Complexity and the philosophy of becoming

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Abstract: This paper introduces Deleuze's philosophy of becoming in system theoretic framework and proposes an alternative ontological foundation to the study of systems and complex systems in particular. A brief critique of system theory and difficulties apparent in it is proposed as an initial motivation to the discussion. Following is an overview aiming to provide an access to the 'big picture' of Deleuze's revolutionary philosophical system with emphasize on a system theoretic approach and terminology. The major concepts of Deleuze's ontology - difference, virtuality, multiplicity, assemblages, quasi-causation, becoming (individuation), intensity and progressive determination are introduced and discussed in some length. Deleuze's work is a radical departure from the dogma of western philosophy that guides the foundations of science and system theory. It replaces identity with difference and being with becoming, in other words, it provides system theory with an ontological ground based on change, heterogeneity and inexhaustible novelty-producing process that underlies all phenomena. The conceptual tools made available by this philosophy seem to capture the fundamental aspects of complexity and complex systems much better than the current conceptual system that is based on static transcendental ontological entities.

KEYWORDS: *ontology, virtual, actual, difference, multiplicity, becoming, singularity, assemblage, system, complexity, dynamics, Deleuze, intensity*

1. Introduction

The subject matter of this paper is the ontological foundations of the study of systems and complexity. Current approaches to complexity already involve significant departures from classical scientific methodologies and their conceptual basis that goes way back to Plato, Aristotle and much later to the Newtonian worldview (Heylighen, Cilliers, & Gershenson, 2007). Concepts such as holism (non-reductionist approach), emergence, indeterminism, incompleteness, relativity of knowledge and more became the foundations of a general system theory which provides, as of today, the most effective paradigm in dealing with complexity.

Yet, complexity stays largely untamed by the theories and the insights applied to it. Despite a large body of knowledge, unarguably complexity is still very complex, which perhaps indicates best how inexhaustible the problem is. Most of the real world problems we need to deal with today such as (just to name very few), climate change, global economy and resource management, social systems and governance, ecology, traffic and communication as well as understanding the human organism and the human mind are indeed very complex. It is necessary for the future well being of humanity and this planet that we gain a progressively better understanding of complexity. For that, we need to seek not only for novel scientific tools but also for fresh philosophical insights as well as new conceptual vehicles.

This paper is an introduction to the revolutionary ontology created by postmodernist philosopher Gilles Deleuze (Smith & Protevi, 2008) during the second half of the 20th century and further adapted to system theoretic language by Manuel De Landa (Wikipedia, Manuel de Landa, 2011). Deleuze's ontology of difference was created as a bold response to his critique on the very roots of western dogmatic thinking where static transcendent essences are foundational while change and difference are secondary and in a profound sense marginal. His ontology offers an alternative not only to the Newtonian worldview but to the deeper understanding of reality rooted in the Platonic and Aristotelian philosophical systems. In that, it proposes novel ontological commitments that exceptionally accommodate dynamic complex phenomena.

My goals in this paper is to present a viable case for a radical shift in *how* we think about existence as reflected through systemic thinking which is so foundational to the sciences; more specifically, to stimulate new manners of thinking about problems in complex systems. Central to this presentation are the concepts of difference, multiplicity, virtuality and becoming which are the primary building blocks of Deleuze's ontology. The application of these concepts requires a non trivial departure from the deeply rooted dogma of a being based ontology (essence-object) towards an ontology of becoming (difference-process). Another, more implicit, goal is to establish a cross-disciplinary bridge reaffirming by that the importance (and necessity) of philosophical discourse to science and of an experimental approach to philosophical problems.

The first section proposes a brief critique on the foundations of general system theory. The critique exposes major conceptual limitations in dealing with complexity and by that serves as both motivation and background to the work presented here. The following sections give an overview of Deleuze's ontology and detailed descriptions of the most

important concepts. The concluding section discusses the relevance of the philosophy of becoming to the study of complexity.

2. A short critique on the conceptual foundations of system theory

System theory has made a long way from classical Newtonian science and indeed represents a major conceptual paradigm shift (Heylighen, Cilliers, & Gershenson, 2007), (Heylighen & Joslyn, 2001). However, the theory still suffers a few serious weaknesses having to do with the deep roots it has in the Platonic and Aristotelian foundations of western thought, and more specifically with its suppositions regarding the nature of reality and the nature of thought. These are briefly outlined below. These weaknesses become more apparent as systems become more complex and their complexity less tame.

2.1. The transcendental approach of systems theory

The essential elements of existence are given, unchanging and eternal. Actual In the philosophical tradition, the concept 'transcendence' indicates that which stands outside and beyond existence. The roots of the concept are to be found in religious thought and particularly in the monotheistic Judeo-Christian system. There, it describes the status of God in relation to existence. But transcendence emerged also as a dominating motif in Greek philosophy becoming since then extremely influential in western philosophy and the sciences.

In Greek philosophy there are the Platonic Forms that stand outside human experience and transcend existence itself. The role of the philosopher is to seek to understand the Forms which shape the world of matter. Such understanding is achievable via the intellect which is considered to transcend the material world as well. Two kinds of transcendence are therefore apparent: the transcendence of Ideal Forms to the material world and the transcendence of the human subject to the material world. The idea of transcendence requires a commitment to two ontological substances; one is matter – the inert and featureless substance, the second is mental or ideal – that which gives form and law. The world is created from matter impressed (literally) by Form. A second commitment required by the transcendental approach is that the Ideal Form is superior and more essential than matter. Form subordinate matter under it and the intellect (logos) subordinate the body (May, 2005, pp. 27-31).

There are three relevant implications of the paradigm of transcendence:

1. The essential elements of existence are given, unchanging and eternal. Actual forms in the world are only copies of these. There is therefore no ontological foundation to change.
2. The human subject observes the world from a perspective which is outside existence.
3. The method of acquiring knowledge (epistemology) is by extracting the essential Forms (ideals and principles) from their lesser material manifestations.

These implications have deeply influenced scientific thought and the way scientific research is carried out. More in specific, in the case of system theory, one of the important tenets is that structure and function can be invariably abstracted from actual implementation. It is indeed coherent with the idea that matter is an inert featureless substance being imprinted with properties, relations and dynamic lawful behaviors whose source is ideal and transcendent to matter itself. From a system theoretic perspective, what is significant in a phenomenon is only those observable abstract properties and behaviors; how such properties and behaviors came to be actualized, i.e. the historical, evolutionary aspect of the observed phenomenon is generally disregarded. Disregarding implementation is perhaps the greatest power of systems theory and is essential to its modeling capacity. In many cases the abstracting away of implementation and history greatly simplifies matters and is indeed practically warranted, yet, it lacks a sound ontological foundation. This lack is not a mere philosophical anecdote; here are, in brief, the difficulties inherent in such approach:

1. The underlying ontological building blocks do not account for change and do not give it a proper status. Not having a proper status means that change is either secondary phenomena or perhaps even epiphenomena. A priori given static entities are far from fitting the dynamic and evolutionary nature of complex phenomena and especially the production of novelty (more on this in the following).
2. The transcendental paradigm allows and actually encourages the imposition of representations and presuppositions on reality and by that often hide (or even replace) what is present behind what is represented. The combination of points 1 and 2 create a bias towards invariance (see also the section on representation and identity below). The least changing theories and models are considered the most reliable and successful.
3. The transcendental disconnected position of the observer outside existence is a profoundly distorted position. This problem is partially resolved by second order cybernetics approach that integrates the observer into the observed system. The solution however is only partial. The observer is still conceptualized as unified and coherent agent whose various faculties operate in concert to produce in thought a re-presentation of the present - observed phenomenon. A phenomenon in turn is similarly a unified coherent source of signs and signals communicating its nature. These two presuppositions regarding the observer and observed are indeed implied by the transcendental approach but seem to be largely unwarranted inventions. Thought as representation and truth as a correspondence between thought and the world are deeply rooted in system theory and scientific thinking at large. (May, 2005, pp. 74-81) (Deleuze, 1994, pp. 129-168) They encompass a philosophical dogma which again profoundly understates the dynamic and heterogeneous nature of existence.

