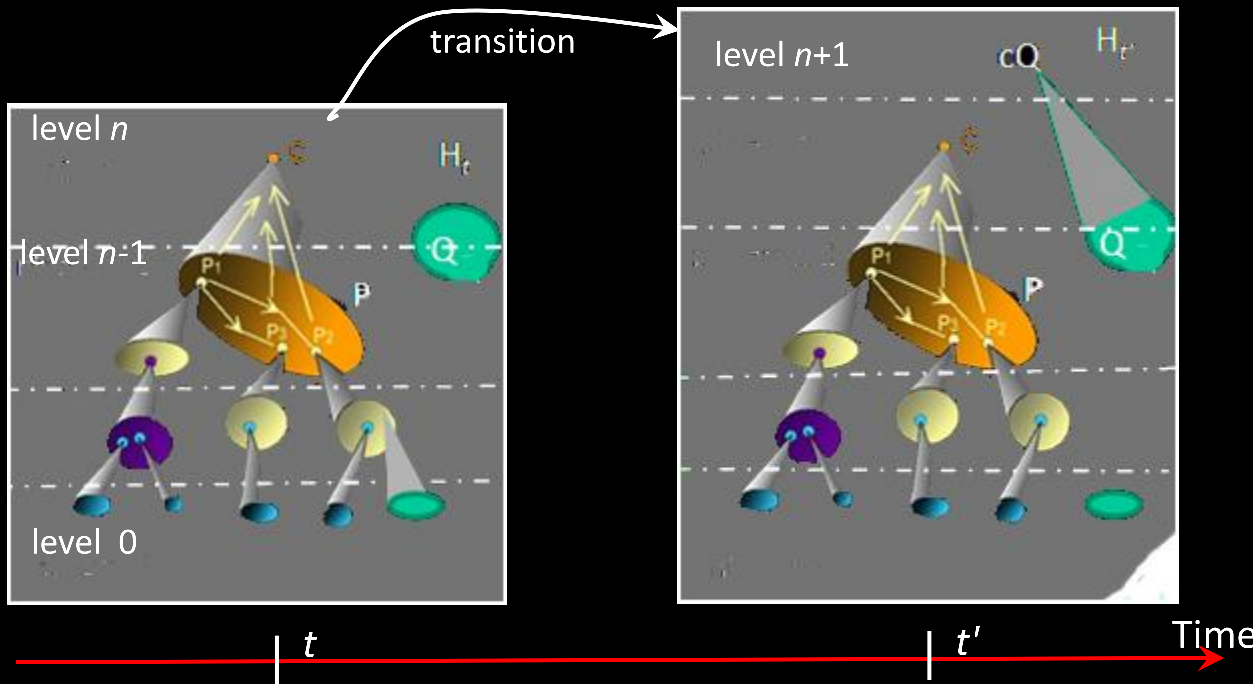
A component C is the aggregate (= 'colimit') of a lower level pattern P.

Multiplicity Principle = Existence of *multiform components* C which can operate through structurally different though functionally equivalent lower level patterns, switching between them.

MP extends the "degeneracy" (or 'flexible redundancy') ubiquitous in biology.

THEOREM: MP is at the root of:
Higher complexity with emergence of new properties at each level,
Robustness/Flexibility/Plasticity of the system.

