Autonomic Computing and Special Systems Theory

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ABSTRACT

The relation between Autonomic Computing and Holonomic Systems will be discussed. The theory of Special Systems will be introduced as a possible basis for Autonomic Computing and Systems.

In this paper I will build on what was said in my paper "Self-Organization, Self-Adaptation and Special Systems Theory" to discuss Autonomic Computing systems. Also we will consider the impacts of Super-Turing Computing on the definition of Autonomic Computing. In general we will bring to bear the ideas of Meta-systems Theory and Special Systems Theory in order to forge a foundation for Autonomic computing. Also the question of Software architectures for Autonomic Systems will be discussed.

Keywords

Autonomic Computing, Systems Theory, Special Systems, Meta-Systems, Schemas Theory

1. INTRODUCTION

"What is autonomic computing? It is the ability of systems to be more self-managing. The term autonomic comes from the autonomic nervous system, which controls many organs and muscles in the human body. Usually, we are unaware of its workings because it functions in an involuntary, reflexive manner -- for example, we don't notice when our heart beats faster or our blood vessels change size in response to temperature, posture, food intake, stressful experiences and other changes to which we're exposed. And, by the way, our autonomic nervous system is always working."

Alan Ganek, VP Autonomic Computing, IBM

The goal of Autonomic Systems were announced by IBM in 2001. Since then a research agenda beyond IBM has been formed around this idea of Autonomic Computing Systems. However, little progress has been made on the foundational theory of Autonomic Systems. This paper will address the foundational issues with respect to this kind of computational possibility. The IBM paper specifies several characteristics of Autonomic Systems which are as follows:

- Self-Knowledge and Self-Identity
- Configuration and Re-configuration under varying and unpredictable conditions
- Self-Healing
- Self-Protection
- Contextually and Environmentally Knowledgeable and Aware
- Open to heterogeneous environment and based on open standards
- Anticipate optimized resources needed while keeping complexity hidden.

These seven properties forms a wish list put together by Paul Horn, V.P. of IBM Research. But what is missing is a theory that would reasonably support these characteristics and how they might be made possible for computing systems. When we look at current computing systems we do not see these characteristics, but when we look at organisms we see them right away. And thus this list is an attempt to say that computing systems need to be more like organisms. But we are a long way from creating artificial life, artificial consciousness, and artificial society that would be necessary to make these characteristics a reality. What is needed is a theory that shows how we get to where we want to go from where we are. And an approximation of that theory is what will be called here Special Systems Theory and the theory of Meta-systems.

The author has already described the relation of this theory to Self-* systems in "Self-Organization, Self-Adaptation and Special Systems Theory." Thus here we will concentrate on applying this theory to Autonomic systems as defined in the IBM manifesto. Notice that Autonomic systems are not the usual set of characteristics that we see in Self-* systems such as Self-Organization, Self-Adaptation, Self-Management, Self-Control, etc. Rather we have a different set of Emergent Characteristics that are desired. What is lacking is a coherent theory from which these possible characteristic flow so that we can imagine how they would come into existence together. Rather than staring with a piece meal set of emergent characteristics we will instead explain a theory which approximates this goal but which is itself unified. Then, we will see how many of the characteristics flow from this theory which are like the characteristics requested by Mr. Horn. Already, we have shown how the characteristics of Self-Organization and Self-Adaptation and other Self-* properties flow from the theory. In general, we want to advocate theory based research in this area, i.e. research based on theories rather than ad hoc experimentation and engineering. But to formulate that theory we need to understand some fundamental phenomena from a theoretical perspective, like Consciousness, Life, Language and the Social. What allows these phenomena to emerge? How can we make phenomena like this emerge in the computing sphere? One way is toward this goal is to posit theories that will give rise to those emergent characteristics and make

them understandable within the context of a particular theoretical framework.

2. Systems and Meta-systems Theory

We begin by extending Systems Theory into Meta-systems Theory. We begin using the General Systems Theory of George Klir in Architecture of Systems Problem Solving, because this is one of the more sophisticated systems theories available. The general question we begin by asking is: What is the inverse dual of a System? The answer we posit to this question is a Meta-system. Here a Meta-system means what is "beyond" the system in question. Meta is taken here to mean 'beyond' not logically above. We posit that a meta-system is like the "operating system" of a system. In other words we posit that it has a completely different organization from the system, which is in fact the inverse dual of the system's organization. We take the example of the difference between Turing Machines and Universal Turing Machines as the formal basis of this difference. Turing Machines are like applications within the context of the Universal Turing Machine which is a Turing Machine that runs other Turing Machines. The difference is that the Operating System provides a context for the Application. Thus it is structured differently in order to make the resources available that the Applications need. In the Turing Machine the incomputable aspect is the halting problem, but Operating Systems are not expected to Halt, and thus this computation is not a problem for them.

