CLUSTERING AND CLUSTERS: A SYSTEMIC APPROACH

POPA, H.L.; MOCAN, M.L.; IZVERCIANU, M. & PATER, L.R.

Abstract: *The idea, that more general theories are preferred over more specialized theories, lies at the heart of systems science. The systemic approaches of the becoming / change and of the progress lack consistency in the absence of a wholly system of concepts about systems to allow a thorough knowledge and a humanist type orientation of the change, meant for turning the progress into a fundamental process of the Universe / Multiverse. The paper presents by the following contributions: integrative definition of the main concepts of systemics; stressing the fundamental role of the clustering and clusters in the systems change (progress / stagnation / regress) in Universe / Multiverse; functional-structural definition and characterization of clusters, clustering and inoclusters; elaboration of a model for the universal cycle of the systems change which emphasizes the essence of progress.*

Key words: *systemics, clusters, clustering, becoming cycle, progress*

Authors´ data: Univ.Prof. Dipl.-Ing. Dr.techn. **Popa**, H[oria] L[iviu]; Univ.Prof. Dipl.-Ing. Dr.econ. **Mocan**, M[arian] L[iviu]; Univ.Prof. Dipl.-Ing. Dr.techn. **Izvercianu**, M[onica]; Univ.Lect. Dipl.-Mat&Econ. Dr.econ. **Pater**, L[iana] R[odica], Politehnica University of Timisoara, Management Faculty, 14, Remus Street, 300191, Timisoara, Romania, hpopa@eng.upt.ro, mmocan@expertconsulting.ro, mizvercianu@eng.upt.ro, lianapater@yahoo.com

This Publication has to be referred as: Popa, H[oria] L[iviu]; Mocan, M[arian] L[iviu]; Izvercianu, M[onica] & Pater, L[iana] R[odica] (2010). Clustering and Clusters: A Systemic Approach, Chapter 19 in DAAAM International Scientific Book 2010, pp. 177-194, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-901509-74-2, ISSN 1726-9687, Vienna, Austria
DOI: 10.2507/daaam.scibook.2010.19

1. Introduction

Irrespective of theories and models of modern science (Dyson, 1989; Adams & Gregory, 2000; Chaisson, 2001; Harrison, 2003; Dick, 2008) on the Universe / Multiverse (?) (infinite / finite; opened / flat / closed etc.), on the progress (Teilhard, 1948/1956; Stonier, 1990,1992,1997; Moore, 1994; Wright, 2005; Costanza, 2009; Stiglitz, 2009), the **becoming / change** (….→ progress → stagnation → regress → stagnation → progress → …) is now approached mainly within the subjects or interdisciplinary (Katseneliboigen, 1997). The systemic approaches of the becoming / change and of the progress lack consistency (Umpleby, 2001, 2007) in the absence of a wholly system of concepts about systems (Watson, 1999; Popa, 2003; Castellani & Haferty, 2009) to allow a thorough knowledge and a humanist type orientation of the becoming / change, meant for turning the progress into a fundamental process of the Universe.

As a general rule, **the progress of systemic approach** of the reality leads (Banathy, 2000; Popa, 2003) to:

● continuous development of a consistent, robust system and of the system related concepts,

● establishment of hierarchic systemic models (non-mathematic and mathematic), more and more accurate, to reflect the structures and the flows of substance, energy, information (self-organization) in accordance with the present / future evolution of the science, to allow the modelling, effective simulation and optimization of all systems, no matters how complex they are,

● continuous development of the systems theory, philosophy and methodology (systemology / systemics).

The present chapter has in view to:

- define the **becoming / change** and the **progress** from a systemic perspective**,**
- analyse and define **clusters** and **clustering** from a systemic perspective as an essential process of the entities becoming / change,
- develop some **models**, useful in the engineering and management practice of cluster-based progress.

The present chapter makes a minute analysis of a new research and action sub-domain called "**cluster-based sustainable integrated competitiveness** (for unlimited term)", highly important for Romania and the European Union.

Future research will go deeper in the identification and optimization of clustering and clusters / clusters of clusters in other domains of reality.

2. Basic concepts of systemics

For the progress of science, the development of systemology / systemics (François, 1999; Watson, 1999; Popa, 2003) is preferred to other numerous notions (holistics, complexity science, new science of networks etc.), which have appeared at the same time with new branches and sub-branches of this synthesis-oriented science. Any systemic approach is based on a consistent, robust, of the system-related concepts.

System S (in Greek: σύστημα, in Latin: systema) means a multitude of integrated components (elements **E**) in internal determined M_{dint} / self-determined M_{aint} which interact and function through cooperation and competition (coopetition) under certain space-time-resources circumstances of proximate M_{pext} external environment, while producing some results in his life cycle, within D_{str} space-time-resources domains considered.

In general the cooperation can be assimilated with attraction, cohesion, compromise, compatibility and competition with repulsion, confrontation, rivalry, incompatibility of the components within D_{str} space-time-resources domains considered.

The **Universe / Multiverse** are infinite integrated systems of systems $\{S_S\}$ (agglomerations, networks, and groups etc. of entities) governed by **universal / general / characteristic laws** (Popa, 2003) which determine the cyclical becoming / change (…. → progress → stagnation → regress → stagnation → progress → ….), the continuous movement within any known $D_{str}(t)$ space-time-resources domains. The Universe / Multiverse can be consider an infinite hierarchy and diversity of $D_{str}(t)$ space-time-resources domains.

A **$D_{str}(t)$space-time-resources domains** means a "portion" of Universe / Multiverse, a supra-system within take place the becoming / change of the components (systems) and his internal environment (milieu). Specific interfaces separate the considerate $D_{str}(t)$ space-time-resources domains from his external milieu (environment) $\mathbf{M_{ext}}$. The systems laws (Kauffman, 1997; Popa, 2003) allows Mankind the knowledge, foresight and, more and more, the control and foresight of phenomenon within $D_{str}(t)$ space-time-resources domains.