TRANSITION. COMPLEXIFICATION

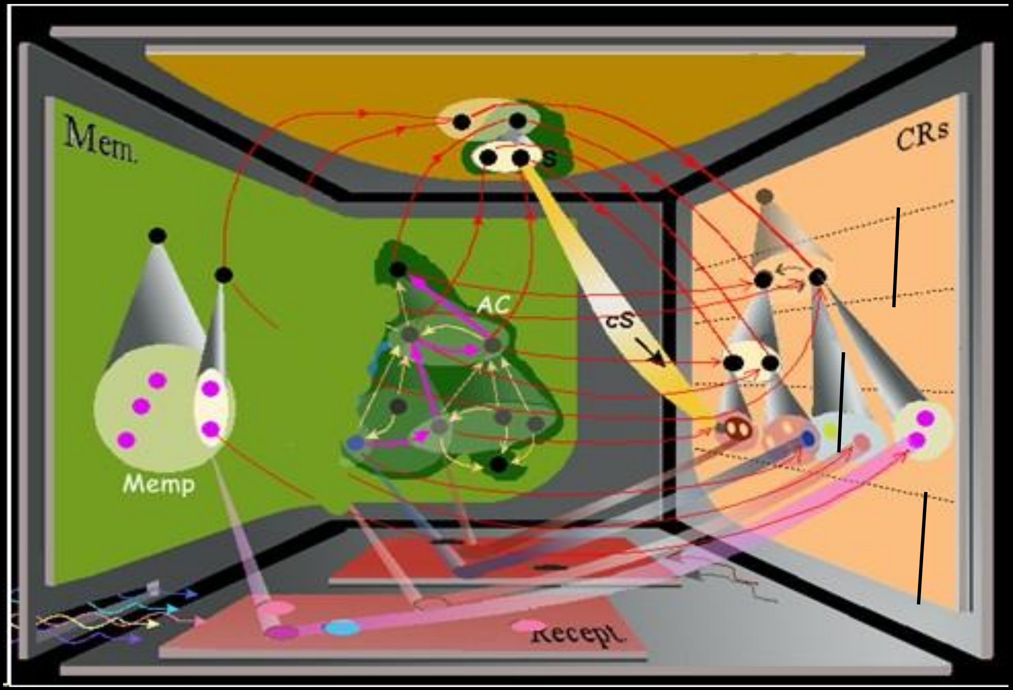


The configuration of the system at t consists of its components and links; each link has a *propagation delay*, a *weight*, and can be *active or not* at *t.*

It changes over time by addition, suppression or decomposition of some elements, aggregation (binding) of some patterns (*complexification process*).

PROBLEM: Explicit the activation process of the links and its role in the complexification process.