We use the ideas of George Bataille from the Accursed Share where he defines the difference between 'General' and 'Restricted' Economies as indicating some of the major differences between Systems and Meta-systems. The treatment of these differences by Arkady Plotnitsky in Complementarities are exemplary. The Meta-system acts as a General Economy and thus provides the Milieu, Context, Media, Ecosystem, Environment of the System. We do not seem to have a general term for this phenomena so we will call them an Open-scape which is the panorama from one point in the landscape to the horizon without movement being taken into account. The meta-system is everything outside the skin of the system till the next horizon. Sometimes that next horizon is the boundary of some higher level system. Thus there is a nesting of Systems at different levels of abstraction. But there is also a nesting of meta-systems interspersed between the systems which are like the spaces between Russian Dolls.

Mr. Horn wants an Autonomic system to be aware of its environment and able to react to that environment. Differentiating the environment of a system from the system is a good first step in that process.

3. Special Systems Theory

Now we ask about the difference between the System and Meta-system. In general that difference seems to be the system boundary. But if we consider that boundary an interspace between the two extremes then we can ask what exists in that interspace. It turns out that there are intermediate thresholds between these two extremes. There are in fact three different intermediate thresholds which I call Dissipative Ordering, Autopoietic Symbiotic, and Reflexive Social Special Systems. They are called Special Systems because they have special Ultra-Efficacious properties. By ultra-efficacious I mean Ultra-efficient and Ultra-effective properties. And it is from these ultra-efficacious properties that the special emergent characteristics of these systems flow. However, they have their own emergent characteristics which are quite surprising, and whether these correspond to the wish list of Mr. Horn is to be seen. In other words the Special Systems are a physical and mathematical reality which is self-determining and we will have to explore whether it gives us Autonomic systems as defined by the IBM manifesto. But certainly it gives us properties like Consciousness, Life and the Social, and it is the special systems that make these emergent characteristics possible. But because the Special Systems are self-determining it is not that we can just make up any property and ascribe it to the special systems, rather we must discover what properties special systems have and that is pre-determined by nature and mathematics conspiring together. However, in general we can say that any property that a living conscious organism that is social might have is probably possible based on special systems theory. And since it seems that living organisms were the guide for the properties of Autonomic Systems we are probably in good shape in deriving these properties for the most part from the theory.

Dissipative Ordering Special Systems are based on the theory of Prigogine who discusses dissipative structures in far from equilibrium systems that are in a far from equilibrium environment. Autopoietic Symbiotic Special Systems are a reworking of the theory of Maturana and Varella of Autopoietic Systems. Reflexive Social systems are based on the work of Barry Sandywell and John O'Malley in Reflexive Sociology. What this theory of Special Systems does is provide a framework for integrating these various theories so that their emergent steps can be understood. Dissipative Ordering means the dispersion of neg-entropic order that reorders and reorganizes some finite space within a far from equilibrium energy stream. Autopoietic Symbiotic is a combination of two dissipative systems into a larger system with a stable boundary which mimics the qualities of a living organism. Reflexive Social are a combination of two autopoietic systems or four dissipative ordering systems such that it mimics social phenomena. All three of these systems are neg-entropic. However, each one has a higher order of complexity and self-organization and other self-* properties. Thus these special systems mimic the properties of consciousness, life and the social in organisms. But the theory explains how it is that these thresholds come into being and remain there as a possibility for systems to achieve given the right circumstances and architectures as well as available components. If we want to achieve autonomic systems which is the baseline for viability and survival of organisms which is the basis for voluntary systems, then we had best have a theory that distinguishes the structure of these systems from other kinds of allopoietic systems.

Special Systems are based on hyper-complex algebras, and other mathematical models such as non-orientable surfaces, and aliquot numbers. But they also have as their basis various anomalous physical phenomena such as solitons, super-conductivity and Bose-Einstein Condensates that give a physical example of the type of organization in nature suggested by the Mathematical Analogies.

4. Autonomics and Special Systems

Let us see how these properties of Autonomic systems fit into the characteristics of Special Systems as a basis for their realization.

- Self-Knowledge and Self-Identity are achieved in these systems because their structure is related to configurations of intersecting mirrors.