2.2. The black box dogma

The black box concept is foundational to how systems are assigned with structure. It is a derivative concept of the transcendental approach which deserves special consideration. A black box is an abstract entity constituted from two abstract distinctions. The first is an arbitrary distinction between an ‘inside’ and an ‘outside’ of a

phenomenon, or, alternatively between agent (system element) and environment. The second is an arbitrary distinction between 'input' and 'output' which also imposes a transcendent asymmetry in subordinating 'outputs' to be effects and 'inputs' to be causes. While these distinctions are epistemological in nature pointing towards how one observes a certain phenomenon, they are often regarded as having an unwarranted ontological status i.e. that inside and outside, input and output are intrinsic to the system and its subcomponents. Moreover, these distinctions are assumed to be mostly invariant, endowing the system with structural stability which greatly simplifies modeling.

It is obvious that the black box concept is not intrinsic to actual phenomena. Complex systems are generally open, with indistinct boundaries and even less distinct and stable input and output functions. Additionally, the black box concept highlights the significance of stable organization and abstract relations between components while disregarding possible implementation dependent effects (the happening inside a black box is irrelevant as long as it implements the imposed input/output relations). In real systems, structure might often become ambiguous, inputs and outputs might unpredictably arise or disappear, connections and causal relations might spontaneously form or disengage and inside/outside boundaries radically shift. Generally, in real systems, there is always more to the parts than what they seem to perform as the components of a larger whole. This fact is unaccounted by the black box concept.

2.3. The idea of cybernetic control, utility and function

The influence of cybernetics on general systems theory cannot be overstated; in many aspects they are synonymous. Two problems are to be considered here: the first is that the cybernetic approach tends to emphasize the significance of stable states and asymptotic behavior upon the transient and non equilibrium phases of the evolution of a system (Ashby, 1962). The problem is at least partially amended by recognizing the immense importance of far from equilibrium open ended processes, but this recognition is not sufficient to cure the paradigmatic weakness at the basis of this bias. The next subsection examines this problem in the particular context of cognition.

The second problem is that feedback systems are often conceptualized as goal seeking, utility/fitness optimizing and adaptive (homeostatic) processes. Here, again, goals, utility functions, and target states are understood as essential and invariant properties of systems or agents in complex adaptive systems. Though it is well understood and accepted that complex systems are staging a theatre of change and transformation, the ontological framework underlying their research program is still based on fixed identities and final causes.

There is a very fine line between describing a feedback system as having tendency towards certain asymptotic states and describing the same system as having a purposeful behavior towards achieving a certain goal. As will be discussed later, tendencies can be understood as properties immanent in the system and guiding its evolution. As such, systemic tendencies have a clear ontological status that provide local sufficient causes at any point along the developing trajectory within an appropriate state space. Purposeful or intentional description is only a metaphor that cannot merit a

similar ontological status. This was already argued by Spinoza at the end of the first chapter of ethics: “There is no need to show in length, that nature has no particular goal in view, and that final causes are mere human figments.” (Spinoza, 1997)

Final causation is especially problematic in evolutionary explanations where traits of certain organisms are explained to have been selected to maximize fitness. Such explanation does not explain anything apart from the trivial fact that fitness was achieved by the organism acquiring a certain trait. It does not distinguish the actual solution from an indefinite number of other solutions not less fit that could have been selected but were not selected. What may explain a certain selection is not the final cause of fitness but the predetermined structural constraints of the organism’s body plan prior to acquiring that trait. Relative to structural constraints, fitness seems to be the least specifying factor (Maturana & Varela, 1998, p. 115).

2.4. Representation and identity

In ‘Representation and Change’ (Heylighen F. , 1990) the author proposes a concept of adaptive representation that accounts for change via an adaptive feedback process where a representation of a phenomenon is continuously corrected by comparing predictions of the model to actual perceptions. There is no doubt that the developing of models with good predictive powers carries with it an evolutionary advantage to organisms which explains why human cognitive systems are so apt at representation. Moreover, there is no doubt that representation is the foundation of epistemology and scientific thought. While the idea of adaptive representation attempts to resolve the problem of dealing with the fundamental dynamic nature of existence, it actually exposes a deeper problem: the feedback mechanism that apparently converge representation to reality is in fact a process that stabilizes identities (invariant properties, qualities etc) in the cognitive process. Indeed, the cognitive mechanisms that produce representations seem to have evolved to predict future events. As such, they are optimized to discover and extract invariants in the stream of sense data (Hawkins, 2004). Similarly, in the general process of scientific observation the focus is always the discovery and highlighting of invariant laws that *explain away* change. We always seek for a representation that will subsume change under an invariant principle. In short, we understand and explain by eliminating change and affirming a stable existence. This paradigm seems to have profound evolutionary roots but it certainly fails to address and properly account for the majority of complex phenomena where change cannot be reduced to regular patterns and subsumed under invariant representations. Dealing with change seems to require a paradigm that goes beyond representation altogether.

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We can now start to appreciate the difficulty invoked by the essences and fixed identities ingrained in system’s theory conceptual framework. These concepts seem to be categorically incompatible with any attempt to allow change an ontological status. Explanatory method based on identities as the fundamental ontological elements fails to explain the transformation of one identity into another. Deleuze offers a radical alternative: giving up altogether the ontology of given, fully formed individuals (identities, beings, agents, states) and instead adopt an ontology that fully accounts for

the genesis of individuals via a process of becoming such as the developmental processes that turn embryos into an organism, or, the evolutionary processes of speciation. Deleuze's ontology accounts, as we shall see, for the *objective production and evolution* of spatio-temporal structure and boundaries of individuals. In that, it introduces a novel conceptual framework that seems to overcome the shortcomings of system theory especially in the context of complex systems.

3. An overview of Deleuze's ontology

Let me dedicate first a few words to the 'greater picture' of Deleuze's philosophical work, as they may provide a background to his metaphysical approach. Deleuze was very ambitious in his philosophical program; it was in his intention to overthrow the hegemony of the Greek philosophical paradigm and much of what evolved from it in human thought. He criticized this paradigm as dogmatic, rigid and based on unwarranted axiomatic presumptions that shaped what he called 'the image of thought' (Deleuze, 1994, pp. 129-168). His ontology is an attempt to replace it with a novel philosophical paradigm which is realist, experimental, and in a manner of speaking empirical (i.e. based on philosophical observations rather than axiomatic presumptions about the nature of philosophical concepts). A philosopher's work, according to Deleuze, is inventing new concepts with primary attention to the significance and relevance of these concepts in relating to real world problems and not necessarily to their truth. Trial and error, tinkering and speculation are necessary tools in a philosopher's toolbox according to Deleuze[1].

Deleuze's ontology is realist, meaning that it grants the whole of reality an observer independent status. Realism sets Deleuze's work apart from the other post modernist philosophies which are basically non-realist. Importantly, Deleuze's kind of realism is conversant with and accessible to the scientific way of thinking (DeLanda, 2005, p. 2).