The results of interactions and working of systems within $D_{str}(t)$ space-time-resources domains during its life cycle, characterised by specific **{v} variables**, are as follows:

- conscious (for systems that include humans), in which case the results represent the partial or total accomplishment of the **competitiveness K(t)** (aim / mission / objectives) of the system **S**, contribute to progress (or, on the contrary, to stagnation / regress), to wellbeing (or, on the contrary, to bad-being) in internal environment and in external proximal milieu M_{pext} of $D_{str}(t)$ space-time-resources domains,
- unconscious (for systems that do not include humans), in which case the results represent the **finality F(t)**, the consequence of the system S interaction with other systems from external environment, contribute to the becoming / change (…. → progress → stagnation → regress → stagnation → progress → ….) within $D_{str}(t)$ space-time-resources domains.

Any real system $\mathbf{S_R}$(natural and / or artificial):

- constitutes an integrated whole of its components and, at the same time,
- constitutes, (except for the Universe / Multiverse considered as infinite) a sub-system of a more complex system, respectively of a super-system (system of systems S_S) of a less complex component system, within $D_{str}(t)$ space-time-resources domains,
- identifies through a system of concepts (Table 1) which characterize any type of system (Popa, 2003; Popa et al., 2009),

•has a structure (the multitude of its **E** components and the relations $\mathbf{R_i}$ among them which determines the system identity, connectivity and functioning in its life cycle) and has in its structure two interconnected functional-structural sub-systems (execution sub-system $\mathbf{S_{Rexe}}$and command subsystem $\mathbf{S_{Rcon}}$ / self-command $\mathbf{S_{Raco}}$):

Systemic approach C and **cluster C components**	**Characterization of Clusters based on concepts of real systems S_R**(natural and / or artificial)								
	Structure **S = E & R_i**	Functio-ning programs **P_f**	Transfor-ming processes **P_t**	External conne-xions **R_e = U & Y**	Varia-bles **{v}**	Exten-sions / limits **L**	Milieu **M = M_{int}& M_{ext}**	Global function /mission **F_g**	Purpose (competi-tivenessK /Finality)
ClusterC - natural - artificial	compo-nents **E [1]+[2]+ [3]+[4]** & interco-nnexions R_i	**P_f**integra-ted, elabo-rate through initiative of [1] and **M_{aint}**of **C**	**P_t**specific integrated processes on components **[1]+[2]+[3] +[4]** of **C**	**R_e** with domain D_{str} input U / output Y speci-fic for **C**	state va-riabiles / input / output **X / U / Y** of **C**	fron-tier **L** of **C**, fluctu-ating, porous	proxi-mate do-main D_{str} of **C**	transfor-mation input U in output Y of **C**	**K_{sC}** sustai-nable competi-tiveness of cluster **C / result**
● Self-determined internal environment (milieu) **M_{aint}**of **C**	compo-nents **[1] +[2]+[3]** and interco-nnexions	**P_f** elaborate together **[1]+[2]+[3]** and integrated for **C**	**P_t**specific integrated processes on components **[1]+[2]+[3]** of **C**	**R_e**pre-valent through [1] and collateral through [2]+[3]	state va-riabiles / input / output **X / U / Y** of **C**	Fron-tier **L** of **M_{aint}**, fluctu-ating, porous	milieu M speci-fic for **C**	determi-nation of **C** existen-ce	**K_C** of cluster **C** / **result**
[1]Comint Internal community (give identity of **C**)	compo-nents and specific interco-nnexions for **[1]**	**P_f** elaborate for achiev-ement Y_1 and K_1& K_C	**P_t** specific integrated for achievement of Y_1 and K_1& K_C	input **U_1** and output **Y_1** specific for **[1]**	state va-riabiles / input / output **X / U / Y** of **[1]**	Fron-tier **L** of **[1]**, fluctu-ating, porous	milieu M speci-fic for **[1]**	produc-tion output **Y** of **C**	**K_1**of Comint / **result** **K_C** of cluster / **result**
[2]Facilit Internal and / or external facilitators (for coope-ration and competiti-veness of **C**)	compo-nents and specific interco-nnexions for **[2]**	**P_f** elaborate for achiev-ement Y_2 and K_2& K_C	**P_t**specific integrated for achievement of Y_2 and K_2& K_C	input **U_2** and output **Y_2** specific for **[2]**, for **C**	state va-riabiles / input / output **X / U / Y** of **[2]**	Fron-tier **L** of **[2]**, fluctu-ating, porous	milieu M speci-fic for **[2]**	stimu-late coope-ration & compe-titive-ness**C**	**K_2**of Facilit / **result** **K_C**of cluster / **result**
[3] Detint Deter minantsof internal environment (**C** life and functioning)	compo-nents and specific interco-nnexions for **[3]**	**P_f**elaborate for achiev-ement Y_3 and K_3& K_C	**P_t**specific integrated for achievement of Y_3 and K_3& K_C	input **U_3**and output **Y_3**specifi c for **[3]**, for **C**	state va-riabiles / input / output **X / U / Y** of **[3]**	Fron-tier **L** of **[3]**, fluctu-ating, porous	milieu M speci-fic for **[3]**	generate prere-quisite for **M_{aint}**of **C**	**K_3**of Detint / **result** **K_C**of cluster / **result**
● Target proximate external environment (milieu) {**M_{pext}**} of **C**	integrated external environ-ments	**P_f** specific integrated in domain D_{str} which incorporate cluster C	**P_t** specific integrated in domain D_{str} which incorporate cluster C	**R_e** with domain D_{str} environement: specific input U / output Y	state va-riabiles / input / output **X / U / Y** specific {**M_{pext}**}	Fron-tier **L** of {**M_{pext}** }, fluctu-ating, porous	proxi-mate do-main D_{str}	locali-zation of external con-nectors **[4]**	**K_D** for domain D_{str} which incorpo-rate cluster C / **result**
[4] Conext External connectors (initial sup-pliers and final consu-mers for **C**) from {**M_{pext}**} of **C**	compo-nents and specific interco-nnexions for **[4]**	**P_f** specific for each external connector	**P_t**specific for each external connector	**R_e** specific for: initial suppliers Y_{ini} / final consu-mers U_{fin}	state va-riabiles / input / output **X / U / Y** of compo-nents **[4]**	Fron-tier **L** of **[4]**, fluctu-ating, porous	milieu M speci-fic for **[4]**	supply initial input **U** /consum -ption final output **Y** of **C**	**K_4** useful for cluster **K_C** / **result**