- Configuration and Re-configuration under varying and unpredictable conditions is achieved because such systems have to understand their own design in order to produce themselves, maintain themselves, and repair themselves according to a known plan.

- Self-Healing is really self repair given in an organism metaphor. Self-Repair is also based on self-knowledge of the plan of the system.

- Self-Protection is achieved by the relation of the Closed Autopoietic System and the meta-system which is its environment. Self-protection is contingent not absolute. In a highly dangerous environment there are predator/prey relations that work themselves out, and thus we would expect these systems not just to engage in passive protection but also aggression with respect to resources just like an organism.

- Contextually and Environmentally Knowledgeable and Aware. This is an interplay between consciousness at the the dissipative level and self-consciousness at the reflexive level in relation to the meta-system.

- Open to heterogeneous environment and based on open standards. The meta-system defines the heterogeneous environment which is open. The open standards is similar to the genome which is shared by organisms though their evolution. This brings up the point that these systems evolve and are not created out of whole cloth because they are symbiotic with each other and fitted to their environment by historical and evolutionary processes.

- Anticipate optimized resources needed while keeping complexity hidden. Such systems are autopoietic and thus closed to inspection, that is how they keep their complexity hidden, but that means that they are non-deterministic. You just never know what they are going to do like an organism. Their first priority is to maintain their viability, and thus their focus is to optimize their resources within their environment to assure continued viability.

Thus it looks like these Special Systems are indeed a candidate theory for the basis of Autonomic systems. However, Autonomic systems are in fact merely one set of characteristics that are satisfied by the Special Systems which have many other self-* properties as well. In effect we can say that Autonomic Systems are a sub-set of Special Systems.

5. Why Autonomic Systems?

The focus on autonomic systems seems to lower the bar from Artificial Life, Artificial Intelligence, and Artificial Society which has been the previous academic goal in this area. The focus on autonomics attempts to reach toward the goal of technology becoming invisible and self-supporting. At the moment we serve the technological infra-structure more than it is serving us. When we look at our own bodies we find that they are for the most part self-maintaining over the short term so that they do not interfere with our focusing on more important issues like survival, like getting food and water, like shelter and self-realization, that they need over the long term. The heart, breathing, circulation, immunity all take care of themselves over the short term. Thus these concerns become invisible to us, unless we are injured or in a threatening environment. Autonomics wants to strive toward this invisibility of the computing infrastructure even to those who have to keep it running, not just invisibility to the user. This is an attempt to realize what Heidegger calls the invisibility of the ready-to-hand mode under the auspices of the present-at-hand mode. Whenever anything breaks as computing systems are now prone to do they are forced out of the ready-to-hand mode into the present-at-hand mode. What we want is for them to stay as much as possible and keep themselves in the ready-to-hand mode, so we can concentrate on the present-at-hand concerns as much as possible.

Invisibility is the natural mode for technology. Autonomics strives for more invisibility for the technological infrastructure in the future. But given our current stage of technologically development with respect to the computational infrastructure even Autonomics is a lofty goal at this time. But that goal is made even more distant by the fact that we have no unified theory that will lead to autonomics. The idea of this paper is to offer up Special Systems as a candidate theory of the basis of autonomics. In autopoietic theory one of the examples is the immune system as being autopoietic. It is precisely this kind of invisible protection that the immune system gives us that is what the autonomic systems are meant to provide to the computational technological infrastructure. In other words the goal is the nature of the autopoietic partial systems that are seen as autonomic. The immune system is autopoietic, the nervous system is autopoietic. All the various parts of the organism that are autopoietic, are autonomic as well.

6. Autopoiesis, Autonomic and Self-organization

First we need to distinguish Self-production from Self-ordering. Clearly if one is to produce oneself one must know the order of oneself, and be able to order things that will become part of oneself on that special order. Another term that is used here is Self-organization. Self-organization is the act of ordering oneself. Self-production includes the production of the parts to be organized. In general we need many of the various Self-* properties such as self-repair, self-adaptation, self-organization, self-design, self-maintenance, self-control, etc. But this leads us to think about the Self-Other relation, and so it is necessary to get straight this distinction in order to associate these characteristics to this Self, rather than the other. There is a fundamental relation between Other-ordering, Other-production (allopoiesis) and Other-organization and those same characteristics in relation to the Self. One must question carefully who is the Self and who is the Other in order to understand what is at stake here.