The Deleuzian ontological program can be summarized in the following points:

1. Immanent properties replacing transcendent impositions.
2. Difference replaces identity as the most fundamental ontological element.
3. Multiplicities replace essences and ideas.
4. Becoming (individuation) replaces being[2] (given, a priori beings).

The combination of these four points constitutes a novel ontological system that rejects both the transcendent ideal ontology of Plato and Aristotle's typological categories[3]. If ideal and typological essences are being rejected, the question that needs to be

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[1] This revolutionary approach causes more than a slight discomfort to many orthodox analytical philosophers that often describe Deleuze's work as obscure, non consistent and highly speculative.

[2] The contrast between becoming and being can be traced back to the influential works of Heraclitus and Parmenides, but it is only in the work of postmodern philosophers such as Nietzsche, Bergson and prominently in Deleuze's that becoming regains primacy.

[3] Typological categories bestow ontological status on generalizations through the concept of species.

answered is what grants existence? To answer this question, Deleuze adopts Spinoza's concept of substance. In his unique style, he radically reshapes the concept yet keeping it faithful enough to Spinoza's idea in at least three important senses: univocity and immanence (May, 2005, pp. 32-39).

Deleuze's substance is pure change, infinitely and inexhaustibly expressive and productive – ever producing myriad different expressions of itself in itself. Substance if so grants existence but it does not grant any specific constant expression to existence. Existence therefore is a process of becoming – a continuum of pure changes (Williams, 2003, pp. 63-69). Physical matter is only one kind of expression of substance. Specific kinds or configurations of physical matter, biological tissues, populations of organisms, ecologies, societies and other phenomena can be related as expressions of substance that are not necessarily mediated by (or reduced to) physical properties. Expressions of substance are called multiplicities. Each multiplicity is a pattern of becoming that give rise to phenomena associated with it. All multiplicities are laid out and meshed on what Deleuze calls 'a plane of immanence' or 'plane of consistency' (Deleuze & Guttari, 2005, p. 9). The 'plane' is one of Deleuze's most fundamental ideas. It carries no resemblance to a geometrical plane; it is rather an abstract continuum formed by all multiplicities – the different expressions of substance. It is a plane because these expressions are ontologically equivalent.

Univocity is the technical term for the ontological equivalence of all expressions of substance. In simple terms it means that substance is one, indivisible and has no types and levels. Additionally it means that the diversity of expressions does not reflect diversity of senses or manners in which substance expresses. Immanence means that *substance cannot be considered apart or separate from its myriad expressions*. Therefore substance *is not* a unitary entity unifying all its expressions. Deleuze's substance is a pure multiplicity, a 'many' without a 'one' that precedes it, unifies it or contrasts it. The 'plane of immanence' is not a metaphor or an analogy but the most fundamental constitution of concrete reality. Reality thus constituted is ultimately complex dynamic and interconnected.

Three ontological dimensions constitute reality (existence) according to Deleuze: these are the actual, the intensive and the virtual dimensions. Each of these is populated by specific concrete elements. The actual is the 'surface' dimension populated by fully individuated phenomena with observable qualities and measurable spatio-temporal extensities. The virtual is the 'depth' dimension populated by multiplicities (as will be clarified in the following sections) that are spaces of pure becoming. The virtual is always disguised under the appearance of the actual and contains the patterns of becoming (morphogenetic patterns) that govern the individuation of all actualities. These patterns exist, as we will see, as independent from any *specific* material implementation yet they are immanent in phenomena and cannot be said to exist independently of any expression at all. The virtual is the realm of infinite potential expressions. It is the aforementioned 'plane of immanence'; no individuated phenomena and no individuating processes are taking place in the virtual, it is causally sterile. Yet, the virtual is not static. On the virtual plane, pure change (as difference) is laid out prior even to time and space or any other quantifiable or qualifiable actuation. If

the actual is the 'external' overt aspect of reality, the virtual is the 'internal' and disguised aspect of reality.

The intensive dimension is the mediating dimension between the virtual and the actual. The intensive dimension is mostly disguised by the actual as well and is populated by productive individuating (morphogenetic) processes guided by virtual patterns and producing actual phenomena. Intensive processes are processes that are driven by differences in intensive properties.

Intensive properties are those properties of matter that are not divisible in contrast to extensive properties like volume, area, mass, electric charge etc. which are divisible. The most obvious examples of intensive properties are temperature, pressure, velocity, chemical concentration etc. Differences in intensive properties, or, in short, intensive differences, tend to equalize by driving fluxes of matter and energy. The most obvious example is how differences in temperature and pressure drive weather systems, or how temperature gradients in viscous liquids drive convection processes. Intensive properties are not necessarily thermodynamic in nature however. The concept can be extended to include other properties that are appropriate to various expressions of substance. For example: difference in scarcity or abundance of a resource can drive economic processes; difference in distributions of predators and prey within food chains can drive ecological and evolutionary processes; differences of demographic distributions within a population can drive social processes; genetic differences within populations drive phenotypic adaptation processes and so on. All these can be considered intensive differences which are not thermodynamic (at least not in any obvious sense).

Intensive differences drive processes of change. Processes of change are driven by intensities and governed by virtual patterns immanent in them reflecting their intrinsic tendencies. For example: a system with a tendency towards equilibrium states will tend, at least in part, to cancel intensities and produce asymptotically stable phenomena or regulated periodic changes (the cycle of seasons in global weather system) that disguise the underlying intensive processes or cancel them altogether. Systems that tend towards far from equilibrium dynamics will, in contrast, produce less tame kind of phenomena and expose an actual intensive process. This is where complexity is observable.

Intensive processes are called individuating because they specify unique actual phenomena and give *rise to individuated identities as effects* (products) of processes[4]. For example: physical, ecological and social systems may share the same immanent pattern of becoming (in the virtual dimension), but each will undergo a completely unique process of becoming will display phenomenal products which do not have any resemblance to each other.

In the ontological investigation of an actual phenomenon, we start by identifying the individuating intensive process that produces the phenomenon. We go from the product to the productive. We are then in a position to study this process and extract from it

[4] In contrast to the primary status identities have in the Platonic and Aristotelian systems.

those patterns of becoming which are immanent in it but independent from its specific (individual) properties and structure. By that, we can uncover the virtual aspect of the phenomenon in the form of a multiplicity that guides the process. The patterns that constitute the multiplicity expose a completely hidden aspect of actuality. They may, for example, indicate tendencies and capacities that were not actualized but nevertheless are immanent in the system. In this sense, the virtual aspect of a phenomenon is its concrete (and inexhaustible) potential of becoming – a source of potentially infinite novelty that goes beyond any specific individuation process and any specific actual product. Deleuze assigns to multiplicities a status of 'concrete universals', and develops an empiricism of the virtual that complements the empiricism of the actual. While the empiricism of the actual is concerned with distinct identities, the empiricism of the virtual is concerned with the complex connections and potentialities hidden in every distinct phenomenon. Here Deleuze repeats and reaffirms Spinoza's assertion: "we do not know what a body is capable of".

This draws, in a nut shell, the big picture of reality according to Deleuze. In the following sections this picture will be greatly clarified as the details fall into place.

4. The virtual

The virtual is the most fundamental and philosophically novel among the three ontological dimensions that constitute Deleuze's ontology. To grasp the concept of the virtual, it is best to stick to the points of the Deleuzian program and see how the virtual is carefully constructed to realize this program.