Tab. 1. The systemic approach and characterisation of clusters C components

1) execution sub-system $\mathbf{S_{Rexe}}$ which achieves / ensures the transformation processes $\mathbf{P_t}$ of $\vec{U}$ entries (substance S, energy E, information I) into $\vec{Y}$ exits (of a substantial, energetic, information type with a preponderance S / E / I, specific for the identity of system $\mathbf{S_R}$),
2) command subsystem $\mathbf{S_{Rcon}}$ / self-command $\mathbf{S_{Raco}}$, which achieves / ensures the steering processes P_c of the S_R system by means of external functioning programs $\mathbf{P_f}$ (of command, elaborated in an exogenous way) and internal functioning programs (self-command, elaborated in an exogenous, unconscious or conscious way).

The system **hierarchy and diversity** is infinite in space-time-resources due to the dynamics of infinite interconnections „…. - systems **S** – environment **M** – systems **S** - ….” in the Universe / Multiverse:
(1) on the unlimited multitude of hierarchic levels {n} (over-ordination / subordination of systems) and
(2) at the same hierarchic level n (by coopetition = cooperation & competition / coordination of systems).

The **frontier of a system** is the limit (limits L) by means of which an active and conscious observer separates, according to its own interests of knowledge / action / command / self-command etc.,
- the internal environment / environments
- the external environment / environments

The **environments $\mathbf{M_S}$ of systems** are delimited space-time-resources domain $D_{str}(t)$, from a structural-functional viewpoint, internally simultaneous (over-ordination) / external (subordination), by means of:
- connexion **interfaces $\mathbf{L_I}$** (action / transfer / confrontation / cooperation / compromise), specific for the systems and real environments considered,
- **frontiers** of identification $\mathbf{L_F}$, defined by a human observer (individual or collective) in accordance with the aims to be followed in the system modelling / knowledge / research / exploitation / command / self-command (frontiers do not always coincide with the system interfaces).

The **relations between the system and the external environment** are unfold through the **$\mathbf{L_I}$ interfaces**, specific for each system and are called:
- $\vec{U}$ **input** / entries (connexions / actions of external environment on the system), expressing the demand (needs) of the system for its external environment and, partially, the offer of the external environment,
- $\vec{Y}$ **output** / exits entries (connexions / actions of external environment on the system), expressing the offer of the system for its external environment and, partially, the demands (needs) of the external environment.

The real systems $\mathbf{S_R}$ (natural and / or artificial) are identified by means of a system of concepts (Table 1) which characterizes any category of system (Popa, 2003):

$$S_R = \{E \,\&\, R_i, P_f, P_t, U\&Y, v, L, M_{int}\,\&\, M_{ext}, F_g, K/F\} \quad (1)$$

These concepts allow a rigorous defining of the notion of cluster.

The **progress** in the Universe / Multiverse is a category of the becoming / change and it is achieved in the space-time-resources domain $D_{str}(t)$ of various dimensions, embedded hierarchic levels, characteristics and life durations, within the life cycle of the various $D_{str}(t)$ components (systems). As a general rule:

● **progress** is defined by the system evolution whose characteristics is the cyclic, temporary or lasting / sustainable (unlimited) increase of **K(t)** competitiveness (Resource availability in the proximal external environment, Competing capability, Flexibility, Value, Demand in the proximal external environment, Efficiency), of the structural-functional complexity **W(t),** of the diversity **Z(t)** and of the **B(t)** welfare of entities in the hierarchy of the system internal and external environments in a living space-time-resources domain $\mathbf{D_{str}(t)}$,

● **stagnation** is defined by the system behaviour with temporary or lasting / sustainable (unlimited) maintenance of **K(t)** competitiveness, of the structural-functional complexity **W(t),** of the diversity **Z(t)** and of the **B(t)** welfare of entities in the hierarchy of the system internal and external environments in a space-time-resources domain $D_{str}(t)$,

● **regress** is defined by the system involution whose characteristics is the cyclic, temporary or lasting decrease of **K(t)** competitiveness, of the structural-functional complexity **W(t),** of the diversity **Z(t)** and of the **B(t)** welfare of entities in the hierarchy of the system internal and external environments in a space-time-resources domain $D_{str}(t)$.

Competitiveness K(t) of a conscious $\mathbf{S_{cu}}$ system is integrating in a Δt time period, in a space-time-resources domain $D_{str}(t)$ (Popa, 2002, 2005, 2008) the following:

● **Availability of $\mathbf{D_R}$ resources** for the S_{cu} conscious system as a result of the meeting of the real / effective demand of consumers in the proximal external environment M_{pext} by the offer of the conscious system (D_R is an effect of values exchange in the space-time-resources domain $D_{str}(t)$;

● **Competing capacity $\mathbf{C_K}$** of the S_{cu} system;

● **Offer $\mathbf{O_{Scu}}$ of the $\mathbf{S_{cu}}$ system** for the proximal external environment M_{pext}, offer that, in its turn, integrates: **Flexibility F** – the variety / diversity of Y exits or {i} products, the Q_i quantity, the T_{cai} assimilating times of {i} variety / diversity, the T_{pi} processing times of R(t) resources necessary for achieving the {i} variety / diversity; **Value V** – the N_{gi} level of {i} „products" global quality of the S_{cu} system and the C_{ci} level of complete resource consumption necessary for achieving the {i} „products";

● **Clustering level** in the proximal external environment M_{pext} available for the $\mathbf{S_{cu}}$ system;

● **Demand $\mathbf{C_{Mpext}}$**[(needs {i} & N_{gi}& Q_i& T_i) & (exchange of available values)] of consumers in the proximal external environment $M_{pext}$of {i} „products" in the S_{cu} conscious system;

● **Efficiency E** (energetic, ecological, economical, ergonomical, aesthetical, social etc.) of the creation, operation by regular restructuring and termination of S_{cu} system;

● **Characteristics of conjunctures: $\mathbf{I_p}$** (of proximal external environment M_{pext}) and $\mathbf{I_M}$(of over-ordinate external environment hierarchy) specific for the external environments of the S_{cu} conscious system.