I would like to introduce the terminology of Jung and distinguish Self from Ego. Self is the totality of who you are, while the Ego is the unity across time of who you would like to be. Many times

there is more to us than we would like to admit in public. And we keep hidden many parts of our self, though the machinations of the Ego. If we read the self narrowly as the ego then there is a completely different meaning to the terms above, than if we read it as widely as possible and include the totality of the self. We can contrast Ego-ordering, Ego-organization, Ego-production, from Self-ordering, Self-organization, and Self-production. In these cases this transforms the other. Buber put it well that we can either have I-it or I-thou relations with the Other. But when we permutated the terms we find that there are also Self-it, and Self-thou relations as well. I would like to suggest that this whole panoply of terms is relevant to our understanding of the task ahead of us. In fact, more generally, we need to take into account not just unity and totality but also plurality and wholeness. Wholeness is the nondual between unity and totality arising out of plurality. Wholeness is more than merely a unified totality, rather wholeness also exhibits synergy.

Autonomics as we would like to define it is a special kind of wholeness, which is neither that of the system, nor that of the meta-system, i.e. neither greater than or less than the sum of the parts but exactly equal to the sum of the parts. But Autonomics is precisely the Autopoiesis of the Part rather than the whole. In other words, the immune system or the nervous system, or other systems within the body, interpenetrate with other systems yet is distinct and autopoietically closed. Those autopoietically closed systems that are less than the whole organism are autonomic. Yet they are still within themselves wholes exactly equal to the sum of their parts. They are reacting to the meta-system within the organism, yet maintaining the system of the whole organism at the same time. Thus we can see that the autopoietic system as the body of the organism is made up of many autopoietic systems with different functions that are autonomic. Each of them takes the body of the organism as an environment but has the goal of supporting and keeping viable the whole system of the organism.

This situation is predicted by the Special Systems theory. It says that an autopoietic system is a balance of two dissipative orderings, i.e. neg-entropic systems within a reflexive system made up of either four dissipative ordering systems or two autopoietic systems. All we are saying is that the organism in itself is reflexive and because of that it has multiple autopoietic systems within it, like the nervous system, like the immune system, etc. when talking about the Autopoietic system of the organism we normally do not extend our analysis to this level and recognize the autopoietic sub-systems of the organism, but autopoietic theory has always recognized them. That is because autopoietic systems theory is a development of an existential biology and so it found that the theory of autopoiesis applies to different parts of the living organism, not just to the whole organism. We want to call every autopoietic sub-system in the body an autonomic system. It is ordering the part of the body that comes under its scope according to autopoietic closure. Thus we have to recognize that Self-organization of autopoietic systems includes the production of autonomic sub-systems within the body. Part of self-organization is the co-operation of these closed subsystems with each other in the enactment of life maintaining its viability.

In this process distinctions need to be made between ego and self, between self and other, between I and thou, and between totality and unity on the one hand and plurality and wholeness on the other. Autonomic is a perfect sub-wholeness within the perfect wholeness of the body as an autopoietic super-system. That means that reflexivity is injected within the body as well as being an outward social milieu. In all these autopoietic systems that are conjuncted as autonomia within the body, there is a concomitant conjunction of various dissipative ordering negentropic systems. The autonomia are regulating the neg-entropic systems, and in turn they are being regulated by the body as a whole of which they are a part. Yet this regulation is indirect because all these systems are independent in some sense due to their closure. Autopoietic systems are standing waves in dissipative ordering neg-entropic fields. When we mention autonomic systems we are saying that these standing waves have sub-waves of various frequencies within the main wave. For instance, if we use the analogy of the breather in relation to the soliton, i.e. a positive and negative soliton falling into each other, then we would have to think of the autonomia as fractal sub-breathers within the overall structure of the breather itself. And it makes sense that this breather structure is fractal so that the sub-breathers exist like the mitochondrial within the cell, as life within life, or embedded life that is symbiotic with the higher life organization of the cell serving the purpose of energy transformation within the context of the larger cell.