MULTI-SCALE SELF-ORGANIZATION

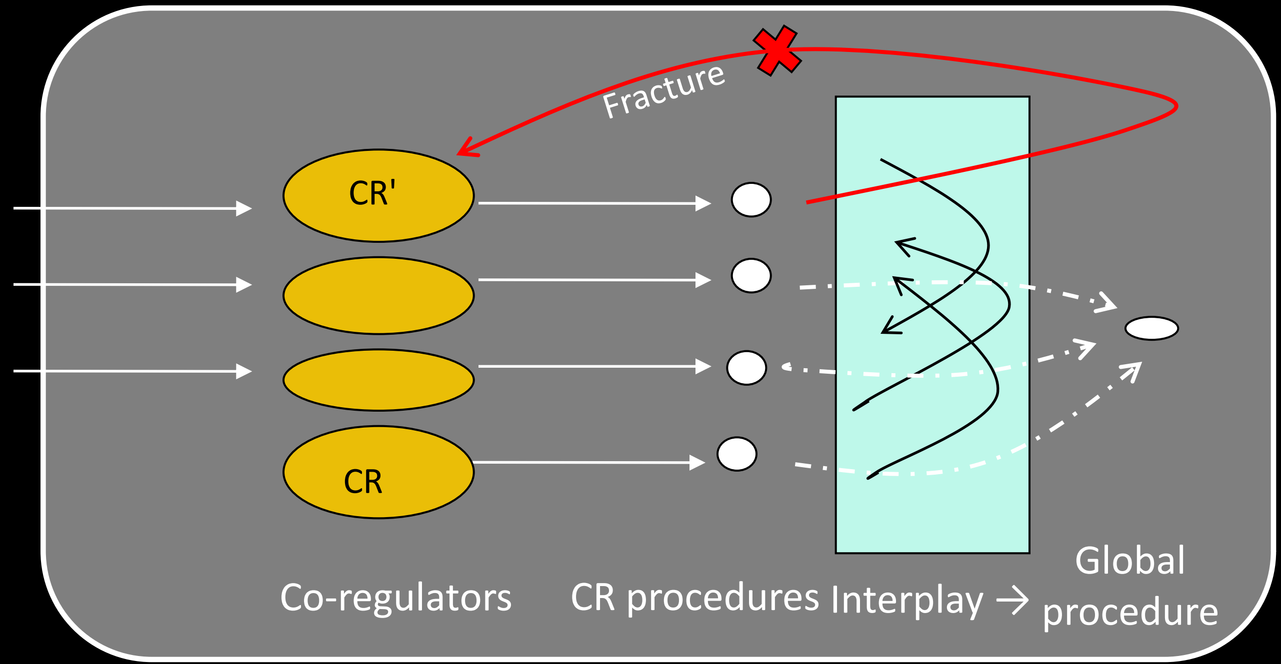


The dynamic of a MES is modulated by a net of agents, the *co-regulators* CR.

Each CR acts stepwise as a hybrid system with its own rhythm and logic, selecting at each step a procedure S in response to the partial information it receives via active links. If S cannot be realized, there is a *fractu*re for CR.

PROBLEM. Make 'computable' one step of a CR by conventional or un-conventional models such as spatial computations.

DYNAMICS OF THE CRs AND THEIR INTERPLAY



The procedures of the different CRs at a time *t* may not fit together.

===> ***Interplay among the CRs*** to harmonize their procedures, to which MP gives more flexibility (through switches).

===> Fracture and, if it persists, *dyschrony* for some CRs, possibly repaired by a change of their period (*re-synchronisation*).

PROBLEM. Develop new methods to model and quantify this interplay, a kind of Darwinian selection between the CRs' procedures.

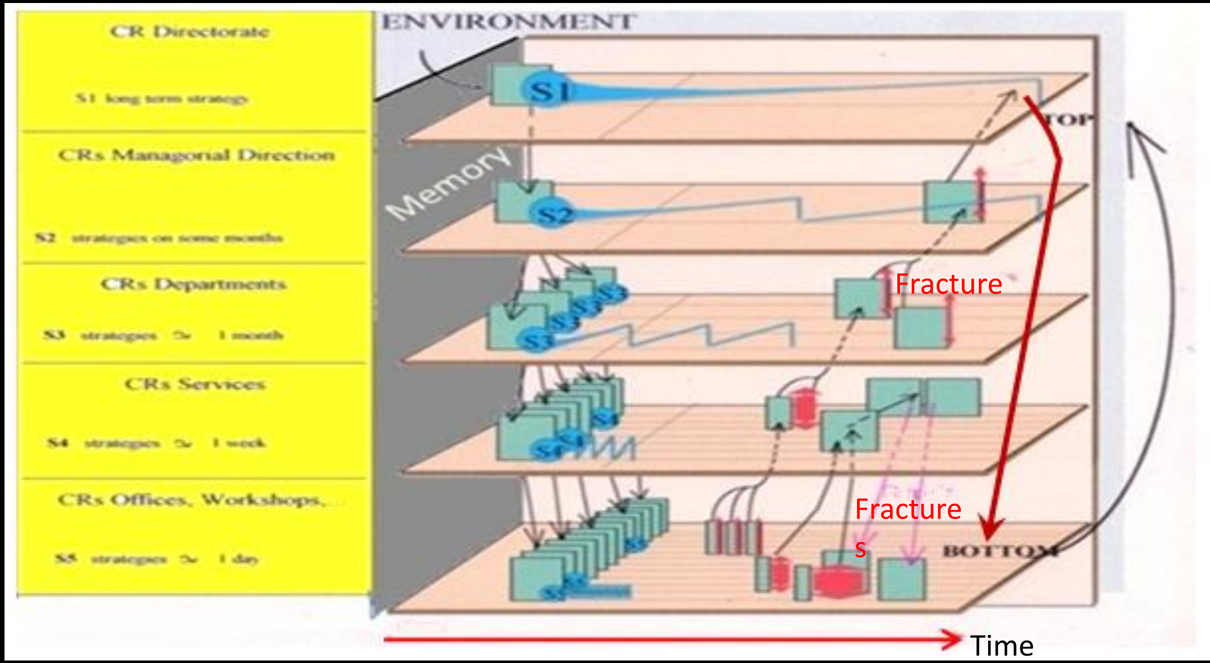
SYNCHRONICITY LAWS. DIALECTICS BETWEEN CRs

Each CR must respect the following 'law', where *d* = period of CR, *s* = least stability span of the intervening components, *p* = their transmission delays:

$$s/p \gg s/d \gg 1$$

Non-respect of these laws leads to loops, backfiring between CRs:

fracture → repair → fracture … up to possible re-synchronisations.

