

**A model for Communication and Information Systems (C3I) to assist crisis management, considered from the viewpoint of cooperation
- an attempt to go beyond the cartesian decision schema -**

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Abstract: This paper proposes a new conceptual framework for the modelling of Control, Command, Communication and Intelligence systems (C3I). The need for a new framework strongly affects C3I users and designers, civilian as well as military. This had a recent confirmation when attempting to apply in an operational context these systems to geopolitical crisis management.

We shall show why the treatment of crisis situations requires models more general than the models based on the rational, linear and deterministic Cartesian decision schema ([Sfez 92]). We use as a basis the apories that the traditional models try to avoid or bypass, to build the model necessary for going beyond and creating the new values typically required by the treatment of a crisis (we consider the crisis as the institution allowing our common values to be elaborated).

We think in particular that in order to obtain C3Is with a capability of interoperation and support for the multiparticipant activities of interpretation in crisis situations, it is necessary to broaden the notion of acquired knowledge including the notion of exchanged idea. For this reason we give here a sketch of a research programme which aims at producing a model of multiagent cooperation not limited to the rational dimension. We present more particularly the hypertiling formalism, a candidate for modelling the desired noosphere.

Warning: Since this research is in a phase of definition, we had the choice between the formalization of only one projection of our model, on the one hand, and an attempt to suggest the general significance of it, at the risk of introducing a potential confusion, on the other hand. We chose the second approach, in order to collect the broadest spectrum of criticisms before addressing the second phase of the research.

Our scientific approach consisted in connecting with an ever finer thread our intuitions of the properties required for the noosphere and a representation inspired by topology, in order to elaborate simultaneously and incrementally the model and representation of the knowledge.

Keywords: Control, Command, Communication and Intelligence (C3I), interpretation of crisis situations, hypertiling, noosphere, criticism of the Cartesian decision model.

1 Preliminary

The use of the classical models allows the construction of the systems composed of large sets of stable objects in reciprocal communication. In these systems, a major part of the communications consists of imperative and asymmetrical instructions which must lead to precise actions. This area is well defined and delimited, and is not a problem here. We mean by system a set characterized by a structure, an activity and an evolution. We shall consider that these systems are endowed with intelligence, i.e. have a reasonable behaviour. We mean by cooperation a distribution of the means of this intelligence over space and time.

A traditional system is perceived as a set plunged into an external environment. Different paradigms allow the representation of this system by associating, for example, a structure with a function in the mechanical framework, or by adding the structure-evolution association to the structuralist paradigm. The systemic paradigm plunges this system into an environment by allowing its finalization. The system contains projects with a capability of self-finalization due to a piloting structure and a possibility of imagination. But the system is perceived as an isolated and reactive entity placed in a foreign environment. The system always reacts to external sollicitations and is designed by an external modeller.

It is possible to try to represent artificial objects by using such systems, i.e. computerized systems having a degree of reasonable autonomy in decision and behaviour. In this case one should accurately specify what this intelligence is. The A. Newell's Knowledge Level assumption is placed in the framework of this problematic - a human operator delegates to an artificial actor knowledge, aims and actions, which are organized by a rational principle and can be translated into the calculable languages of the Symbol Level, in order to arrive at a software system supporting the efficient reaction to external sollicitations. The manner of the knowledge transfer from the operator to the actor, as well as the actual nature of knowledge, are open issues. But in all cases, the system has been isolated, made objective, and it reacts with its environment.

A system of this type can be cooperative; it is then structured on the basis of isolated entities to be organized and evolved by the co-operative communication. The simplest solution for its representation consists in a communicating network of traditional systems. The input/output communication is then extended by the definition of a more or less complex graph made of multidirectional links. The properties of the graphs (connected components, cycles, subgraphs, etc.) allow the treatment of some questions pertaining to the topic. In this case too the model is defined on the basis of components which are subsystems connected by a network. The approach remains analytical - this system is only the sum of its parts.

A co-operative system composed of intelligent systems, human or not, is different from the set union of the generator systems. It is a social body, and the fact to be both individual and multiple, places it in the field of the social objects, in the field of the collective memory, in the domain of the permanent values in the essence where the apories are placed. The knowledge addressed here is not a communication language, but the historically constituted language, a vehicle for ideas going beyond the use proper to each intelligent participant. The Knowledge Level assumption appears in this case too simple, because the modelling of the knowledge at the level we envisage has a very different extension.

Therefore it is necessary to consider a co-operative system as being essentially self-finalizing, social, creative, complex, and, in fact, as a multiple life going definitely beyond the individual. For this reason it is necessary to go beyond the Cartesian vision of the decision - linear, rational and deterministic ([Sfez 92]).

The modelling of the systems aimed at representing close objects that man can use as tools to extend his capability. The co-operative system contains man, as a social actor, who becomes, due to this immersion, non-isolated. The co-operative system will define the man in cooperation - the notion of tool is no longer pertinent because man is plunged into the system, and the modeller himself represents a system containing him as soon as the model is designed, and afterwards too.

The principles of modelling are systemic, but with an extension towards the suppression of the notion of environment, i.e. the system is considered as a partial universe model. The modelling is a method, which may exclude neither a science nor a philosophy.

It is impossible to build the model from disjoint physical objects, endowed with personal autonomy because it is actually global since it includes even the modeller. We shall define it on the basis of the social man, and by using an approach of philosophy, cognitive sciences, mathematics and distributed artificial intelligence.

Here are the first building blocks of a different model for which communication is viewed, far beyond the technical level of the link medium, as the central eidetic fact for those who make complex decisions through cooperation. We think that this approach goes beyond classical models, by taking into account the collective events and the characters of the decision users usually place outside the rational field, like doubt, inconsistency, contradiction, intuition. In this way, the thinking man is plunged into a model we mean to be essentially collective.