Once we understand that the autonomia is the fractalization of the autopoietic standing waves, and its reflexive embedding of life within life, then it becomes clearer how it will be necessary to bootstrap such systems into existence. In general autopoietic systems pop into and out of existence, they are not built up step by step. This is because these systems are more like instantatons based on their heritage in solitons, than they are like constructed configurations. Their popping into existence is their self-organization and self-production as a single coordinated self-action in relation to themselves. That action clearly demarks the self from the other by establishing the boundary of the body. It brings in one fell swoop the wholeness of the body into existence. Once that body exists until apoptosis occurs, when the viability of the body collapses, that body contains autonomic systems embedded within it reflexively as fractal autopoietic systems. The difference between the image of that body as ego and its totality as an embodiment is the key to understanding the relation of the autopoietic system to the projection mechanism by which the body throws forth its world. In the process of unifying its experience it must be forgetful of much of its self. But that totality of who-it-is is not lost, but rather transformed. And in the external reflexive social milieu such a body can recognize others who is like itself, upon which it projects a theory of mind, and in that way it can take Self-Thou instead of Ego-It relations toward things in its environment that it recognizes to be like itself. Part of this effort is continually maintaining the distinction between Self and Other. This is essential even for the autonomic subsystems within the autopoietic body. The immune system needs to keep straight what is part of the body and what is not, other wise what occurs are auto-immune diseases like AIDS where it attacks itself as if it were an intruder. Cancer is a similar malady where a cell forgets what kind of cell it should be given its context in the body. We are plagued by diseases of forgetfulness of who we are ourselves in our bodies. In some sense these are the most ravaging diseases like Alzheimer disease where we forget even our personality.

So Autonomic Theory is a part of Special Systems theory, which has its own particular place within the overall theory. Autonomic Systems are Sub-autopoietic systems within the body. This suggests that if we knew how to build technological systems that were in accordance with Special Systems Theory then autonomic systems would fall out as a part of that. It also suggests that it might be impossible to build systems that are only autonomic without being autopoietic as well. It suggests that isolated autonomic systems without autopoietic might be a false hope. However, what is clear is that if something were to become autonomic then it would also be autopoietic at the same time. So perhaps Autonomic systems are only a reframing and reemphasis in relation to the program of creating artificial consciousness, artificial life, and artificial society. It seems like a lesser goal but our theory says that it is really part of the same thing, i.e. part of an existential embodiment of the special systems.

7. Self-Organization and Emergence

Now I would like to explore the relation between Emergence and Self-Organization in relation to the article of DeWolf and Holvoet[1] on this distinction and consider the relation of these two terms to Special Systems theory. We will accept their definitions of these two phenomena, and concentrate on the sub-concepts that they bring out of the literature and try to look at those in relation to Special Systems Theory.

Emergence:

A system exhibits emergence when there are coherent emergents at the macro-level that dynamically arise from the interactions between the parts at the micro-level. Such emergents are novel w.r.t. the individual parts of the system. (De Wolf & Holvoet)

- Characteristics of Emergence:
- Micro-macro Effect – This is inherent in Autopoietic Theory of Maturana and Varella that in such a system there is a structural level as distinction from the organizational level. The organizational level stays the same while the structural level fluxes in and out of the system over time. The emergent effect in Autopoiesis is the arising of the self-organizing system that is autopoietic and its lasting as a viable entity for some time.
- Radical Novelty—The radical novelty in special systems theory are the thresholds of emergent self-organization at the dissipative ordering, autopoietic symbiotic, and reflexive social levels.
- Coherence—Coherence is the imposition of not just Unity and totality on the structural plurality at the organizational level but also the production of wholeness.
- Interacting Parts—In special systems the parts interact but in a special relation of conjunction which is a type of juxtaposition, like the plus signs in the complex numbers, or like the cells of a matrix in matrix mathematics.
- Dynamical—The Special Systems are dynamical because they need to constantly maintain their negative entropy within the far from equilibrium environment in which they exist. The law of nature is Entropy and the Special Systems escape from that locally but at a cost of greater disorganization beyond their boundaries.
- Decentralized Control—Due to the fact that Special Systems are juxtaposed in conjunction that makes it necessary for the control to be decentralized.
- Two-way Link—This is the link between the Organizational whole and the structural parts of the system. The organizational whole is emergent on top of the structural parts, but that emergence must be based on strict supervenience. The organizational whole draws its embodiment from the structural parts, but the structural parts draw their organization from the whole.
- Robustness and Flexibility—For closure to be maintained it must adapt to perturbations in the environment which assumes some degree of robustness and flexibility to remain viable in a changing environment.