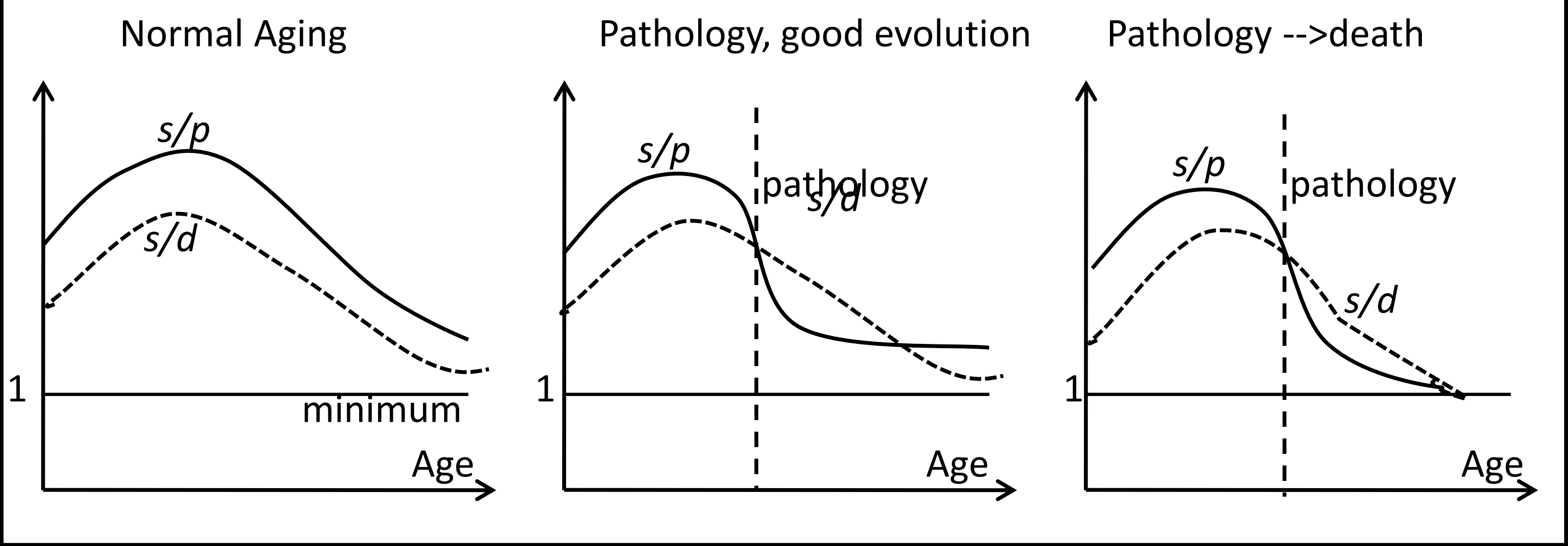


APPLICATION: Complex events processing, e.g. in enterprise management

APPLICATION: A THEORY OF AGING

Aging for any kind of organism can be defined as a progressive decrease of the average ratios *s/d* and *s/p* relative to different co-regulators, forcing a *cascade of re-synchronisations* to higher and higher levels.

===> ***Theory of Aging by a cascade of re-synchronisations*** for co-regulators of increasing levels (EV 1993).