The virtual comes to describe the intrinsic nature of existence without resorting to anything transcendent or essential. It characterizes a universe of becoming without being. In such a universe there is nothing essential to individuals and they possess no fixed identity. Individuals (actual individuated phenomena) are effects, outcomes and expressions of a dynamic substance – a pure becoming.

The virtual is radically different from the actual in that that virtual elements do not possess a determinate identity. Virtual elements are determinable but never determinate. They are therefore not objects or events per se, but rather in a state of *pure becoming*. In the common manner of thinking actual objects or events are determined by their essential properties or the ideal essences that describe them. Properties and essences are the basis of identifying, categorizing and comparing between objects. According to the Deleuzian ontology of difference, actual objects are determined by their history of individuation, or, in other words, by the irreversible process of becoming by which their character is progressively determined.

Since the actuality of each and every object is necessarily complemented by its intrinsic intensive and virtual aspects, no actuality is entirely and finally determined. Underneath every actual appearance there are always intensities - active individuating forces, governed by immanent virtual tendencies that constitute an open ended potentiality for change. The metaphor that describes becoming best is embryogenesis, where progressive phases bring about the separation, discrimination and individuation of parts

and qualities of the system which in antecedent phases are more or less fused and indistinct.

Difference is the most primal ontological element of the virtual. As we will see in the next section Deleuze constructs a completely novel concept of difference unlike anything known before him. It is this ontological element that stands at the foundation of his ontology rightly named therefore 'ontology of difference'. Difference replaces essential identity as the elementary building block of existence. One might immediately wonder difference between what and what? It was the ingenuity of Deleuze to recognize the conceptual trap embodied by this question and devise a concept of difference that avoids it altogether.

The structure of the virtual is given by the second most important ontological element that is multiplicity. A multiplicity is how differences are organized, relate to each other and become affective in the individuating processes of becoming. As was mentioned before, all multiplicities are meshed into a continuum – the plane of immanence which is the virtual in its entirety.

Difference and multiplicity are the subjects of the following sections.

5. Difference

In the Aristotelian ontological system that deeply influences the way we think, difference pertains to how we discriminate between beings and essences. Aristotle's principle of non-contradiction states that "the same attribute cannot at the same time belong and not belong to the same subject and in the same respect". This axiomatic principle ensures that objects cannot differ from themselves and therefore it is in fact a principle of (numerical) identity. Once we establish the identity of X by specifying all its essential properties, we can, from then on, establish for any X' whether it is identical (X' is X), similar (X' and X are identical in concept but can differ in some non-essential properties) or different (X' and X are different in concept, i.e. in at least one essential property). There exists also a radical difference where X and X' do not share any essential property and are said therefore to be opposites. It is also important to note that within this understanding of difference, if X is different from X' it necessarily follows that X' is different from X. In other words, difference is a symmetric relation. A symmetric relation of difference is what conventionally makes two things distinct from each other.

In all these, difference is secondary to identity in that that it must rely and derive from identity. When we try to understand what difference is according to the Aristotelian dogma, it is readily apparent that difference is not only secondary but has no concept at all and describes only a modification of identity. It is definitely of concern that difference which plays a major part in our understanding of life, evolution and cognition lacks a clear concept, only filling the gaps, so to speak, between a priori given identities.

The problematic nature of difference as understood by the Aristotelian system especially that it has no concept, was a primary motivation to Deleuze's work. As a foundation of his philosophical program aiming to replace the Aristotelian system, Deleuze suggested

a novel and revolutionary theory of difference: instead of identity having the primary ontological status and difference only a secondary status subordinated to and deriving from identity, Deleuze made difference the primary ontological element and identity secondary to it. He rightfully describes his attempt as a Copernican revolution in philosophy (Deleuze, 1994, p. 40). His theory establishes a concept of difference which is *independent of the concept of identity*. This new concept of difference is critical to the understanding of the virtual.

What is, if so, difference according to Deleuze? It is "… the state in which one can speak of *determination as such* (my italics). The difference 'between' two things is only empirical, and the corresponding determinations are only extrinsic. However, instead of something distinguished from something else, imagine something which distinguishes itself - and yet that from which it distinguishes itself does not distinguish itself from it. "In yet more concise form: "Difference is this state in which determination takes the form of unilateral distinction." (Deleuze, 1994, p. 28)

The Aristotelian symmetric difference that can only exist between two determined identities is replaced by a unilateral relation: X' can be different from X, while X is still indistinct from X'. This seemingly 'cosmetic' modification carries immense consequences. We can now describe situations where X' is *becoming distinct* from X yet *not entirely distinct* from it (because the symmetry of the difference is not achieved). If X' is a difference relative to X, it still does not gain an independent identity because it cannot be said to be fully distinct from what it distinguishes itself from. This new ontological object, in all its simplicity, is the very tool by which identity based existence is upturned. Substance as difference in the new ontology explains how substance modifies itself in expression without ever becoming entirely distinct and separated. All the expressions that constitute existence are series of differences and differences of differences recursively to the n^{th} order. All is difference yet all is connected – a unity in multiplicity. No substance therefore is distinct from the differences which are its expressions. There is no 'original oneness' in existence only an ever differentiating variety which is multiplicity without a 'one' to contrast it. To describe difference, Deleuze is using metaphors such as 'larval' and 'embryonic' to emphasize the new ontological state of a partially formed identity, or, pure becoming. Additionally, since there are no final and complete distinctions, all differences form a continuum – the virtual plane of immanence.

Differences as indeterminate identities have characteristics which initially seem counter intuitive to conventional thinking. An element X can become a source of a series of consecutive differences (X', X'', X'''…). Since X persists (immanent) in X' and all the differences that arise from it, in a sense, X can be said to differ from itself through the differential elements that become unilaterally distinct from it. From a parallel perspective, the series of differences (X', X'', X'''…) can be said to constitute the intrinsic depth of X. Intrinsic depth means the inexhaustible number of manners in which X is different from itself *in itself*. This is also the inexhaustible manner by which X's partially determinate identity could be further determined and become more distinct (but never completely distinct). These simultaneous parallel perspectives where X is intrinsic to

anything unfolding from it while any unfoldment of X is also found as its intrinsic depth, is unique to the virtual.

Though it will not be discussed here in the length it deserves, in the mathematical sense, differences are topological in nature and not metric. This is intuitively apparent since there is no way to define a proper distance function between two elements that possess only partial identity. In a series of unfolding differential elements such as (X, X', X'', X'''…), the elements hold between them only ordinal relation and possibly ordinal distance[5]. Each element is distinctly positioned only in relation to the previous one. There are no privileged elements in the virtual. There are no 'original' elements; there is no hierarchy of similarities or proximities to an original object. All these stand in contrast to the common notion of actual (extrinsic) difference as something that can be quantified or qualified. Pure differences – the elements of the virtual, cannot (DeLanda, 2005, p. 74).

6. Multiplicity

This section describes how differences are organized into multiplicities, that is, structured continuums of differences. Multiplicities present intricate systems of relations among differences and by that constitute the structure of the virtual dimension.

6.1. Multiplicities in a system theoretic framework

In presenting the concept of multiplicity in the context of system theory and with the aim of making it accessible to scientifically oriented thought I follow DeLanda's reconstruction of Deleuze's work (DeLanda, 2005, p. 14). It should be noted however that Deleuze's development of the concept multiplicity is primarily metaphysical though he appeals in many places to mathematical terminology (Williams, 2003, pp. 143-146). The utilization of mathematical and system theoretic terminology in the following should therefore be regarded as an attempt to bridge between disciplines: metaphysics on one hand and system theoretic thinking on the other. In terms that will become clear only later, the development of the concept multiplicity here can be regarded as an individuation (and actualization) of Deleuze's multiplicity. It is the application of Deleuzian method on the subject matter. As such, it understandably (and necessarily) leaves certain aspects of multiplicity disguised, obscure and incomplete. Yet, it exposes enough as to stimulate novel approach in system theoretic thinking.