Self-organization:

Self-organization is a dynamical and adaptive process where systems acquire and maintain structure themselves, without external control. (De Wolf & Holvoet)

Characteristics of Self-Organization:

- Increase in order—Neg-entropy means that order is dissipating throughout the special system ordering it differently from its environment and at the same time disordering the environment more than it would be otherwise. Self-Organization implies ordering from nothing by the self throughout the lifecycle, while autonomy implies maintaining that order over time within an autopoietic sub-function of the organism.
- Autonomy—Autonomy can be read as Self-Order and as Independence. As self-order it implies discipline of the self. As independence it implies freedom from external constraint, or external support. Autopoietic systems are self-sufficient unto themselves, and this self-sufficiency is the basis of their independence and freedom of action. But there are various scopes for the exercise of this freedom and independence and that depends on which level of organization we are discussing.
- Adaptability or Robustness w.r.t changes—Self-organization implies resistance to Other-organization from the outside. Robustness implies the degree of resistance, and the changing environment suggests that one must be adaptable to changing circumstances.
- Dynamical, (far from equilibrium).—Self-organization as Kauffman suggests springs from nowhere within dynamical systems where the number of possibilities for organization are overwhelming from a combinatoric standpoint. The ability to seize on these possibilities and impose order that realizes them demands negative entropy that can only arise in far from equilibrium systems. But now we know the whole universe is a far from equilibrium system, as it is accelerating in its expansion,

[1] De Wolf, Tom & Holvoet, Tom. "Emergence verses Self-Organization: Different Concepts but Pomising when Combined." ESOA 2004, pp1-15, 2005

so this is not as far fetched as one might have supposed previously.

De Wolf and Holvoet make the point that Self-Organization and Emergence can exist independently or together. When they exist together that is what I have called in the past an Emergent Event. In many of my papers I discuss the meta-levels of Being and their structuring of the Emergent Event. In short, there are five meta-levels of Being and these meta-levels distinguish the genuine from the artificial emergent events. Genuine Emergent events wipe away nihilistic backgrounds, while artificial events contribute to nihilistic backgrounds. Part of Nihilism is not being able to distinguish between self and other, or ordering and disordering. The study of the literature that De Wolf and Hovoet have performed and their careful definition of the two phenomena help us focus on the nature of the emergent event.

The arising of special systems is an emergent event. This is because the special systems are the way of differentiating the kinds of Being from each other. They represent a model of existence which underlies our model of Being as a projection process, i.e. the ecstasy by which the autopoietic system projects its world from its ego based on the totality of it's self. But what we learn when we focus on Autonomic systems is that such emergences are fractal in the sense that their embodiments will have introjected or embedded in them autopoietic sub-systems that are autonomic. They act with autonomy so we can forget them and get on with our business, and so they become invisible to us within the panoply of the full autopoietic special system embodied.

8. Self-Organization as Knotting

Although we applaud the work of DeWolf and Holvoet in disentangling these two important terms that have become confused in the literature, we would like to suggest a different way of defining them in relation to each other. We start with Self-organization and would like to suggest that the field of knots are the archetypes of self-organization. If you think about it a knot is precisely something that is organized with respect to itself. It has a continuity in spin of 720 degrees of angular change which is fraught by the necessity of self-avoidance, and the self-avoidance has a pattern which is a specific ordering. So if we take the knot as an analogy for self-organization then we would not expect the concept to have anything that the knot does not have and also we would expect the concept to fulfill all the features found in the knot.

Characteristics of Self-Organization as knot:

- Three dimensional space needed for a one dimensional winding—additional dimensionality of the environment is important to the existence of this property of self-organization.
- Spinor—The knot is a spinor, i.e. it is sufficient to keep itself stable in spacetime with its movement.
- Time-quanta—It takes a quanta of time for a knot to be what it is, a particular embodiment of a specific pattern of knotting based on a knot archetype with so many self-crossings.
- Continuity—The knot has continuity of the thread which is knotted though space.
- Discontinuity—The discontinuities are the pattern of self-avoidances.
- Self-avoidance—The knot must be minimally aware of itself in order to avoid itself as it winds its way though space.
- Increase in order—The increase of order is from one level of ordering to another when something self-organizes. But the self-organization achieved is a plateau where the particular organization is maintained after it is established. So increase of order is incipient and not essential whereas embodying the order of the self-organizing archetype is essential.
- Autonomy—We can think of self-ordering as the time it takes for the spinor to spin 720 degrees of angular motion avoiding itself in a particular pattern approximating a knot of a specific type in the table of knots. Self-ordering is maintaining this complex dance during the spinning. The self-organizing system must be free to spin and free to describe the dance that corresponds to the knot. Thus from the perspective of knot theory independence is circumscribed in scope.
- Adaptability or Robustness w.r.t changes—The perspective of knot theory is that adaptability is the change necessary due to obstacles on the path which might prevent the completion of the circuit. Robustness is the ability to complete the circuit in spite of these obstacles. But the obstacles may cause another path to be taken so that a different knot state is attained which is simpler or more complex, and thus the level of self-organization would change due to these obstacles.
- Dynamical, (far from equilibrium).—The basic dynamism is the spin of the spinor. But that spin is driven by energy, but if we think of the spinor as part of a spin liquid and as such a Bose-Einstein condensate at absolute zero, and the energy as the dark energy that is pushing the accelerated expansion of the universe, then this dynamism is possible anywhere, not just in far from equilibrium systems of the classic type. In other words this dynamism is endemic in the universe and not a special case.