Our method cannot be reduced to an analytical decoding of the system's multiple characters, but is a global capture of the "meaningful object as a functioning organization" (see Lichnerovitch). The model is built according to the principle of co-organization relationships, producing a system animated by a continuous reorganization movement. So, we adopt a systemic approach ([Le Moigne 77], [Le Moigne 90], [Morin 86], [Morin 91]).

Our model allows us to think a global system, apprehended as artificially intelligent, representing an organization which operates in it and on it, from a substratum formed of reality and ideas made objective. The major epistemological categories form the initial structure of this substratum and allow the induction of multiple topologies. The users of the system are plunged into it, and the same is true for the ideas they reveal. The spatio-temporal evolution is globally viewed as a flow of decision making acts, concurrent and simultaneous at multiple scales and including the apories, and placed in topological fields.

In this preliminary version, we present a rapid analysis of the insufficient characteristics in the present C3Is. Then we set down the central principle which must guide, in our opinion, the modelling research in the domain. Finally, we propose a general modelling satisfying this principle. We describe it rather globally in order to allow the characteristics to be specified and constructively criticized, through research work, until an effective system can be built.

This new system will belong to new users, because the ontological aspect is apparent in the system itself, and therefore the notions of values are, for the user, definitely different. Our method is thus based on self-reference, since the system modifies the man who modifies the system. But is it still possible to envisage communicating systems where the man intervenes, but excludes himself from them ?

2 Problematics

2.1 Present principle of C3I modelling

A C3I is presently a communicating system, integrating technical computerization, in charge of the follow-up of complex situations, and assisting the users in making strategical decisions. The classical modelling of the C3Is is based on the following general principle:

General principle in classical models: The problem is characterized by an explicit aim, structured through bottom-up or top-down analysis which allows all parts to be specified and whose functioning is considered to be rigorously deterministic in all cases. The essential advantage is the possibility of an easier decision making through adequate and deterministic choices, in compliance with the general aim.

Classical C3Is present a simple form, on the basis of this principle. A C3I is a large communicating system composed of two distinct parts: a description regards all physical elements and their modes of use, while another one defines the mechanisms for the utilization of information provided in the first part.

When the system must represent the consistent management, for general reasons of optimization, of distinct parts which are not initially designed for being aggregated, a flaw can appear due to inconsistency. The effects of the flaw are propagated and the global consistency is no longer maintained, with negative consequences on the aim, as well as the consistency of subordinated local parts. The system contains a fault (we can say that a crisis occurs), because the result is not allowed by any deterministic modelling - a contradiction.

The aim of the rational method is always to remove the contradictions, to come back to a deterministic logical system, which can be mastered. We think that it is definitely futile to try to attain this aim. Negotiated adherence and contradiction are inherent in the system - they are "native" and pervade the system itself.

2.2 Inadequacy in case of crisis

The C3I is sometimes supposed to assist the management of a large crisis progress. A crisis is defined here as a violent, phenomenal and vast fracture, with low predictability and very high energy consumption and information exchange occurring in a socio-industrial and cultural space where the armed forces intervene. In the C3I, the crisis is managed by men who treat it as an urgency, with a possibly considerable level of responsibility concerning the decision making. Any intentional action addressing an action is called a decision. The decisions are based on a very large volume of information, with a more or less successful propagation and multiple and imprecise, vague, partial, and sometimes destabilizing characteristics.

The limit of the rational models is the existence of natural contradictions which cannot be reduced within the system. First this can be due to the elementary contradiction of a choice between equivalent and simultaneously applicable antinomic decisions. In this case, modelling in a broader framework including modal or temporal logics could be a solution - the resolution is then equivalent to making deterministic this choice, by valuation followed by classification, or by heuristic reduction ([Pearl 90]). Remark that this reduction does not go beyond the alternative, by integrating it through changing the intentional level or viewpoint, but is a resolution by elimination.

Other contradictions however exist, and are definitely irreducible. For example, no reasonable man deliberately accepts death, searching it as a goal. A combatant in the first lines of fire is in its neighbourhood, and his action as a thinking actor is essentially in conflict with his possible sacrifice. When this paradox is taken into account, it partly invalidates a deterministic representation. In the same way, the order leading to the sacrifice given by a man to another one represents a relationship between thinking actors in essential contradiction with a social behaviour. More generally, an armed engagement implying the destruction of well localized human targets is in conflict with the evolution of the society towards its harmonious development. And this problem explicitly occurs when the military intervention cannot be separate from the strongly mediatized humanitarian action where the death of a particular man can become a symbol or even a myth, and contradict an offensive strategy.

There are other examples of contradictory adhesions and apories, being in almost all cases apparent, e.g. general-particular, local-global, real-ideal, spirit-matter, or furthermore, substance-form, continuous-discontinuous, analysis-synthesis, mechanical-organical, determinism-chance, finality-causality, unity-plurality, permanence-change, appearance-essence.

This long and non-exhaustive list of definite contradictions cannot entail a radical treatment through their evacuation. Man cannot be reduced to an operating organic object, implying an excessive simplification of the model. The contradictions are to be taken into account essentially in the model, and must be represented as a native and essential constituent of the system; this possibility is required here.

2.3 Necessity of a new general model for C3Is, from the viewpoint of cooperation

The modelling method is then different. One must integrate the rational method, i.e. the classical modelling with its outstanding, but partial results, on the one hand, and the introduction of the irrational universe of the decision made by man and for man, who will be in the system, on the other hand. The problem is not the catenation of two disjoint layers, whose communication cannot be represented, but the development of a general model allowing different and irreducible categories to exist in conjunction and symbiosis by using self-reference.

This method is not new. An attempt towards the integration of the contradictions is found when authors try to broaden the field of classical logic without giving up its framework (see Lupasco and Bearden). This is also the method of those, who being more ambitious, tried to produce a global modelling of the system, e.g. Wittgenstein ([Wittgenstein 61]), as a first attempt to go beyond Descartes. We are here inside the framework opened by many works (Vico, Lakatos, Desanti, Amsterdamski, Kuhn, Foucault, Maruyama, Le Moigne and Morin).