6.1.1. State spaces

Following the history of dynamic systems science, DeLanda argues that much of what constitutes multiplicity can be derived from mathematical methods that were developed

[5] Ordinal distances measure the degree of dissimilarity between differential elements. They can be compared but a difference between ordinal distances cannot be cancelled because they are not quantifiable measures. For example one can know that A is more different from B then C is from D, but there is no meaning to ask how much it is more different. This becomes important when two series of differences are related via a third series of differences, which is the manner by which differences connect on the virtual plane to form a continuum.

to model dynamic systems; primary of each is of course the idea of state space (Abraham & Shaw, 1992, pp. 13-47). Briefly, a state space is a multidimensional space whose dimensions are the various parameters that fully describe the state of a dynamic system. Every point in the geometrical representation of a state space represents the state of a system at a given moment in time. Continuous sequences of such points form trajectories. A trajectory is a sequence of successive states of the system that describes the dynamic development of the system between two instances. The shape of trajectories reflects the mathematical relations held between state variables that in turn describe the development of state dynamics. Trajectories, therefore, express geometrically the lawful dynamics of the system. Additionally, neighbor trajectories generally have a similar characteristic shape that sooner or later converges into well defined subspaces (basins) of the state space called attractors.

Metaphorically speaking, the physical properties and dependencies of the parameters that describe the system are encoded into a topography of the state space. The trajectories which are distinct dynamic developments of the system are bound to follow the topographical shape of the state space. In the classic view of dynamics, the actual trajectory of a system is determined by a combination of the state space topography and the initial starting point – encoding the initial state of the system and determines which of the infinite distinct trajectories will trace the actual dynamics of the system[6].

Further development of system dynamics was the discovery of attractors. Attractors are special points, curves and surfaces of any number of dimensions and of a specific geometrical shape that characterize the topography of state spaces. These are called attractors or singularities because they seem to change and organize the trajectories in their vicinity bounding them into distinct classes of shapes. These classes correspond in turn to classes of dynamic behaviors of systems, for example: the converging into fixed stable states, simple periodic oscillations, or other more or less complex recurrent patterns.

Interestingly, various configurations of attractors were discovered to be recurrent in diverse physical systems. These systems sharing more or less the same topography would behave dynamically in exactly the same characteristic manner even though their actual physical manifestation will be radically different from one system to another. At the end of the 19th century and during the 20th century it became evident that different systems share generic characteristics of their state space topography (technically termed phase portrait). Such generic characteristics are independent from any specific implementation. The behavior of such systems follows therefore dynamic patterns which are independent from their specific physical construct and depend only on their shared state space topography (DeLanda, 2005, pp. 182-183) , (Abraham & Shaw, 1992, pp. 349-360).

[6] Initial point or initial condition of a system is a practical and arbitrary imposition made by an external observer. A dynamic system does not have privileged initial conditions of any kind. An initial condition marks only the state of the system when observation began.

6.1.2. State space's topological nature

Another development important to the understanding of the concept multiplicity took place with the advent of complex dynamics and chaos theory towards the second half of the 20th century. This development has to do with the structural stability of state space topographies. Many systems, it was discovered, may display a complex dynamic behavior that is expressed not only by complex trajectories within stable state space topography, but also by the topography itself becoming sensitive to certain systemic variables. Metaphorically speaking, depending on such variables, the state space topography transforms: valleys can turn into mountains, ridges can appear or disappear, gentle slopes can turn into steep or ragged areas and so forth. State spaces if so are also characterized by their structural variability; that is how their overall topography changes in response to perturbation of certain systemic parameters. Such structural variability necessarily requires that in the most general case state spaces are topological in nature and can accommodate a variety of metrics.

Complex systems may display even more radical changes of behavior as single trajectories may bifurcate at certain points into a multitude of possible trajectories. Which branch of the trajectory will be selected after the bifurcation is infinitely sensitive to initial conditions and therefore unpredictable. Each outgoing trajectory thus selected at a bifurcation point may lead to entirely different domains of the state space and encode radically divergent behaviors. On top of this, points of bifurcation are not necessarily rare. Multiple bifurcations can take place in sequence along a trajectory which makes the corresponding system's behavior entirely unpredictable. For example, bifurcations can take the system into a domain where the very number of parameters governing its behavior changes. As a result, different domains of the system's state space may be of different dimensionality altogether and the system's dynamics may gain or lose degrees of freedom (the latter is a more simple frequent case generally known as self organization). In the following sections we shall see how these kinds of behavior are constitutive to the process of becoming.

6.1.3. Manifolds

Two additional important mathematical ideas that were developed in the course of researching the mathematical properties of geometrical spaces in general (Gauss and Riemann) and state spaces in particular (Poincare) seem to be clearly reflected in Deleuze's construction of multiplicities (DeLanda, 2005, pp. 10-14). The first is the idea of manifold and the second is the associated vector field of rate of change that can be defined on manifolds. The idea of manifolds was a breakthrough in the way geometrical spaces are mathematically described and manipulated (Wikipedia, Manifold, 2011). Before the time of Riemann, curved geometrical objects were only described using functional methods, meaning that each and every point in the curved object was described as a function of a few independent space coordinates. For example, a two dimensional curved object like the surface of a sphere had to be described within a containing three dimensional space. Additionally, a single mathematical function had to be found to describe the whole curve. Manifolds changed mathematically and conceptually this manner of treating curved objects. Gauss and then Riemann found a way to treat such curved objects as spaces on their own and describe them *without*

resorting to an external coordinate system. In other words, manifolds are described in terms of an intrinsic coordinate system with exactly the number of dimensions of the object itself. A sphere is then understood as a curved space of two dimensions without an artificially containing three dimensional coordinate system. Another important characteristic of manifolds is the fact that a single curved space can be described by a multitude of overlapping coordinate systems which are independent from each other and can even be of variable number of dimensions. A manifold therefore can be described in terms of a multitude of locally valid descriptions (coordinate systems) that overlap each other; none of each is capable of describing the whole manifold. This was a departure (and a profound extension) of the single global function per entity that was possible before Riemann.

6.1.4. Differential vector field

Last and perhaps most important, is the method initially developed by Gauss and extended by Riemann of expressing the properties of curved spaces not in terms of their spatial variables but in terms of local changes (differentials) of these very variables, or, in other words, *in terms of differences*. The whole description of a manifold can be given if so in terms of assigning to each point in the curved space a vector that specifies the direction and amount of the greatest change at that point. This vector expresses everything which is significant about the point; it is computed locally from the specific relations of differences between the point and all other points in its immediate neighborhood. The whole shape of the manifold is therefore determinable by a field of *intrinsic local differences* (vector field) that expresses the *tendencies* of the shape (curvature) at any given point.