Once we have a mathematical analogy for Self-Organization things become simpler because we can base our concept on that mathematical analogy both limiting it to the analogy and extending it to the extent of the analogy. This gives the concept natural limits and a natural context in mathematical terms.

9. Emergence as Synergy

It turns out that there is not just one form that has this property of embodying 720 degrees of angular motion, but four: Knot, Mobius Strip, Torus, and Tetrahedron. So the way I would like to try to relate Self-organization to Emergence is to say that it is, at the level of the Form Schema, like the relation of the knot to the other forms that embody 720 degrees of angular motion. This way we get to see some ways in which self-organization of form fits

into the field of the manifestation of the entire emergence of form. There can be other types of emergence than the emergence of form, but here we will pretend that it is the emergence of form that we are interested in. The mobius strip embodies non-orientability from a topological standpoint. The torus embodies orthogonality. The tetrahedron embodies minimal structure within three dimensionality. Each of these are important concepts in relation to the emergence of form. Form is not just self-organized when it is autopoietic, but it is also such that it is non-orientable topologically, it is orthogonal, and it is minimal within its dimensionality. The fully emergent form has all these properties not just self-organization. These are the properties that it accrues due to its stability in spacetime, and the fact that it takes time for it to manifest as form in spacetime, and that it must be a spinor. The temporal spin is reified by us into this minimal system of forms that are fully emergent.

- Micro-macro Effect –The emergent effect of the advent of form is seen in the four different embodiments of the spinor. The emergent is the whole form that precipitates out into these various embodiments. Those embodiments organize themselves in space differently with respect to their content. There are three different levels here. The spatiotemporal spinor, the reified spatial forms, and the contents of those forms that are dimensionally organized in different ways.
- Radical Novelty—The radical novelty is the fact that these very different forms all represent embodiment of the spacetime spinor in space very differently.
- Coherence—But these four forms have coherence within themselves and within their embodiment of the spinor in spite of their radical differences.
- Interacting Parts—Each of these figures can be considered from a temporal point of view as a construction, and in that construction the whole form is drawn in such a way that all the parts together fit into the archetype of the form.
- Dynamical—In this way of looking at the emergent form it is dynamical with respect to spacetime, but frozen in time. The essential dynamism is discontinuous as it flashes from one form to another.
- Decentralized Control—Each embodiment of the spinor is independent as a separate form, and thus control over the production of each form is independent.
- Two-way Link—There is a specific link between the spacetime form, the spatial form and its content which can be seen as written dynamically.
- Robustness and Flexibility—Robustness and Flexibility can be seen in the way that the writing of the form on its content is maintained despite obstacles in the environment that would attempt to forestall the completion of the writing of the form on its embodiments.

Synergy—The emergent form has a higher dimensional aspect which comes from the relation of the torus and the hypersphere which share the same surface equation, and the tetrahedron and the penta-hedron in four dimensional space which can be created by the addition of one orthogonal point to the tetrahedron. Synergy in emergence is the reuse of elements multiple times in an overdetermined way to create the higher dimensional forms.

Environment-System relations—The form emerges as a function of stability in spacetime. The spinor is the fundamental unit in spacetime which is both temporal and spatial together, but when these separate and there is a symmetry breaking then we get reified forms of different kinds that approximate the higher dimensional spacetime form.

Virtual-Actual relations—The spinor is a virtual unit that we do not see, what we see are the four reifications in form that are actualized when the space time symmetry breaking occurs.

Representation-Repetition relations—The four forms give us a field of sub-schemas which represent the relations between representation and repetition as defined by Deleuze in Difference and Repetition. Two forms appear completely three dimensional, but two are two or one dimensional in themselves yet need three dimensions as their environment. Thus if we think of the sub-schemas as the decomposition of the whole form schema into Picture, Plan and Model, then we see that the mobius Strip is the equivalent of the Picture, the knot is the equivalent of the plan, and the tetrahedron is the equivalent of the model, so that means that the torus is the representation of the whole schema. Thus we lose information when we represent the whole schema (torus) as a picture (mobius strip) and then we lose even more information when we represent it as a plan (knot) but then the plan can be used as a basis of repetition in order to build up the model (tetrahedron) which then approximates but does not achieve the qualities of the whole schema. Both the torus and the tetrahedron are related to four dimensional prototypes that are virtual, which then again are housed on the space of form which is five dimensional.