The determinant factors of becoming / change in a space-time-resources domain $D_{str}(t)$ are very numerous. The categories of changing factors and their origin are presented in Table 2.

Factors **Type** of change / becoming	**Categories in accordance with factors origin**			
	Components of $D_{str}(t)$ domain and her competitiveness	Proximate external environment M_{pext} of the components of $D_{str}(t)$ domain	Self-determined internal environment M_{aint} of $D_{str}(t)$	External environment of $D_{str}(t)$
Progress (+) progress cycle within $D_{str}(t)$ domain through: - functional cycles c = 1, 2, ….,f - system generations g = 1, 2, …., s, ….	- Integrated available competitive and renewable Resources $\mathbf{R_i(t)}$ - Complexity **W(t)** of entities $\{E_K\}$ - Diversity **Z(t)** of entities $\{E_K\}$ - Integrative-innovative competitive **K(t)** Clusters $\mathbf{C_{ino}}$ (resources, execution, govern & clusters of clusters $\{E_K\}$) - Competitive **K(t)** entities $\{E_K\}$	- Periodical stability of proximate external environment M_{pext} of the components of $D_{str}(t)$ domain - Positive demand (+) $\mathbf{C_{Mpext}}$ of consumers within proximate external environment M_{pext} for „products" {i} of $\{E_K\}$ entities - Cyclical characteristics $\mathbf{I_p}$ (conjuncture) of proximate external environment M_{pext}	- Periodical stability of internal environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_{MD}}$ (conjuncture) of internal environment of $D_{str}(t)$ domain	- Periodical stability of external environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_M}$(conjuncture) of the hierarchy of external environment of $D_{str}(t)$ domain
Stagnation (≈) stagnation cycle within $D_{str}(t)$ domain through: - functional cycles c = 1, 2, ….,f - system generations g = 1, 2, …., s, …..	- Available and renewable Resources $\mathbf{R_i(t)}$ - Preclusters **PC** and Clusters **C** (resources, execution, govern & clusters of clusters $\{E_K\}$) - Insufficient competitive / non-competitive entities $\{E_K\}$	- Relative instability of proximate external environment M_{pext} of the components of $D_{str}(t)$ domain - Stagnant demand (≈) $\mathbf{C_{Mpext}}$ of consumers within proximate external environment M_{pext} for „products" {i} of $\{E_K\}$ entities - Cyclical characteristics $\mathbf{I_p}$ (conjuncture) of proximate external environment M_{pext}	- Relative instability of internal environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_{MD}}$ (conjuncture) of internal environment of $D_{str}(t)$ domain	- Relative instability of external environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_M}$(conjuncture) of the hierarchy of external environment of $D_{str}(t)$ domain
Regress (-) regress cycle within $D_{str}(t)$ domain through: - functional cycles c = 1, 2, ….,f - system generations g = 1, 2, …., s, ….	- Insufficient available Resources $\mathbf{R_i(t)}$ - Non-competitive Preclusters **PC** and Clusters **C** (resources, execution, govern & clusters of clusters $\{E_K\}$) - Non-competitive entities $\{E_K\}$	- Instability of proximate external environment M_{pext} of the components of $D_{str}(t)$ domain - Negative demand (-) $\mathbf{C_{Mpext}}$ of consumers within proximate external environment M_{pext} for „products" {i} of $\{E_K\}$ entities - Cyclical characteristics $\mathbf{I_p}$ (conjuncture) of proximate external environment M_{pext}	- Instability of internal environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_{MD}}$ (conjuncture) of internal environment of $D_{str}(t)$ domain	- Instability of external environment of $D_{str}(t)$ domain - Cyclical characteristics $\mathbf{I_M}$(conjuncture) of the hierarchy of external environment of $D_{str}(t)$ domain

Tab. 2. Determinative factors of becoming / changewithin $D_{str}(t)$ domains

3. Clustering and clusters as determinant factor of becoming / change

A **cluster** is a grouping of a number of "something" (physical or abstract entities) potential competitive in its proximate external environment. The notion

"cluster" is more and more used in science (physics, astrophysics, chemistry, biology, health sciences etc.), computing, economics, management etc. and have a systemic character. Yet, the cluster is not defined in a rigorous and systemic manner.

Despite its lack of profoundness, generality and conceptual clarity, (Martin & Sunley, 2003), the notion of cluster has gained wide recognition as a model of industrial promotion and policies at both national and regional level (Porter, 1998; Press, 2006). Are known little and limited systemic approaches of cluster concept in economics (Sölvell, 2008; Jensen, 2009).

In our Universe, clusters are the systems of systems $\{S_S\}$ which generate becoming (progress / stagnation / regress) in space-time-resources domains $D_{str}(t)$ of natural and / or artificial environments, from macro-cosmos to micro-cosmos (Popa, 2003; Popa et al. 2009). Clusters are a mix of "self-determined internal environments $\{M_{aint}\}$ & target proximate external environment $\{M_{pext}\}$ of $D_{str}(t)$, are the source for the increase of organized complexities, being implicitly innovative when created (a new structure in the outer environment). But, the lasting / sustainable progress in all domains is generated by **inoclusters,** by integrative-innovative clusters. (Popa, 2003, 2007).

The **inoclusters** (innovative clusters) are systems of real systems $\{S_S\}$ generating progress in the natural and / or artificial environments, from macro cosmos to micro cosmos, in various time dimensions (transient, temporary, lasting, sustainable). The **sustainable inoclusters** generate progress in all natural and / or artificial environments, from macro cosmos to micro cosmos, on unlimited term, by the systems of real systems $\{S_S\}$ successive-parallel generations. Mankind tenaciously tends to turn into a sustainable macro-cluster, since the beginning of the 21^{st} century.