3 Expected qualities of the new model

3.1 Decisive constraints of the situation

A C3I adapted to the treatment of the situation where man is, exists and fulfils his projects, shall take into account the following characteristics:

- maximum adaptation of the operators to new, or even unknown, situations
- maximum adaptation of the operators to changing situations (changes may be very rapid)
- adaptation of the decision process to the evolution of the information process supporting the evolution
- non-isolation of the operators during decision making thanks to multiple communications having a cognitive meaning
- broadening of the information field perceived by operators towards the globality, i.e. with a generalization of the notion of viewpoint and feeling
- taking into account the intentions of information producers, including non-formulated cultural or political intentions
- taking into account the polymorphous characteristics of information, i.e. its multiple aspects including cognitive and eidetic aspects
- taking into account the irreducibly irrational behaviour of man, mainly during a crisis situation
- taking into account rational contradictions, and contradictions which appear in a model centred on man

3.2 Characteristics of modelling: towards a general principle

The characteristics of the chosen model for designing a C3I which operates under the constraints previously defined (in particular the last one) are completely different from those of the classical model:

- globality: the a priori view of the system is global, and this approach is contradictory with bottom-up analysis, which tries to reconstitute a set from multiple elements whose combination is not perfect.
- hologrammatic principle: to assure the system's global consistency when some components become unstable or contradictory, the integration of the following principle in the model is compulsory - each item identified in the system contains in some way the perception of the whole. This is incompatible with a hierarchical decomposition where levels are defined.
- ontology: when the aims are typically relative to classes of values (e.g. social judgment through humanitarian action) operators cannot avoid the essentially ontological character of action and information, and must integrate the intention, the perception and the human irrational aspect. The entire human dimension of the operator is to be expressed in the model.
- principle of communication by cooperation: when the military action is plunged in an environment with multiple comparable systems or essentially different organizations (Non-Government Organizations, media, politics), decision making must integrate characteristics of highly extended distributed cooperation, rather than hierarchical piloting with action/reaction.
- non-application of the principle of reduction: the global consistency of the system is not produced by the sum of local consistencies obtained by optimization. The global consistency

can be attained only when contradictions are eliminated. The system contains in all its parts dialogue loops.

- principle of recursivity: Any action produced by a decision is both a consequence and a cause in the system.
- principle of local algorithmic integration: the different optimization techniques generally implemented to establish deterministic choices are used locally - as common tools when the perceived situation is reducible to a mathematical space in which its application is possible. Classical logic and (Cartesian) determinism are retained.
- hypercommunicating orientation: taking into account integrally the communication and its technical means supporting the generalized use of hypermedia environments (towards the virtual reality MMI).

A law can be established for any modelling compliant with these characteristics.

Law: Any modelling which must comply with the characteristics set forth has to go beyond simply rational models, but their complete integration, without any reduction, is required. Its domain is the universe of real things, forms and ideas, in a simultaneous dialogue framework. Its medium is the communication of ideas in, by and for this universe.

We have to specify the characteristics and consequences of this law through a comparison of our modelling with that defined, for example, on the basis of level decomposition such as "Knowledge Level" and "symbol level" by A. Newell.

3.3 Fundamental characteristics of the model

A modelling based on the characteristics previously defined and the law set forth, is equivalent to an inversion of the classical model's form. The model is no longer built by using an operating part implemented on the top of a static part, which is usually organized by nomenclatures. It is viewed as a global intercommunicating, morphological system, natively based on the communication's meaning. The meaning of perceived facts and intentions has to be a centre for the constitution of operating forms. This supposes a preliminary existential representation of what is meaningful, i.e. the definition of a virtual noosphere of ideas ([Teilhard de Chardin 55]). Noology represents the sufficient and organizational characteristics of this noosphere [Morin 91]), and constitutes the first part of our research. The second part regards the machinery operating in this organized noosphere.

We apply, for the definition of this model, a principle of self-organization for the cognitive system ([Morin 86]). The actors use and modify in this model multiple meanings made objective, through reflective actions. These actions change the form of the cognitive and sentient space for the communication. This viewpoint characterizes a primitive perception of the model, independently of a reference to the Knowledge Level. However we shall try to maintain the link with this level and the Symbolic Level, in order to describe finally an operation model.

In our model the act of decision making is represented in its essential dimension by taking into account the contradiction and the absence. Therefore, any human operator, at any level, must perceive some multiple characteristics of the objective decisions made elsewhere, and generates the best decision for himself, by extended cooperation (dialogue). Our model has the following characteristics: typically systemic (von Bertalanffy [Bertalanffy 73] and Le Moigne [Le Moigne

90)), noospherical (Teilhard de Chardin [Teilhard de Chardin 55] and Morin [Morin 86]), communicating (Wilden [Wilden 72]), and based on dialectics (Hegel [Hegel 72]).

3.4 General lines

We apply first a leading principle to position the modelling.

Leading principle. The crisis, whose evolution is to be represented, is a natural and regular fact in the physical, societal, cultural domains where it occurs.

So, the crisis is not extraordinary, but is a state of the reality. The model must comprise the crisis as a distortion of the situation considered to be usual.

The main lines of our modelling are then as follows: "space" is the place where the crisis occurs (the universe). This is a general space, including the reality with its physical objects and the virtual noosphere with the ideas made objective, knowledge and cultural facts pertaining to/contained in this reality. This space is neither a priori quasi-decomposable nor reducible by deductive logical formalization. It will be structured by different topologies on multidimensional tilings having a semantical character. A dynamic system will allow the modification of the space morphology and consequently the spatial representation and treatment of the crisis. This represents the definition of a morphological model for dialogue-oriented reactive communication which integrates the different forms of the meaning.

4 Description of the proposed model

4.1 Basic definitions - the components of the space

a - Where the crisis space is defined

Idea: From a Hegelian viewpoint, the universal principle of evolution, which generates by dialectical development the nature and the spirit.