Each vector in the vector field is in fact *a relation between differences.* Consider two variables X and Y: a relation such as Y=f(X) relates a determination of a certain Y to the determination of certain X, where X is determined independently of anything else. Consider alternatively a relation of the kind dy/dx: this relation relates differences in a manner which determines neither X nor Y[7]. Even dx and dy which are differences do not have an independent specification or an independent identity. The only determination is of the relation dy/dx. *This relation is symmetrical, determining dx and dy reciprocally while allowing no independent determination neither of dx nor of dy*. This differential, reciprocally determining relation can of course be extended to any number of differential elements; each being an intrinsic difference corresponding to a specific dimension of the state space. It is important to note that in this manner of reciprocal determination of differences *no final value and therefore no complete identity are brought forth* (Deleuze, 1994, pp. 170-176).

6.1.5. Multiplicities in system theoretic perspective

The combination of the above concepts provides the necessary ground needed to understand the concept multiplicity from a system theoretic perspective: *A multiplicity is an abstract topography of change underlying the dynamics of actual phenomena.* This is

[7] Conventionally the differential dx is derived from X and therefore secondary to it. In Deleuze's analysis of the philosophical meaning of calculus, the differential dx is primary in the ontological sense. The differential dx corresponds to the kind of difference described in the previous section.

a deceptively simple definition to a profound revolutionary concept. Multiplicity is not a mere mathematical representation or an idea *about* material reality; neither it is external to material reality in the sense that it is conceived in the mind of a thinking observing agent. The generic characteristics of state space topographies do expose, according to Deleuze, a deep structure of existence. Generic topological structures express a pure dynamism immanent in all actual phenomena but independent of any specific actual realization. It is not entirely clear whether Deleuze was familiar with the developments of dynamic systems theory, especially the work of Poincare, however, his construction of the virtual as a dynamic immanent dimension of reality clearly resonate with the mathematical and philosophical insights achieved by dynamic systems research.

It is very important to note that the concepts of manifold and the differential vector field are instrumental to the Deleuzian program in showing how geometrical representations of dynamic systems may indeed reflect ontological elements. Without these conceptual breakthroughs there would be no convincing ground to argue that the structures arising from state space representation of dynamic phenomena indeed reflect an underlying ontological dimension which is a. Immanent to actual phenomena, b. Constituted from pure differences and thus encode structure without identity and c. Independent from transcendent concepts and observing agents external to it. These are briefly discussed in the following subsections.

6.1.6. Multiplicities are immanent in actual phenomena

Multiplicities are manifolds in the sense they are structural elements that need no external reference system and no external determination (description) for their specification. Whatever is specified in multiplicity is specified only in terms intrinsic to it: the number of its intrinsic variables[8] (dimensionality) and the reciprocally determined relations between the differential elements associated with these variables.

Additional critical point must be noted in Deleuze's careful construction: There is no stand alone pure virtuality and multiplicities do not have a disembodied existence of the kind that Platonic ideas have. There is always a necessary correspondence principle between multiplicities and their actual manifestations. Every multiplicity must have a variety of actual manifestations as Deleuze writes: "A multiple ideal connection, a differential relation, must be actualized in diverse spatiotemporal relationships, at the same time as its elements are actually incarnated in a variety of terms and forms." (Deleuze, 1994, p. 183). In fact, the structural features of multiplicities are only implied from observing actual phenomena. We only can conceive the effects of change not change itself.

Multiplicities are therefore necessarily immanent in material existence and their structure is intrinsic. No transcendental element is needed for their specification, neither an externally imposed frame of reference nor an external observing agent. By

[8] These variables are just differentiated elements of pure change. There is no indication in multiplicity as to what they stand for.

this very fact, the construction of multiplicity satisfies the first point of Deleuze's ontological program.

6.1.7. Multiplicities are partial identities

The name 'multiplicity' informs that this concept belongs exclusively to the 'many' without the need for any unifying element or principle. Multiplicity is an inherent diversity in itself. There is absolutely no 'one' or 'oneness' in multiplicity. Thinking about multiplicity in terms of abstract manifolds highlights an intrinsic multiple structure: there need be no externally imposed reference system and there need be no single unifying description (coordinate system). Multiplicity can be characterized solely by intrinsic dimensions and a multitude of local and independent descriptions.

Next, we have to attend to the differential relations that shape a multiplicity. Thinking of multiplicity in terms of a differential vector field highlights an expression of pure change in terms of local relations between intrinsic differentials. Multiplicity is a continuum literally weaved of reciprocally determined differences. The structure, therefore, at any point and in its entirety possesses only partial identity (determinable yet indeterminate). It is intrinsically incomplete. The elements of the multiplicity have neither sensible form nor conceptual signification, nor, therefore any assignable function (Deleuze, 1994, p. 183). Clearly, in spite of being structured, multiplicity has no anchor in fully determinable identity it is constituted solely from differences. Multiplicity thus conceived accomplishes the second point of the Deleuzian ontological program.

6.1.8. Ideas as multiplicities

One of the most significant and innovative propositions of Deleuze's ontological work is replacing the Platonic concept of pure transcendent ideas with multiplicities. Ideas as multiplicities are those structured patterns of change immanent in actual phenomena. Ideas are only conceivable as implied by the affects of their phenomenal actualization. Remarkably the place of the Cartesian thinker is rendered marginal in the existence of ideas as multiplicities. From what we already know about multiplicities, ideas as multiplicities are immanent in actual phenomena and therefore enjoy an observer independent status. Ideas need not be the ideas of someone, of a thinking agent. Every actual phenomenon has an intrinsic ideal element – it thinks itself in itself and actualization is but the incomplete manifest of this unending thought (Deleuze, 1994, p. 254). This is the core of Deleuze's realism as proposed by the third point of his ontological program (understandably there is much more to discuss here which is beyond the scope of this work).

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As differences are the elements that constitute multiplicities, multiplicities are the structural elements that constitute the virtual dimension of existence. Deleuze relates to multiplicities as 'concrete universals' and argues that they can be known by an 'ideal empiricism' (ideas are virtual phenomena) of their own which is parallel and complementary to the empiricism of the actual. In order to gain a better grasp of the nature of multiplicity, we need to further develop this 'empiricist' approach to

multiplicity. For this, two additional concepts are introduced next: singularity and assemblage.

6.2. Singularities

Multiplicities are structural elements. As already explained, structure is given locally by the reciprocally determining relations of differences. A multiplicity is first and foremost characterized by its number of dimensions that correspond to the number of state parameters in the phenomena it may correspond to, and by the reciprocally determining relations of the differential elements that correspond to each of the dimensions (expressed for example as partial differential equations). These give rise to the characteristic global structure of the multiplicity. It is very important to note that the given dimensionality and the differential relations that define a multiplicity are *solely* implicated from actual phenomena. Virtual structure is indeed immanent in the actual. Both the actual and virtual are inseparable and irreducible.

If we go back to the helpful metaphor of state space topography, we can see that the topographical structure of the state space expressing the system's dynamics is described by the distribution of mathematical singularities within the state space[9]. These singular points and curves also called attractors are locations of convergence that *express the general tendencies* already apparent in the vector field mentioned above (see for example Figs 1-2). It is extremely important to note the conceptual difference between trajectories in the phase space that are continuous successions of actual states of a system and the tendencies of the differential vector field that are made apparent by the distribution of singularities. Contrary to trajectories, the vector field embodies information about *unrealized* tendencies of the system. These tendencies have no actuality, not even potential actuality, whatsoever (DeLanda, 2005, p. 31). They only express manners of pure change and possess therefore only partial identity[10]. Such is the reality of the virtual: the distribution of singularities describes a distinct and rigorous topography of change while being entirely obscure[11] in the sense that it is the hidden dimension underneath the actual but by which the actual becomes what it is!