From a general functional-structural perspective, **clusters** are **spatial-temporal agglomerations / concentrations of systems** in $D_{str}(t)$ domains of the Universe (from macro-cosmos to micro-cosmos), having within their structure four categories of functional components (Table 1):

● three categories of components of the self-determined internal environment M_{aint}

[1] Internal community (**Comint**) which gives the cluster its identity (crowd, group / team, network, colony, component society etc.) and provides / offers value / „range of products" for the consumers in the target proximate external environment M_{pext} [4],

[2] Internal and / or external facilitators (**Facilit**) which stimulate cooperation and competitiveness of the internal community components [1] and of the determinants [3],

[3] Determinants (**Detint**) of the self-determined internal environment M_{aint} specific features of the cluster which ensures the life and functioning of the internal community [1] and of internal and / or external facilitators [2],

● a category of components of target proximate external environment $\{M_{pext}\}$

[4] External connectors (**Conext**) for components [1] & [2] & [3] which ensures the cluster's connexion with the target proximate external environment $\{\mathbf{M_{pext}}\}$ of **C** (initial suppliers and final consumers for cluster).

Irrespective of the category (natural and / or artificial), the clusters are implicit and transient innovators, by creating the $M_{crS}(t)$ critical masses of the components E and products that form the systems of real systems $\{S_S\}$, generators of becoming /

change processes (…. → progress → stagnation → regress → stagnation → progress → ….).

Clusters / inoclusters can be natural (created without human intervention) and / or artificial (created with human intervention). The infinity of the Universe and the complexity of life environment have determined and will continuously determine the clustering and the clusters characteristics, as follows:

(U) Infinite Universe in space-time-resources has generated and will generate, in a cyclic, successive-parallel and relatively slow manner, all the categories of natural clusters / inoclusters S_{SN}:

- non-alive (physical-chemical, cosmological clusters etc.), in the entire Universe / Multiverse,
- alive (bio-clusters, bio-socio-clusters etc.), on the planets / satellites that provide favourable life conditions,

and

(L)planet Life environments, more and more complex,with more and more intelligent beings, have generated and will continue to generate, in a cyclic, successive-parallel way, at a certain moment, the categories of artificial clusters / inoclusters S_{SA}, specific to human civilizations:

- spontaneous (self-adjusting clusters in external environment – for example, the pre-clusters in a certain economic sector, established by the companies that cooperate and strive for increasing competitiveness),
- planned, designed, accepted and established in various external environments (competitive durable clusters / competitive sustainable clusters – for example, the cluster established by a leading transnational company in global market).

Clustering is a continuous process of creation, functioning by current restructuring and dismissing of successive-parallel generations g = 1, 2,…., n, n+1, …., of clusters / clusters of clusters in D_{str} (t) space-time-resources domains of the Universe which meet the existence requirements of $\{S_S\}$ systems of systems. An **optimalclustering level** N_{Copt} (Popa, 2007), defined by the maximal integrative competitiveness K_{ismax} (sustainable), can be determined in any D_{str} (t) domain.

The general model as illustrated in Figure 1 shows in details **the universal cycle of systems becoming / change**, considered as an sample (functional cycles c=1, 2, ….,f) or as a type (system generations g = 1, 2, …., s). The becoming / change of systems under review can be progress (+), stagnation (≈) or regress (-), in accordance with the evolution in time of the four major critical factors categories $\mathbf{\{f_c\}}$:

- dynamics characteristics of system outer environments $\mathbf{M_{ext}}$,
- dynamics characteristics of system inner environments $\mathbf{M_{int}}$,
- specific change-generating critical masses $\mathbf{M_{cr}}$ (clusters),
- integrative innovation in systems environments.

The progress in our Universe relies on competitive sustainable inoclusters (the progress-generating specific critical masses M_{cr} and the integrative innovation in the system environments) within D_{str}(t) space-time-resources domains.

In any space-time-resources domain D_{str}(t) of the Universe characterized by stability within favourable / unfavourable limits for the existence of $\{S_S\}$ systems of systems, the clustering cyclically generates more complex E entities **(+ΔW),** more diverse **(+ΔZ)** and in big quantity **(+ΔQ)** that produce as exits more or less