Space: A real and eidetic universe, formed of the set of things and ideas which characterize it. Therefore this is a space, a substratum of ideas made objective with the incorporation of the reality. This is a noosphere.

b - How the characteristics of the crisis space are identified

Tile: A named item, of a constitutive knowledge and action idea (basic dialectics) on the space. This is an eidetic granule, a form occurring at the actual and virtual level, composed of different facets according to the characteristics proper to the item. A tile owns the means and elements of its existence and development (reproduction) in the space. It represents a quasi-permanent ontological entity. Furthermore, it has a geometric structure. It attributes, by its creation, a notion of granularity to the space. It is built from the paradigm of the epistemological entities.

Facets: The facets constitute the (semantical) interface of the tile. This is the extension and intension of this object with respect to others. A tile intrinsically supports the communication with other tiles via facets. A facet has a subjective size (large, narrow, etc.). The perception and

emission by a facet depend on its size. The size acts as a restrictive or amplifying (semantical) filter for the communication. The degree of a tile is the number of its facets.

The tiles can be entities corresponding to complex actual objects such as an area HQ or a company. In this case, the facets are elements defining the behaviour of these objects. The tiles can also be complex actual entities of the communication such as a communication line, a relay, a communication interface.

The tiles can be specific eidetic entities of the communication/cooperation. In this case the facets are elements of the qualification/modification of these entities.

Tiling: Coverage of the whole space by tiles, presenting the notions of finiteness, proximity and locality. The sizes of the facets induce a specific morphology of the space. A tile is an eidetic granule which can be represented.

State: A tile can be considered, by itself or by others, and can become active. When it is activated, it automatically propagates this activity in the connected neighbourhood induced by its facets. In the tiled space, there are always a number of active tiles (the non-existence corresponds exactly to death). A propagated solicitation corresponds to a more or less active semantical communication field, modulated by the effect of crossing a tile. An inactive tile can correspond to a loss of attention or memory, or to a disappearance. The solicitation can only come from the space itself - the notion of outside does not exist.

Channels: The tiled space is a communicating space. This space is not necessarily chaotic, the activity of the tiles must generate a form of communication by using preferably some facets. This is equivalent to the existence of privileged (revealed) channels of variable intensity in the tiling. This fairly corresponds to the existence of a collective memory having a form, and to the notion of processed flow in the system theory. It allows strong and weak lines in the noology to be defined.

The local dimension of a space tile subset is given by the local tiling (dimension of the geometric space generated by the connections of the facets). It varies from two to infinity, with a possibility of being fractal.

c - Generalization to the action supporting the contradiction

Open set: We consider the tiled space. The notion of action is introduced in it. This space will be organized to allow it to integrate in the action both logical and rational behaviours and contradictory and irrational views. An open set is a set of connected tiles meaning by themselves a pertinent idea for an aim. Therefore they integrate by association constitutive ideas (the tiles). The borders of these open sets are fuzzy (this means that it is always impossible to define totally the determinants of an action without reducing it to a deterministic fact, beyond which we try to go. This new object, produced by integrating and going beyond the objects composing it, has not necessarily the same nature as those (principle of non-decomposability). The notion of fuzzy borders is semantical, and represents the proximity and distance of the action's characteristics - the aim is formulated, limited, but still imprecise. It can be infinitely precised and broken down, with a contingent and, maybe, even paradoxical nature. The open set is the essential constituent of the space, because it is the essence of the expressed aim. For an aim set forth as such, the open sets will exhibit how it can be apprehended.

Topology: The set of the tiles and the notion of open set induce space topologies. These topologies express the categories of the noology that operates towards the aims, the decision making acts defined according to the principles of reality, virtuality, or presence/absence of meaning. It is possible to define and interpret the classical notions of topology (adherence, closed, regularity of the initial tiling, density, isolated or weakly connected subset, coverage and strongly connected coverage graph, with or without points of articulation). What is intended is to represent in topological terms the essence of the aim.

As a general rule, a decision of action, i.e. an objective, will be related to the limit of a sequence of tiles. The notion of separated topological space, allowing a unique limit, will be studied as well as the adherence values of a sequence. Some topologies can lead to a metric.

Remarks:

1- The space will not be homogeneous with respect to space dimension and tile degree. Its form will be a global indication of the existential situation.

2- The notion of outside is in fact implicit in this model. It is possible to envisage the notion of stimuli emitted by the context on some tiles, but we limit this fact to the change of state for a facet adapted to the perception of such stimuli.

4.2 First justification of the choice of tilings and open sets

We justify the choice of these basic elements which serve to represent the communicating space. A tile is a local item and is not sufficient in itself to elaborate a decision. It accounts for the non-homogeneity of the basic items, what is excluded by the nodes of a graph. It has a value of judgment in the sense that it can connect its subject to a predicate. The facets reveal an a-temporal passage between items, i.e. the association of ideas, the similarity of concepts, the free union of objects. Like copulas that serve to associate words, they have neither "depth", nor media function. If the gestation of these association operations is a problem, an intermediate tile will embody it (e.g. the time interval). The tiling denotes an intention of recovering the whole space, because the decisions are made anyway, and must be represented, even if the justification is not possible or desired. This coverage is dynamic and its morphological complexity follows the evolution of the system.

At this level, the tiled space is related to the notion of semantical network where two kinds of tiles, conceptual and relational, would be defined. We do not assume this distinction, which appears restrictive.

An open set introduces the notion of meaning produced by consistency, sufficiency and aim from the subjacent substratum. Obviously its nature is different from that of these tiles, because it goes categorically beyond them. This is the locus for the possible deduction and the syllogism, whilst the tiles are that for determining the characteristics. It is generated by them, but also reveals them by giving them a meaning. This principle of dialogue is present everywhere in the system. The open set reveals another strong principle - the hologrammatic principle - an open set contains the possibility of generating supertiles, which generate by themselves other open sets in topologies possibly having a larger meaning. A part contains a kind of morphogenetic means for expressing

the whole. The space is generated, and the dialogue and hologrammatic principles are represented by the fineness of the chosen topologies.