What we see here is that when we think about emergence as the emergence of form then we can directly relate it to the idea of self-organization in terms of the analogy with the knot. Notice that spacetime is seen as broken up into spinors as a spin liquid condensate. But these spinors are four dimensional and the only way to see them is to reify them into forms like the four we are discussing here. The spinors are inherently dynamical and yet stable in spacetime. But we cannot see them. We can think of this stability as like that of the Autopoietic system, and that means that while they are in spacetime the forms are Autonomic as Autopoietic subsystems. But their autonomic nature is broken along with the autopoesis of the stability of the whole spinor in the spacetime framework. What we are seeing are shadows of those autonomic parts of the autopoietic whole of the emergent form. Self-organization is the most basic of these forms as it is one dimensional in a three dimensional space. Up from the self-organizational feature we have then the mobius strip and its topological non-orientability. This gives the form a self-duality of a strange type which is actually nondual. In other words from here we derive the relation between local and global. We cannot distinguish sides globally but we can distinguish sides locally. Ultimately every distinction in the emergent form is nondual, i.e. distinguishable locally but not globally. Next up there is the tetrahedron which is created by repetition of parts fitted together into a minimal system. It is formed on a lattice which is self-dual and which is related to the fundamental geometrical elements of point, line, surface, solid. This organization comes from the Pascal triangle which generates each minimal solid for each dimension. What we have here is constructability by repetition.

This is where the self-production though construction comes in. So we see that self-organization is the most basic element of the conceptual constellation, but then we must distinguish between self and other, between order and disorder, between one side topologically and another. We can make that distinction locally but not globally, but based on that local distinction we can create a production mechanism to build up our picture of the minimal structure based on an assignment of fundamental elements to a lattice. Finally there is the torus. The torus embodies orthogonality. Once we have orthogonality within the whole then we can imagine four dimensionality, as the next orghogonal step up from the three dimensional, and in that way we can approximate the original unity of the spinor itself. But that spinnor is broken in its image between the hypersphere and the pentahedron. The hypersphere has the same surface area as the torus, and thus there is a topological connection there. But the pentahedron is one more point added to the tetrahedron, which then generates five separate tetrahedrons intertwined in four dimensional space. But a pentahedron is also two entwined mobius strips so that the pentahedron is related to the mobius strip in a different way than the kleinian bottle which is also composed of two mobius strips. Finally the knot relates to the spinor itself, because it has a 720 degree circuit with the various interferences that give the knot its order. So the knot is the closest thing to how the spinor must look in terms of its spinning when translated into a three dimensional image. Thus the knot which is the lowest dimensional representation actually portrays in a fashion that is closest to the spinor in the space of form which is five dimensional, i.e. that is the space in which the hypershere and the pentahedron inscribed on it merge. But those are still spatial images while the circuit of the knot is inherently dynamical, more dynamical than any of the other representations because it has the most degrees of freedom.

Our hypothesis is that the Autonomic is like the temporal relations between the spatial embodiments of the emergent form within the spinor state. That spinor is seen as autopoietic because of its stability in spacetime. That is to say it is a closed circuit which has its own momentum and continues to spin independently in its environment. But that spin has moments, and we call those moments the Quadralectic. When those moments are reified spatially then we get the four forms which are embodiments of those autonomic phases. By reading back from the spatial forms into the temporal realm of spacetime prior to the symmetry breaking into time and 3d space, then we can intuit what these various autonomic aspects are like. There are four of them. One of them is related to self-organization based on the archetype of knots. We might call these the cellular autonomic sub-system of the autopoietic system. Then there is the mobius strip which distinguishes locally but cannot distinguish globally, and this is like the immune system, it is constantly distinguishing self from other when they are actually the same thing globally. Next there is the built up structure of the organization of elements into a whole that produces a form from repetition. This is like growth, and the replacement of dying cells. Finally there is the torus that can be seen as orthogonal hyper-cycles that produce the control structure that controls self-organization as an activity. All these elements working together gives us the emergent form as an eventity. The appearance of the emergent form is an emergent event.

10. ACKNOWLEDGMENTS

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