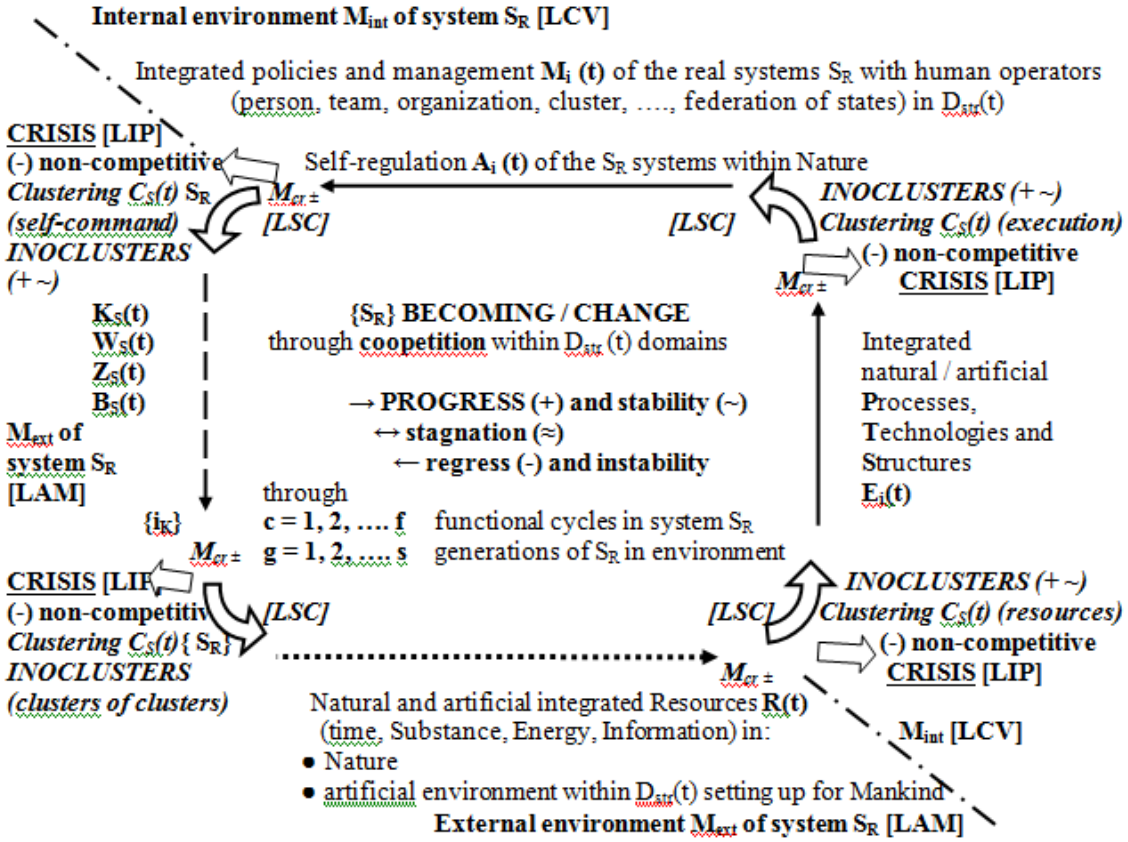

Fig. 1. Principled model for the causal cycle of becoming / changing of real systems {S_R} in the space-time-resources domains $D_{str}(t)$ of the Universe / Multiverse (?)

- **Results of cyclic change through coopetition** (COOPEration & compeTITION) in **sustainable** time horizons (unlimited) / **lasting** (long term) / **temporary** (medium term) / **ephemeral** (short term)

  $\boldsymbol{M_{cr\,\pm}}$– critical mass, embryos of *clustering* $C_S(t)$

  $\mathbf{C_S(t)}$ – Clustering of real systems S_R in the hierarchy of external environments M_{ext}

  $\mathbf{\{i_K\}}$ – competitive assortments produced and transferred by S_R to external environments M_{ext} within c = 1, 2, …. f cycles of the g = 1, 2, …. S generations

  $\mathbf{K_S(t)}$ – Competitiveness of real systems S_R in the hierarchy of external environments M_{ext}

  $\mathbf{K_{tots}\,(t)}$ –Sustainable total competitiveness mainly determining **PROGRESS**

  $\mathbf{W_S(t)}$ – Complexity of real systems S_R in the hierarchy of external environments M_{ext}

  $\mathbf{Z_S(t)}$ – Diversity of real systems S_R in the hierarchy of external environments M_{ext}

  $\mathbf{B_S(t)}$ – Welfare / Prosperity of real systems S_R in the hierarchy of external environments M_{ext}
- **Universal laws of real systems S_R**determine (Popa, 2003, 2008a) the causal cycle of becoming / changing of real systems {S_R} in a S_R space-time-resources existence domain $\mathbf{D_{str}(t)}$: regular oscillation of resources and performances (±); increase of performances (↑); decrease of performances (↓); lawful differentiation / distribution of systems, resources and performances (∩); limitation of resources and performances (<)

[LIP] – The law of existence (perfectible imperfection)
[major effects: $\pm \Delta K_S$ (t); K_{Sg} (t) < K_{SgMAX} (t); partial ↑ Z_S(t)]

[LSC] – The law of change through clustering (competitiveness through ino-clustering)
[major effects: S_R distribution in accordance ∩ K_S (t); ↑ C_S(t); partial ↑ W_S(t); partial ↑ K_S(t)]

[LAM] – The law of equilibration / balance (environments self-adjusting law)
[major effects: $\pm \Delta K_S$ (t); ∩ K_S (t); partial ↑ W_S(t); partial ↑ B_S(t)]

[LCV] – The law of life (life cycle law)
[major effects: K_{Sg} (t) < K_{SgMAX} (t) şi T_{cvS} (t) < T_{cvMAXS}; ↓ K_S(t); ± B_S(t)]

competitive {i} „products" **(± ΔK)** which become / may become resources for the next becoming / change cycles and determine more or less the **(± ΔB)** welfare in the **D_{str} (t)** domain. The internal clusters (of resources, execution, governing) and the clusters of clusters that give birth to the{i} „products" (Figure 1) are the main becoming / change generating factors. Integrative innovative clusters (inoclusters) C_{ino} are the only one to generate lasting / sustainable progress in the space-time-resources domain D_{str}(t) (Table 2).

Long time progress can be achieved within D_{str}(t) space-time-resources domains only by the system lasting / sustainable integrative competitiveness **K_{ids},** as effect of the prevalence of positive critical factors / causes (+). The **lasting K_{id} / sustainable K_{is} integrative competitiveness** means the ability and the capacity of a (S_S) system of systems to optimise from an integrative-hierarchy perspective its internal environment, to be a winner in the coopetition (confrontation and / or cooperation in successive-parallel cycles and generations) of its external environment, without causing damage, to simultaneously achieve welfare, for a very long („lasting") / unlimited („sustainable") period of time.

At the Universe / Multivers scale, sustainable progress (…. → cosmologic → biologic → anthropologic → humanist through civilization and culture → anthropologic → biologic → cosmologic → ….), on unlimited term can be achieved only if it is governed by intelligence, affections and a superior power. At the beginning of the 21st century, Mankind is still far from meeting these requirements, but it has real chances to promote progress.

Stagnation is achieved through insufficient competitiveness K, as effect of the prevalence of neutral (≈) and contradictory (±) critical factors (causes).

Regress is achieved through non- competitiveness, as effect of the prevalence of negative (-) critical factors (causes) and crisis.