At this level, the tiled space having topologies is a generalization of the notion of production system. In the case of production systems, the rule allows a representation of the knowledge from the granules. It is possible to think that the tiles correspond to knowledge granules. The main problem with production systems is to extract a good set of conflict, allowing further inference by filtering based on facts. The open set will be the locus of the deduction, but not through filtering. From an intention revealed by the substratum of the tiles (the triggering context which corresponds to the fact base), a set of forms (the open sets) is unfolded, which will attain the aim through its morphological constitution, depending on its characteristics. The form of the "production rule" type can be represented on the basis of channels going through tiles. But these open sets contain all the possibilities of deductive extensions valid for the substratum (the tiles). In some way, the production rule changes and is unfolded during the operation. Its static characteristics do not exist here - the representation only regards its form, through the channels.

4.3 Initial construction

It is specified that the items which characterize the problem, from the constitutive ideas of the domain (concepts, categories, kinds, etc.), represented by words or sentences. The different meanings of these constitutive ideas are typically the different possible utilizations. A tile is named, and one of its facets is a meaning of its existence. Its facets serve to specify its generic character. The definition of the initial tiling, then that of the induced topologies, are the subject of our present work in the framework of defining the noology.

The initial construction initiale is typically systemic and is carried out according to the nine construction levels of the General System ([Bertalanffy 73], [Le Moigne 90]).

A tile is defined in a class of epistemological entities, because an item of the description can transmit dialogue-oriented meaning to another one. A tile is not defined individually, but by propagation. This represents a desired consistency with the functioning in the space. This communication of meaning is reflected by the existence of facets, near/far induced tiles, channels. This is a complex organizational construction - that of the noology. It will describe in fact the minimum basis of a general artificial spirit endowed with reasoning, feeling and operation.

4.4 An example

Any modelling of this space is based on the degree of fineness of the original tiles. The example treats a "coarse-grained" case. The facets of the various tiles are to be specified. It is obvious that a tile cannot have an excessive number of facets, and thus a reasonable trade-off (the language induces it) is to be found between a tile (an idea) and what characterizes it (its usual meaning). The open sets constitute the first operating structure (ideas directed towards action) on tiles. We do not address here the question of how different open sets are composed.

- Original tiles for a "coarse-grained" modelling:
 - HQ-area-1, Company-1, Group-1
 - strategy, force, will, honour, service, flag, homeland, interest
 - energy, obligation, norm, use of the forces

- tactical means, technical means, media means,
 - fear, jealousy, ambition, hatred, incompetence, cowardice, anguish, opposition
 - treachery, friendship
- "Coarse-grained" open sets on some of these original tiles:
 - engagement-Company-1, mission-Group-1, engagement of the forces
 - treatment of an objective, attempt to avoid, local offensive
 - withdrawal, desertion, flight, cover

4.5 Rule of use: a starting assumption

The definition of the space is in fact equivalent to the possibility of defining topologies for it - the tiles are only the basic (fundamental) means of this process. Now, we apply a construction rule to determine in the native space two initial topologies. This is minimum assumption on duality.

The definition of the tiles is transitive and must lead to the definition of at least two initial topologies. The first topology characterizes deterministic problematics as a view of the world (rational dialogue observation-action). The second, in conjunction, must characterize a non-deterministic view of the world (global emergence of irrational aspects). The symbiotic existence in the same substratum of these two topologies characterizes the intrinsic apory. So, a tile is involved in decision making simultaneously as a sign having an indicative or instrumental character, and as a symbol (in the philosophical sense, not that of computer science) with an evocative character ([Morin 86]). The non-reducible duality represents the two existential modes of the decision making. The choice of only one of the two modes characterizes a decision as purely rational or purely subjective/intuitive, and is considered as highly reductionistic.

This choice is not definitive and we characterize native topologies through classifications of larger categories (e.g. the ten Aristotelian categories, or the Kantian ones).

Any choice of a topology must precede the representation of space. We specify now the evolutionary process of the self-organizing structure for this space. We recall that in the model the medium is the meaning given to communication.

4.6 Decision making

A neighbourhood of a tile is a set containing an open set, to which the tile belongs. The topological space is "separate" if two distinct tiles own disjoint neighbourhoods. A co-operative decision in this space implies the existence of a convergent sequence of active tiles.

If the topology is separated, it is known that the limit, if it exists, is unique. In this case it is a well identified unique tile. This case corresponds to a clear decision obtained by following a patent principle of rationality. The object of interest is then constituted by the minimum subsequences converging on the same limit, i.e. the means for optimizing the decision. If the topology is not separated, the limit is formed by some neighbourhood. The result of the decision is an open set. The decision is ambiguous and contradictory. This means that it is definitely not reducible to a named item.

We deliberately choose the framework of a space having at least two topologies. The separated topology leads to decisions in the form of convergent sequences. The non-separated topology produces no clear limit for decision processes. However, the sequences produce identifiable open sets in which the limit can be approached by investigation. Remark that these two topologies are neither contradictory nor complementary, but must, through natural operations on and in the space, be extended simultaneously and replaced by the creation of other open sets. A difficult problem leads to other problems and not to a reduction able to exhibit a debased solution.

5 Primitive operations on tiles

5.1 Ontology

Some tiles generate new information (a perception is effective or an order for action is transmitted, corresponding to the effect of an input in classical systems) which, by changing the state, will modify the state of the tile and, therefore, the space. We specify here the modality of this space change.

Any spatial change is an internal operation. The defined operations proceed in a reflective mode - the whole space is a tile, at least since the initial tiling, and will change by itself its coverage and complexity by following the effect of the communications in the channels, or by creating them. No external world is useful here. Any information comes from at least one tile, and addresses another one - communication is the essence of the model.