Deleuze's philosophical understanding of singularities is unorthodox compared to the relatively simple mathematical meaning of singularities[12]. For him singularities and their distribution are conceptual tools constructed to understand a deeper aspect of reality. Deleuze is very pragmatic in his approach however. He divides the structure of

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[9] This proposition is extended later.

[10] The fact that trajectories are computed by performing mathematical integration over the vector field can be deceiving. There is a deep philosophical significance to this integration. It is part of the individuating process that must be carried out to actualize anything.

[11] For Deleuze multiplicities are distinct but obscure. While becoming actual phenomena they undergo a philosophical phase transition and become clear (observable, not hidden, given to representation) yet confused because what is apparent in actuality is clear but never express to the fullest the hidden pattern that connects each manifest to the whole of the virtual plane (Deleuze, 1994, pp. 213-214), (DeLanda, 2005, p. 16).

[12] In most cases it is impossible to compute the distribution of singularities. Such computation is achievable only in extremely simplified cases. But having even a qualitative partial knowledge of such distribution may already contribute much to the understanding of a complex system.

multiplicity to regions of ordinary points and significant points. Significant points are all singularities. These are the points that impart structure on their state space neighborhood. These are attractors, bifurcation points, saddles, ridges separating between basins of convergence or divergence etc. Singularities are what is *interesting* about the multiplicity, their distribution fully characterize it. Ordinary points are points of monotonous change that fill the gaps between singular points. In a manner of speaking ordinary points are governed by the singularities in their vicinity. Nothing is interesting about them beside the fact that they may eventually appear on an actual trajectory. The distribution of singularities if so is the major object of observation when it comes to the empiricism of the virtual dimension. In Deleuze's jargon each singularity is an event. Not a temporal event, but an ideal a-temporal event - a turn of destiny in the process of becoming. For example, the point of zero degrees Celsius for water is an event. Whether water turns from solid to liquid or from liquid to solid, something significant is always happening at the point of zero degrees. Each of the sides of the zero point can be both a future and a past in different actualizations.

Two more comments are in place: The virtual space shaped by the distribution of singularities is not a metric space but rather a topological space. Changes in the relative locations of singularities do not qualitatively affect the dynamic patterns of any actual phenomenon as long as the multiplicity undergoes only topologically equivalent transformations. Clearly, topologically equivalent multiplicities produce topologically equivalent trajectories and such trajectories correspond in turn to actual patterns that can differ only quantitatively but not qualitatively. The structure of multiplicities is given if so in topological terms and can therefore be described as fluid in nature. Remarkably, the topological character is coherent with the understanding of difference as a non metric or rather proto-metric element. As mentioned before, virtual series differences are ordinal. In all cases when certain parametric perturbations may alter the structure of the multiplicity into topologically equivalent configurations the multiplicity is still considered structurally stable (DeLanda, 2005, p. 32).

The second comment has to do with the more difficult aspect of structural instability, the one that involves, among other structural transitions, bifurcations. A bifurcation can be understood as a deformation of one vector field into another topologically nonequivalent one (DeLanda, 2005, p. 32). A bifurcation unfolds embedded levels of the multiplicity (Fig 3). This is why in a multiplicity not all the levels are given at once. Certain domains of a multiplicity may become accessible only when a process of becoming has already selected certain trajectories that lead into a bifurcation that unfold in turn further embedded levels. Indefinitely many bifurcations may take place in a sequence along a trajectory having a profound complicating effect on the structure of multiplicity. Different levels of such a multiplicity cannot belong to the same moment in time because they necessarily unfold in a sequence of moments. It can be said that in such a case the process of becoming brings about time itself (DeLanda, 2005, p. 107).

This is where DeLanda's definition of a multiplicity is the clearest: "A multiplicity is a nested set of vector fields related to each other by symmetry breaking bifurcations, together with the distributions of attractors *(singularities)* which define each of its embedded levels." (DeLanda, 2005, p. 32)

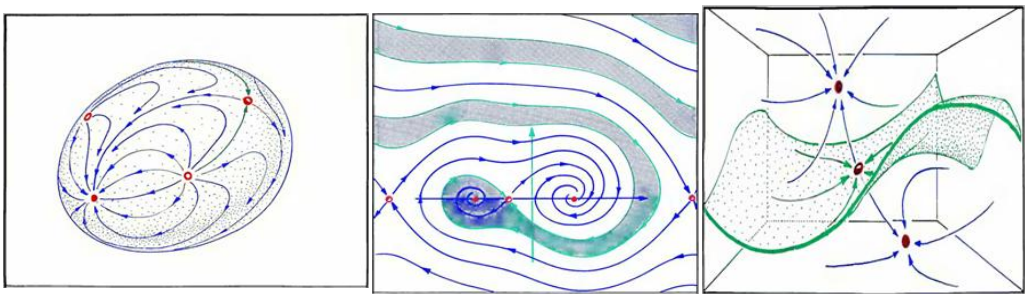

Figure 1: Distribution of point singularities over a 2 dimensional surface (left and middle) and a 3 dimensional surface (right).

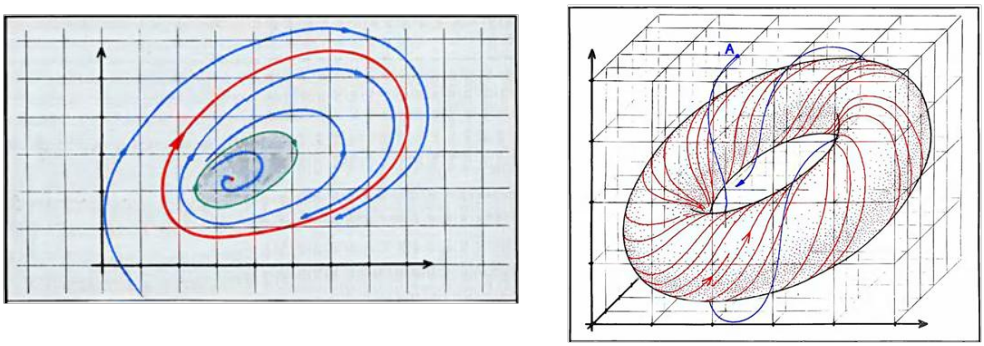

Figure 2: Left: Curve singularities (limit cycles) in Red (attractor) and green (repulsor); Right: a torus shaped surface singularity (trajectories converge into torus).

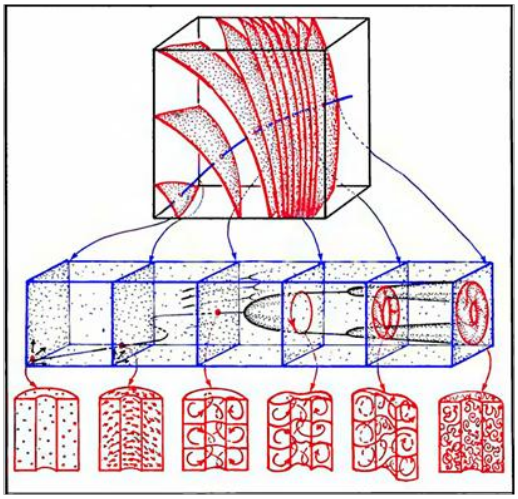

Figure 3: A sequence of bifurcations in the formation of a turbulent fluid. Each point on the blue curve above corresponds to a space of vector fields (the rectangular in the middle). Every point in the rectangular represents a vector field of the system. All vector fields on the same plane share the same global properties depicted on the diagram below. Each bifurcation opens multiple nested vector fields. A multiplicity with bifurcation points is necessarily structurally unstable.