The general model as illustrated in Figure 1 and Table 2 shows **four determinants of becoming / change of systems**:

(1) periodical stability / instability of the hierarchical D_{str}(t) space-time-resources domains features, in favourable / unfavourable limits of the each D_{str}(t) space-time-resources domains life,

(2) hierarchical D_{str}(t) space-time-resources domains internal and / or external **clustering**, like **main generator of becoming / change, of self-organization**,

(3) becoming / change cycle within each D_{str}(t) space-time-resources domains, like effect of universal / general / characteristic systems laws,

(4) becoming / change category (progress / stagnation / regress) within D_{str} (t), like effect of competitiveness levels K(t) on the D_{str} (t) domains hierarchy.

The infinity of the Universe / Multiverse and the complexity of life environment have determined and will continuously determine the clustering and the clusters characteristics.

4. The clustering in business and innovation environment

In economy and innovation the clusters (synonyms: pôles de compétitivité – France; Kompetenznetze - Germany) are **dynamic agglomerations / bunches / geographical concentrations** (street in a locality, …, global market) **of organizations,** having within their maximal structure (innovative clusters / inoclusters) four categories of flexible / fluctuant integrated subsystems (Popa, 2002, 2005, 2007, 2008):

[1]Company networks (**RF**) with: **[1.1]** Leader companies ("product assemblers" or network coordinators) / groups of coordinating organizations in RF; **[1.2]** Innovation, production / services, sale, training companies; **[1.3]** Research-Development-Innovation companies (Universities, R&D institutes / companies); **[1.4]** Financing institutions(Banks, non-reimbursement financing funds, national and EU financing programs etc.),

[2]Facilitators (**Facilit**): Institutions / organizations / networks for cooperation and competitiveness under stability or crisis conditions, with: **[2.1]** Centres of Competitiveness, Councils of Competitiveness; **[2.2]** Chambers of Commerce, Industry and Agriculture, other business organizations; **[2.3]** Development Agencies (regional, county, local); **[2.4]** Other facilitators: legal and monitoring institutions and bodies, employers associations, unions, professional organizations, media etc.

[3]Local PublicAdministration (**LPA**): **[3.1]** local / **[3.2]** regional / **[3.3]** euro-regional / **[3.4]** national Government

[4]External connectors (**Conext**): **Consumers** on target markets / segments / niches with specific demand, in continuous behaviour changing and consumers from other proximal external environments (natural, demo-psycho-linguistic, socio-cultural, political-juridical-administrative, military etc), **Initial Suppliers** from external environments.

In a strict sense, clustering ("cluster development" or "cluster initiative") is defined as business and innovation cluster establishment and development in economy.

Clusters are created and develop in a natural or planned manner in the geographic / administrative regions, in villages, towns, cities / municipalities, areas, counties. Based on the cluster definition, any inhabited locality or region, by means of the local public administration, is co-determinant for the establishment of one or several clusters belonging to some distinctive economic branches / sectors.

The **factors** that determine clustering and cluster development and competitiveness in the business and innovation, technological and managerial environments at the beginning of the 21st century are very numerous. The most important are the following:

- **culture and skills of partners** from the cluster (determine cluster establishment and influence C_{KC} competing capacity of clusters)
  - cooperation and competitiveness culture, common beliefs and competence of partners
  - trust and lasting respect among partners as basis for cooperation development
  - integrative innovation and extended innovative spirit, as basis for clusters progress
  - learning / imitation and coopetition (cooperation and competition), as basis for adaptability
  - proactive / developed entrepreneurship in all cluster components, within the cluster as a whole, as basis for cluster dynamism
  - knowing / acquiring integrative management of competitiveness (Popa, 2008b)
- **external conjunctures of** cluster and cluster components(determine cluster promotion, establishment, development, certification and longevity, cluster life-cycle duration $T_{cvC} \rightarrow$ max; or, determine cluster termination)
  - conjunctures at micro / mezzo level (communities, organizations outside the clusters / counties)
  - conjunctures at macro level (regions, states, state federations, expansions / national, federal economic and political crises etc.)
  - conjunctures at global level (climate, biodiversity, pollution, wars, terrorism, lack of resources, expansions / world economic and political crises, demographic crisis etc.)
- **resources,** cluster internal and external connexions (determine cluster creation, development, certification and longevity, cluster life-cycle duration $T_{cvC} \rightarrow$ max)
  - nominal capital concentrated in the geographic area, determining communication, trust and continuous expansion of cooperation among people and organizations of various categories, with a view to simultaneously developing individual and community value
  - creation of competitive multidimensional networks, capable of flexible and agile cooperation
  - qualified / poly-qualified labour force by means of continuous training
  - continuous communication with the outside, in order to identify / foresee opportunities and dangers in real time
  - specific material resources (infrastructure, high tech machines and equipment, natural resources etc.),
  - financial resources for cluster various life cycles stages,
  - necessary informational resources (integrative management, know-how etc.).

Clustering in business and innovation environment is carried out under several **stages and phases** (Potworowski, 2003; Popa, 2008; Sölvell, 2008) in the framework of cluster life cycles. The following are the most important ones of these stages:

(1) Mobilization – development of interest, knowledge and participation of various organizations as potential members of the future cluster

~ orientation of the organization creation / designation (leader company, group of companies, association etc.) for the cluster establishment, dedicated to fulfil its goals

~ creation of a project team and a council for monitoring the cluster establishment

~ identification and evaluation of „pre-cluster potential embryos **(GP)**" (dynamic, offensive companies C / Networks of Companies NC) and of **(PC) pre-clusters** with local cluster establishment potential
~ recruitment of highly cluster-oriented and committed leaders
~ identification of economic / innovative opportunities and incentives, attractive for those interested in increasing competitiveness by means of clustering
~ stimulation of private / public organizations interest in participating to cluster / pre-cluster oriented actions
~ stimulation of cluster potential interested bodies and "champions"

(2) Diagnosis and prognosis – evaluation of resources, marketing opportunities and infrastructure necessary to an effective cluster
~ attraction of an independent, objective analyst
~ analysis and group diagnosis / prognosis by advanced methods (complex SWOT analysis, benchmarking etc.) for long and medium term definition:

(3) Cluster and clustering cooperation strategy – working group analysis with competent representatives ([1] Network of organizations & [2] Facilitators & [3] Local Public Administration) of cluster challenges, potentiality, priorities and elaboration of cluster policy / strategy
~ organization of work meetings for the confrontation of opinions and the commitment of the organizations in the future cluster
~ organization of a complete, open working group (critical mass), oriented towards the market and the environment, to define the stages in the cluster establishment and development
~ selection of a competent working group able to recruit participants in the cluster and monitor the stages in the cluster establishment
~ determination of viability for each stage and training of interested bodies
~ formulating the clustering strategy and cooperation for cluster establishment
~ applying the cooperation strategy to cluster establishment

(4) Cluster establishment – expanding the group of interested organizations, creating / designating an organization to create and establish the cluster de facto
~ creation of a group to control and promote cluster establishment
~ facilitating cluster sales and procurement by expanding company networks
~ expansion of cluster financing sources
~ development of cluster oriented leadership
~ cluster juridical and physical establishment **CC** (alliances-group, leader company that „assemblies" complex products, coordinating-company, organization associations etc.)
~ involvement of clusters in regional development and social responsibility

(5) Cluster operation by regular restructuring and increase of competitiveness– development of competitive cluster / generations of sustainable competitive clusters on extended markets: local, …., global
~ cluster development at regional level CD, based on competitiveness strategies and tactics, with regular sub-improvements
~ cluster initial certification – at regional / euro-regional level
~ cluster development at national level CE, based on competitiveness strategies and tactics, with regular sub-improvements

Level K_C / Target market		micro / Mezzo / MACRO								
		street	district	locality	area	county	region	country	federation	global
CE	**1** Cluster leader in global market									•
	2 Cluster in Top 3 worldwide								•	•
	3 Cluster in Top 10 worldwide								•	•
	4 Clusterimportant interna-tional						•	•	•	
	5 Clusterimportant federal						•	•	•	
CD	**6** Clusterimportant national					•	•	•		
	7 Clusterimportant regional			•	•	•	•			
CC	**8** Clusterimportant at level area		•	•	•					
	9 Clusterimportant local	•	•	•						
	10 Establish Cluster	•	•	•	•	•	•			
PC	**11** Existing Pre-Cluster	**O**	**O**	**O**	**O**	**O**	**O**			
GP	**12** Potential embryonic Pre-Cluster	Firm / Network	Firm / Network	Firm / Network	Firm / Network					

Tab. 3. Priorities in analysis, promotion, establishment, assessment and clusters C certification

K_C – cluster C competitiveness (level of target market and market share)
CE – International Extended Cluster (cluster competitiveness level K_C = 1, …. 5)
CD – National and regional Developed Cluster (cluster competitiveness level K_C = 6, 7)
CC – Regional, local, establish Cluster (cluster competitiveness level K_C = 8, 9, 10)
PC – Natural Pre-cluster (cluster competitiveness level K_C = 11)
GP – Potential embryonic Pre-cluster
● – Preferable analysis, promotion, establishment, assessment and clusters C certification
O – Preferable assessment and promotion of pre-clusters PC
~ cluster second certification – at national level (ex. France in 2004 & 2008)

~ cluster development at European / global level CE, based on competitiveness strategies and tactics, with regular sub-optimization

~ cluster third certification – at European / global level (ex. in UE, European Cluster Observatory, active after 2007)

In all the countries that lack competitiveness, the managerial and political culture (scientific management, clusters and clustering, competitiveness policies and management etc.) is rather precarious at all levels and the domestic capital clusters are very rare or they do not exist at all. In these countries, there are pre-clusters **PC** naturally established, within 3 - 10 years since the establishment of the leader company (of „product assembler" or „network assembler" type). In case these countries attract important direct investments, the transfer of resources (management, technologies, cooperation and quality culture, financing etc.) is effected relatively easy and through the following:

- rapid establishment of regional clusters **CE** linked to the global market by means of „foreign mother-companies" (solution used by all multinational exporting companies),
- link / inclusion of efficient domestic companies and foreign companies operating on the national territory to the clusters of clusters of trans-national companies,
- short-time establishment of a national / global cluster by a joint venture or foreign leader company acting as a „complex product assembler" (ex. The automotive cluster in Romania, having as leader company Dacia Group Renault Pitesti, with 188 1st rank suppliers of which 54 from Romania and thousands of suppliers on the national and global market, was ser up in 4 years, 2000-2004)

In the countries and regions where the clustering process is rather slow, the analysis, promotion, establishment, evaluation and certification of clusters / clustering shall be done within a **more complex / comprehensive vision** (Table 3), starting with "pre-cluster potential germs (GP)", to be identified in the top of competitive companies, which can "crystallize" pre-clusters and clusters.

5. Conclusion

The modern science progresses when a more general theory is formulated, which explains as many phenomena as possible with as few statements as possible. This idea, that more general theories are preferred over more specialized theories, lies at the heart of systems science.

The clustering systemic approach explains a great number of phenomena related to the becoming / change in the most diversified domains while using a small number of concepts and models.

The present article presents in details the new research and action sub-domain defined as "cluster-based sustainable integrative competitiveness (on unlimited term)", by the following contributions:

» integrative definition of the main **concepts of systemics**,

» functional-structural definition and characterization of **clusters, clustering and inoclusters**, which allows the systemic approach and the unitary application of these concepts, in most various domains of reality [science (physics, astrophysics, chemistry, biology, health sciences etc.), computing, economics, engineering, management, policies, politics etc.],

» elaboration of a **model for the universal cycle of the system becoming / change**, which emphasizes the essence of progress in any domain of reality: cluster-based sustainable integrative competitiveness,
» systemic analysis of clustering within business and innovation environments, of the progress ways in this domain.

Future research will go deeper in the identification and optimization of clustering and clusters / clusters of clusters in other complex domains of reality (science, engineering, management, economics, policies, politics, culture etc.).

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