An operation is always carried out conditionally - a tile participates in the open sets of different topologies. Its imprint in the space depends on the other connected tiles, which will modify it (via the facets) according to the trends of the recovering open set(s) - deduction, induction, abduction, temporal evaluation induced by the classical open sets will stimulate a behaviour, whilst surprise, lack of understanding, rejection, fear or hatred stimulated by other open sets belonging to another topology will cause a different behaviour. The tile then reacts by performing space structuring operations (all those which are allowed) and simultaneously transmits emulations to connected tiles via some of its facets.

These generic restructuring operations form the unfolding algebra of the tiles over space and time.

- neutral openness: awakening, but operation is refused (neutral transmission and neutral element of the set of the cooperations). This corresponds to a "black hole" in the communication.
- increase (decrease) of a tile: a tile has an increased/decreased degree. A morphological change occurs then in the connected space.
- emergence of a tile: a tile augmenting the size of one of its facets (local semantical importance).
- creation of a tile: a tile creating in its locality a connected tile (the problem of the embedding is then set forth) from its facets.
- augmentation: augmentation of the local dimension of the space by the augmentation of the links of existing facets.
- embedding: new link of a facet with another tile (possible augmentation of the space dimension).

- closure: a tile becomes dormant and the communication via its facets is locked. The perception of this non-communicable being has a mythical character for other tiles.
- destruction: annihilation of a tile, consenting to it.

5.2 Remarks

These operations represent the aspects of the eidetic communication, which is the essence of the model and characterizes the system as being in perpetual expansion (in continuous re-creation). The synthetical aspect of the model versus an analytical aspect (in the sense of the Kant's judgment, [Kant 80]) can represent knowledge coming from deduction (which is already programmed and can be executed). For example, the implementation of a sophisticated optimization algorithm is the answer of a tile facet flow, to which a semantical and sensitively perceived question has been submitted by the existence of the body of an open set. This viewpoint does not reduce in any way the classical treatment, and even allows its integral inclusion in the model, but at its own place.

The operations allow a representation of death if it is accepted for the disappearing tile, but forbid murder (outside does not exist).

We shall define below another operation, whose starting space is more complex and has a character of generality.

In decision making, when the supporting viewpoint addresses a non-separated topology, the sequence that carries out the decision is accumulated from a given moment in an open set. The structure of this open set is non reducible. It embodies an aporetic decision which can be studied by specialization supertiling operations (they are in fact subtilings) as deeply as desired. So, it is possible to specify, infinitely, the conditions for the elaboration of this decision. But the reasonable decision to be made in this case is the rapid definition of the supertiles going beyond this framework, however without reducing it. In this way we go beyond the paradoxical viewpoint, which is the only solution of the problem. Remark that in that case, the problem is changed and the solution regards a new one, appreciably different. This operation of supertiling is implicit in the model, which is designed for carrying it out.

5.3 Space as an embedding of tilings

The communication through generating operations enriches and complicates the semantical level of the open sets. Therefore it is necessary, in order to maintain a global sense of conceptualization and to understand the notion of generalization or semantical union including the apories, to create other topologies of tilings for the space beyond the native topologies. This reveals the intrinsically multidimensional character of the model. It reflects also the organizational and consistent character of this model.

The operation of passing from a tiling to another one is called **supertiling** operation. This is an internal operation in the set of the tiling topologies, therefore, from an open set of a tiling to a tile created in another topological space (the conceptual meaning can be the generalization, the particularization or the taking into account of the irreducible apory, and the supertiling can be of a higher or lower order).

A supertile is in some way a generalization through the co-operative action of the eidetic open set of the subtiles which generate it. This may be a simple set union, a natural synthesis, or furthermore a decision established according to what tries to make it. In all cases, the created supertile denotes a character of local autonomy, an existence proper to some idea dwelling in the space.

A richness of granularity in tiling embeddings reflects the strongly justified semantical consistency, while risky assumptions would be represented by the existence of some supertiles original and atypical with respect to the substratum.

It is possible to recognize, in an elementary approach:

- a deep or fine tiling, which will be residual and non-understandable (maybe the initial tiling or a part of this initial tiling)
- a tiling generated on it (first supertiling) through capture of environments (agglomeration of tiles for producing a meaning-tile having a character of readability on its subjacent substratum). This tiling is a first primary reading of the space with incomplete expressions for decisions.
- a set of open sets generated on the two previous tilings, which offer a readability (progression of the abstraction via open sets towards the emergence of effective decision strategies).
- particularizations, with creation of lower supertilings.
- an embedding of tilings and open sets at different levels, so that low parts are always kept (low readability of primary meaning) beside highly eidetic and decisional parts. This characterizes the knowledge of the space with its ambiguity and irreducible irrationality.

5.4 Second justification of the choice of tiled spaces with topologies

Our model integrates and tries to go beyond the classical technical means of representation. The tiled space allows a representation of the sequences of decisions as modification/creation of the tiling substratum. Any deductive trajectory modifies the morphology of the space. But all deductive trajectories are not considered as purely logical. It is considered that it can be so, according to open sets allowing it, but can be forbidden with the open sets having a meaning of facts that follows an irrational approach. This permanent struggle can be represented by the tiled space with several topologies.

Therefore, the solution is not the simultaneous functioning of contradictory inference engines on facts viewed as being in opposition, but the propagation, by a continuous rebuilding of the space, of the behaviours proper to the open sets whose meaning will be provided by supertiling (because it was not necessarily planned and the meaning is in fact a reflection on oneself). It is not possible to consider that a co-operative collective spirit simply owns a knowledge base which is not connected to facts and engines - the paradigm of the Artificial Intelligence allowing this distinction is here too reductionistic. Furthermore, the representation of the more or less static knowledge of the classical systems must be extended to integrate the creation (supertilings), the apory (the different active topologies and the operations) and the continuous development (reproduction of/in the space by the different operations). The Knowledge Level is to be discovered again for co-operative systems.