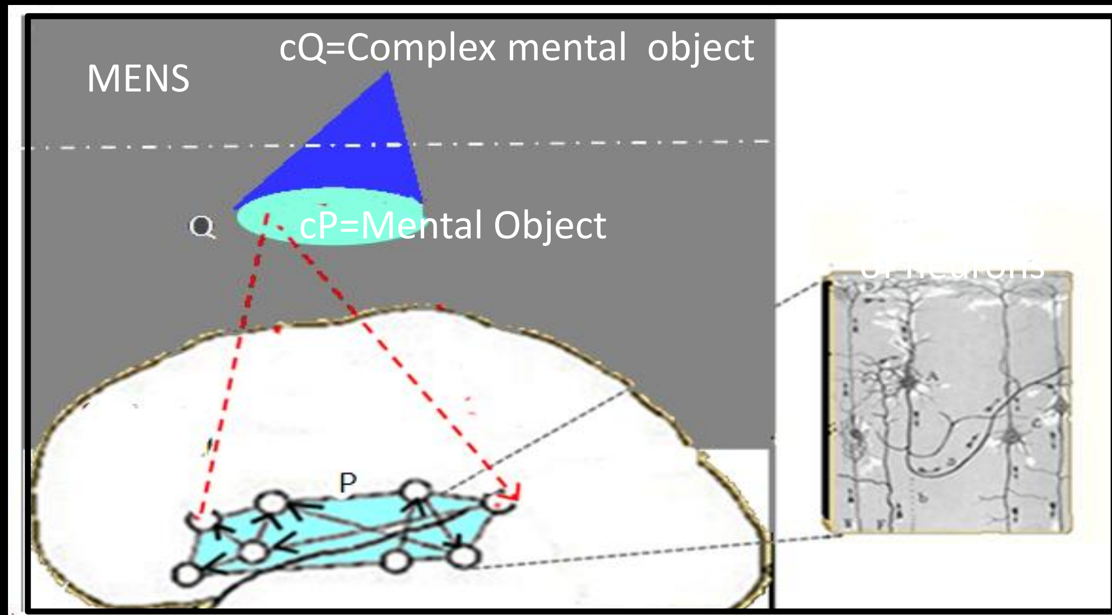


PROJECT. Develop better medical supervision of aged people

Internal monitoring project of some physiological functions and current aging pathologies, with real time data integration for prevention and start of repair strategies

	Internal interfaces	Internal automatic measures	Internal strategies	External Strategies
Physiology				
Muscles	Multiple nanometric sensors and 1 specific chip integrating all the muscular data	Electromyography Enzymatic measure of rhabdo-myolysis. Differential measures of sarcopenia by constant measure of muscle mass near the sensors	Muscle electrostimula-tions depending on the results of the data on the chip by activation of double action sensors	
Vision	Glass-analysis during reading, manual or physical activity, twice a month during 2 hours	Analysis of convergence, keenness and reactivity abilities to change of position, reading (oculo-motricity)		
Pathology				
Lungs Arteries Veins Heart Metabolism Kidney	Multi-sensor monitoring	Enzyme assays of lung inflam-mation, blood gases test Sensors of embolism, thrombosis, artery inflammation Enzyme assays of ischemia, cardiac decompensation, embolism Metabolic balance Kidney functions	Specific alarms generated by the chip and sent to the external terminal	Diagnosis and treatment worked out by the external terminal

APPLICATION TO COGNITION



MENS = MES whose level 0 models the (physical) neural system and the higher levels model mental objects represented as the aggregates of the synchronous neuronal (hyper-)assemblies which they activate.

MENS accounts for the emergence of higher cognitive processes, up to consciousness.

PROBLEM: Apply MENS to develop new strategies for coping with cognitive deficiencies, or for better approaches to education, risk analysis, decision...

CONCLUSION : A CALL FOR PARTNERS

The *Memory Evolutive Systems* propose a methodology in progress on the way to a comprehensive approach to multi-scale complex systems such as living organisms or systems in the socio-economic area.

Up to now this model is more qualitative than quantitative.

Partners are welcome

to make it amenable to some kind of computation and to develop specific applications. Among the possible directions figure the use of 'spatial computations', of 'geometric super-structures', and a project WLIMES to combine MES and P. Simeonov's 'Wandering Logic Intelligence' (which he will present).

FOR MORE INFORMATION

Ehresmann & Vanbremeersch, *Memory Evolutive Systems: Hierarchy, Emergence, Cognition* (Elsevier, 2007).

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THANKS