6 Immediate effects of the approach

6.1 Transverse viewpoint

A transverse viewpoint is a reading of some embedding of tilings. This is a projection in the space and reveals some tiles. A transverse viewpoint is strongly consistent if it addresses tilings at regularly nearby levels, and appears reasonably regular in the architecture of the tiles. It is extremely inconsistent if the native tiling is globally dense in tilings having heterogeneous high levels. An unsolved crisis situation will be at the origin extremely inconsistent. Remark that the clarification of a transverse viewpoint comes from a request formulated somewhere, and thus will modify the space. Without plainly applying here a principle equivalent to the Heisenberg's

uncertainty principle, it is possible to remark that the result is not likely to be deterministic, have no influence, or be a kind of view on a database.

The generation procedure for supertilings is automatic and is an operation performed by an open set of the source topology of the tiling which generates in the new tiled space (which already exists or is created for this). A substratum tile cannot generate by itself supertiling tile because with this operation the created tile keeps the initial topology (the operation is then generic).

6.2 Globally dense generation granules

We think that a notion of local consistency through dialogue-based cooperation (notably through the channels) which is locally perceived (creative cooperation that does not exclude, in particular, the contradiction) must allow the generation of a supertile. This is a trend of the space (and one of the spirit). A reproduction facet of this type may be contained in most of the tiles which try to communicate (junction and disjunction) and to generate. Let us say that the gestation of the supertiling is globally dense but its measure is null in each tile, and it essentially regards the voluntary cooperation. This point is fundamental. It corresponds to the true creation notion and is the basis of the scaling notion. The characteristics of the generation are primary. They correspond to association, dissociation, rejection and unification. They have logical (conjunction, disjunction, exclusion and inclusion) and irrational (apories including the contraries without possible separation) corresponding operations.

6.3 Simplified view and monotony

A simplified view is the projection of a closed set of the tiling following some facets of its tiles. This is a true projection and represents what a facet can want to consider at a given moment after the sollicitation. A more or less semantical reduction of the space's being appears. Remark that man being an open set, the simplified view can be only a reductionist schema having weak consistency with what he understands at a given moment.

A monotony of the space is the property of mutual regularity of the different topological tilings. This is strangely a crystal-like stable situation. The system would present a natural trend to stability if a deterministic law could be applied (character imposed to the model), but this is excluded because it is completely inadequate with respect to perceived reality. Our model will have an unstable character (instability is possible and even globally dense).

6.4 Knowledge and consciousness

Knowledge is represented in the system by tilings, open sets and channels. Its character is strongly marked by the competence induced by propagation in the channels, a propagation carried out by assuming the voluntary means necessary for attaining an aim. It is expansive, since the main operation in the space is supertiling. Its principle of development follows the applications of the generic operations and that of supertiling. Like in a spirit (because this is the situation here), knowledge is driven by an aim - it has an aptitude to be reproduced and is used as a temporal process. The meaning of the topologies makes its pertinence.

This model has thus the form of a typically associative memory - this is a space of forms where trajectories are stored (from process to action) by supertiles, open sets, channels. This is very

different from index tables and narrow knowledge proper to expert systems, but a similar situation could however be found sporadically inside some tiles.

The model describes an intelligent collective system. This is a thinking system in the sense that decisions made by users are ideas made objective by tiles. Cogitation in the system is the diffusion flow of ideas along some channels, a temporal association of tiles, for and towards some aims. The (internal) choice of the channels characterizes a part of the system's intelligence. This act organizes the knowledge, in the sense that this diffusion operates a synthesis of the multiple ([Kant 80]). In fact, any organization of knowledge implies the action of the knowing actor who operates it, while incorporating his identity in this act ([Morin 91]). The actor will therefore operate a reflective action on knowledge, and this is the source of consciousness.

In our model, the consciousness occurs thanks to supertiling. The creation of supertiles, causes in some way a reflection of thinking on itself, and, distantly, on action. Remark that this consciousness is collective and distributed. The supertiling open set goes beyond knowledge due to the consciousness of it. This is a major point. It cannot be bypassed by any system considered to be artificially intelligent, where it is impossible to represent knowledge without a reflective means of self-knowledge, i.e. without consciousness. Furthermore, the progress of this artificial consciousness is highly significant, because it must lead in the system to the collective values of a noosphere and to the notion of myth. A system of distributed, co-operative, hypercommunicating, collective decision making, is a general artificial consciousness which occurs directly in the collective memory of a culture, with which it is directly connected. Therefore the study of the epistemological entities of this consciousness is our problem. We cannot and must not avoid it.

6.5 Dynamic system

The space is now operational. It was built from native tiles on which topologies has been placed. Generic operations are possible for each tile and open sets can generate a topological form beyond their essence through hypertiles. But which crisis this space wants to represent? The answer is implicit. Our space is morphological, topologically structured. Therefore these are catastrophes in the Thom's sense (second sense of the catastrophe theory specified by Jean Petitot, [Petitot 88]) which will support the evolution of the crisis by morphogenetical change of the space.

The dynamic system on the space with its topologies is the product space of topological spaces by time. Temporality is a facet of each tile of the native tiling. So, time is native (natively perceived) in this model.

A tiling can have a consistency over time (for some topologies) but a supertiling can be in another space-time. The temporal link is to be specified without involuntary generation of paradoxes or inconsistencies.

The dynamic system reveals the temporal evolution of the space. The study will regard the morphological changes of this space, thus the geometric interpretation that the model provides. This geometric representation must give a meaning to the evolution of the represented crisis.

6.6 Attractor and attractor conflict

In an open set of the space, it is the pregnant character of some tiles (tiles or open sets) that produce their own operations and inhibit the operability of the local open set's neighbours via the major channels it generates. An attractor produces a semantical local regularity, by forcing the cooperation of the connected tiles in a constrained sense proper to it, and maintained over time independently of the created tiles of the open set. A pregnant attempt to inhibit the antinomic creations appears in the neighbourhood. An attractor can be transverse to tiling topologies, having in this case a very important role at the transcendental level. This is a temporal entity, which appears, evolves, then possibly is closed. Remark that this fundamental element of the crisis is viewed as a regulator. The space is for us a priori unspecified, and even chaotic - the consistency is produced by crises.

The meaning of the attractor is as follows: it is the existential and essential character which, in the system viewed as a collective spirit with knowledge and consciousness, generates the aims. The attractor is the fundamental meaning of the system's life. Therefore we can attribute epistemological categories to attractors by using the trend to a rational choice, or the life permanent characteristics such as pulsions, wishes, needs, fears.

The attractor conflict corresponds to the typical situation of any minor or major crisis, i.e. of any life. If the domains of two attractors overlap and they appear antinomic in the aims of the open sets they imprint, a distortion of the tiled space occurs by the creation of multiple tiles in both domains (this can lead to a locally fractal tiling) and the modification of the channels.

This evolution will represent that of the C3I, towards its multiple and paradoxical aims. For example, this evolution can lead to:

- inhibition of one of the attractors by its destruction or closure
- unstable oscillating system (resonance)
- growth of an attractor while the other one becomes subordinated
- spatial collapse with a variation of the space's dimension
- generation of other attractors which extend the conflict

Remark: The morphogenesis of the tiling topologies can be studied by using the action of the attractors, and, in particular, its epistemological interpretation.

The potential lines of force between tiles, defined by the major facets, will represent an intense and rapid knowledge flow (representation of serious, extreme cases). At points where these lines are forbidden (incompatibility, impossibility, etc.), and if these points exist, a bifurcation is defined (an essentially geometric character). When these locked lines of force are used, a catastrophe occurs (in the René Thom's sense, [Thom 72]), with structural change of the tiling in the open sets covering the line of force. This represents the spatial visibility and the treatment of the crisis.

Remark that it is possible to represent a system sensitive to initial conditions, in the sense that a very local attractor can propagate a discontinuity causing a fracture of the space. The morphology of the neighbourhood areas of these fractures, where the decision topples, can lead to particularly interesting studies.

6.7 Decision making

The activity of some tiles reveals the perception, at the model's level, of facts that can be considered as new. These facts are automatic information on the scene or observer's impressions. The activity of these tiles is propagated, depending on the modalities of facets and channels, to connected tiles. The propagation, in all cases, is a structural change of the space, by supertiling. Otherwise a change of the facet structure occurs for some tiles. Some of these propagations will lead to the activation of other tiles, transitively. The open sets which contain these active tiles change for this reason the structure of their internal organization. These open sets will try, according to their essence, to respond to this modification. Remark that the answer is carried out through the continuous change of the structure, and has thus a character of regular adaptation. This answer is performed according to a principle of discontinuity - the emergence of attractors in some tiles of the open set, which will force a type of behaviour. Since several topologies recover the tiles, this answer will be performed by the emergence of several attractors. It is possible to consider that some of them will be antagonistic - the attractors which amplify the crisis and those which try to reduce it, in simultaneous action on the same tiles.

The reduction attractors of the crisis are in fact the sollicitation, for tiles having a character of decision making, to treat the event according the character of this attractor. In general, a sequence of local decisions, co-operative sollicitations, answers and negotiated advices, forms a wave, which is carried out and converges on the final effective decision. This sequence could normally have a rational character and would be the logical chain of the reasonable deductions to be made to arrive at the well-founded decision. But simultaneously, the destabilization attractors force some tiles, old or new, to react differently, to annihilate the development of the convergent sequence either by interrupting it, or by forbidding its convergence, or by generating other sequences whose interpretations are contradictory with the first one. This inhibitive action is the form of the apory, subjective imprint, error, always present in human decisions.

The convergence of a sequence of active tiles in/by the action of the open sets of the different topologies becomes actual through generic tiling operations or the creation of open sets. This decision then appears as a discontinuity in the morphology of the space. Remark that the system learns this structural activity because the channels have changed their qualities. A second sollicitation of the same type will lead to a morphological transformation while taking into account the analogy so allowed.

7 Conclusion

The eidetic semantics of the native tile is the basis of the model. This is an eidetic granule, like a part of a larger idea. The tiling characterizes the diffusion and the tile constitutes the space in its primitively essential character. It produces the minimum meaning. The notion of open set represents the established idea or the conceptual understanding. This understanding represents consciousness via supertilings. It has projects and aims induced by the attractors which force it. So, the open set reveals an activity, viewed as organizational, of understanding the eidetic forms necessary for the aim. This will be a reasoning method, with reflective capability, or any other form of possible enrichment. By simplifying, we shall state that the open set is the cognitive method. A supertile must be considered as a meaning generated by reflection with a character of personal adherence (notion of identity) from the subjacent open set and its subtiles, categorically co-operative with each other (in the sense of category theory). This is both an extension, in a cognitive

direction, by a possible integration of apories generalizing the notion of viewpoint and an extension in the reflective direction of the consciousness, where the collective consciousness of mankind's culture is met with.

The facets of the tiles are receiver-creator elements taking and giving, first on other facets, then in the context, in the form of waves. A facet can be perceived as an eidetic fact character of the domain. The understanding is a link of forms making sense in a supertiling tile, therefore conscious of its knowledge. This is the emergence of an intention, an aim to be attained, and therefore, a reflectively thought transformation of space to be carried out (it can be viewed as going beyond a trajectory in a phase space). But this aim is forced depending on contradictory pregnant characters of attractors, and will then generate other intentionalized aims (supertilings), representing the crisis in evolution.

Our research will further address the refinement and confirmation of these notions. We shall also develop the notions of complexity, in the sense of organization complexity (see Benett), as well as the new notions of interface between user and system, which we call MSI (Man System Immersion).

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