<u>Illustrations of kinds of singularities:</u> *The Singularities are structural features and do not correspond to a particular physical manifest. The fluid system in Fig 3 is given for illustrative clarity only. Figures 1-3, Image credits:* (Abraham & Shaw, 1992).

To conclude, here is quote describing a singularity in Deleuze's poetic expression. It is important because it restores, at least in part, a metaphysical sense being somewhat lost in the systemic description developed here: "What is an ideal event? It is a singularity – or rather a set of singularities or of singular points characterizing a mathematical curve, a physical state of affairs, a psychological and moral person. Singularities are turning points and points of inflection; bottlenecks, knots, foyers, and centers; points of fusion, condensation and boiling; points of tears and joy, sickness and health, hope and anxiety, 'sensitive points' . . . [Yet, a singularity] is essentially pre-individual, non-personal, and a-conceptual. It is quite indifferent to the individual and the collective, the personal and the impersonal, the particular and the general – and to their oppositions. Singularity is neutral." (Deleuze, 1990, p. 52)

6.3. Assemblages

To complete the picture of the virtual dimension of reality, we still need to account how multiplicities mesh together to create the virtual continuum, what was already termed before as the plane of immanence. By now it is already clear that the plane is not a plane in the simple geometrical sense. It is rather a vast interconnected mesh of all multiplicities with varying number of dimensions that span an inexhaustible variety of structural configurations with no unifying principle. The plane is the ultimate manifold – the underlying virtual dimension of the whole of existence.

The way multiplicities mesh is by forming assemblages. The concept of assemblage comes to describe the inherent capacity of multiplicities to affect and be affected by each other. The abstract mechanism at the basis of assemblages is the relating of two series of differences[13] on the virtual plane through a third series which is a series of differences of differences, or, second order difference[14]. An assemblage between multiplicities is formed quite simply when a series of differences belonging to one multiplicity is connected with a series of differences belonging to another multiplicity via a third series of second order differences that expresses certain non-random correspondence properties (Deleuze, 1994, pp. 117-118). When this relation of correspondence or resonance is present, the two multiplicities are said to communicate. It is important to note here that while mathematically any two series can be related by a third difference series, not any such relation is communication. There is no way to predict what joint tendencies (and their corresponding actualizations) might arise when two or more multiplicities form an assemblage via a number of series of differences. These joint tendencies emerge as multiplicities affect each other through corresponding or mutually entrained differences. In their potential, not yet actualized virtual state, these joint tendencies are called capacities (and in some places affordances). Capacities

[13] A series of differences is a collection of consecutive differences that embodies a partial identity. A dimensional variable of a multiplicity or a mathematical combination of such variables can be expressed as a series of differences that reflect (or implied by) a certain type of behavior in the dynamics of actual systems associated with the said multiplicity.

[14] Higher order differences represent the inherent 'depth' of the virtual dimension because they embody even less identity compared to the lower order differences they relate.

as such, complement the distribution of singularities in characterizing the structure of multiplicities[15].

In the actual dimension, an individual (an individuated phenomenon) may be characterized by a fixed number of properties and yet possess an indefinite number of *capacities to affect and be affected* through interactions with other individuals. The degree of openness of this set of potential interactions will vary from individual to individual (DeLanda, 2005, p. 62). If every individual is an actualization of a virtual multiplicity, the variety of capacities available to an individual corresponds to the number of assemblages its originating multiplicity is capable of forming with other multiplicities. This number of potential assemblages is of course indefinite.

Capacities and assemblages are important for a few reasons: theoretically they describe the manner by which the virtual continuum is being formed from distinct multiplicities. In the actual dimension assemblages give rise to emergent capacities and interactions which are a major source to unpredictable novelty. We can never have a complete knowledge of the capacities of any individuated phenomenon. The best example for a very complex assemblage is ecology. An animal may form different assemblages with the ground (digging a hole), with bushes and trees (climbing or hiding), even with ponds (diving underwater) in order to avoid a predator. Each of these activities is a capacity with a corresponding assemblage of multiplicities. Ecology, in general possesses an immense potential of novelty through the formation of such assemblages. Other, more concrete examples would be the phenomenon of symbiosis, the co-evolution of species and coordination of actions within social assemblages of organisms (Maturana & Varela, 1998). In all probability, it is assemblages (as not accurately fitting systems) that were the enabling factor for the greatest explosion of novelty in life - the emergence of multi-cellular life forms from single cells about 800,000 million years ago. Recently, against the accepted dogma that rigid structural formation of proteins through folding is necessary to proper function, it was discovered that many proteins, especially those which are involved in multiple cellular functions have significant parts that are not rigidly folded. These proteins actually form a variety of flexible assemblages (Chouard, 2011). There is no doubt that assemblages are involved in the vast novelty life produces at all scales from the intra cellular level to the whole biosphere.

In every such example novel capacities to affect and be affected emerge in the actual individuals participating in the assemblage. In a later work with Felix Guttari (Deleuze & Guttari, 2005, pp. 3-25), Deleuze introduces the powerful concept of Rhizome which is a heterogeneous assemblage. Rhizomatic systems are structures that significantly depart from the orthodox scheme of stable and well defined input/output relations. Connections are not pre-given but are produced as part of the system's dynamic.

Assemblages are serendipitous opportunistic and inexact[16]. They stand in sharp contrast to the Newtonian mechanistic view of ultimately deterministic and rigorous connections

[15] An interesting approach to assemblages can be found in (Kauffman, 1990). Kauffman's strings and random grammars can be understood in terms of differences and multiplicities.

between physical elements interacting through universal laws. The formation of assemblages does not come to argue a case against physical laws. Assemblages, on the contrary, show the immense novelty allowed by the laws of physics and the unpredictability of the phenomena they bring forth in real world situations i.e. outside the narrow class of very simplified highly controlled experiments carried out in laboratories.

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In conclusion it is worth to reflect on the conditions that allow speaking about multiplicity as having a concrete structure. The virtual, being a landscape of pure difference is of inexhaustible expression but nothing in it *presupposes* structure. Remarkably, however, not everything goes either. How come and under what conditions, if so, can we speak of the virtual as having any structure at all?

As already explained the structure of multiplicity inasmuch as such structure can be brought forth and spoken of[17] is always implied from actual phenomena. There are no multiplicities which can be otherwise structured. The specification of multiplicities as structured elements (i.e. their dimensionality, the reciprocally determining differential relations and their corresponding distributions of singularities) always derives from diverse empirical observation of the actual. This necessary derivation establishes one direction (actual -> virtual) in the profound reciprocally determining relations between the virtual and the actual dimensions of existence in Deleuze's ontology (Williams, 2003, pp. 7-13). Next, we develop the concept of becoming as the complementary direction of this reciprocity, namely, the manner by which virtual patterns guide the individuation of actual phenomena (virtual -> actual).

7. Becoming

Difference, multiplicity and the virtual plane of immanence answer the 'What?' of existence, namely, what are the ontological elements of existence. The following sections are dedicated to answer the 'How?', or, how actual existence arises as the expression of virtual patterns. Virtual patterns are a continuum of undetermined non-individual partial identities. The actual - the phenomenal aspect of existence, in contrast, is populated by clear individual identities and the distinct characteristics and qualities that define them. The process of becoming is the process by which the former are incarnated in the latter. The actual is an effect - a product of becoming. Inasmuch as the actual is sensible (given to the senses i.e. empirical) it tends to hide and cover the history of its becoming. It is like a landscape that hides the historical geological processes that shaped it. Whatever can be known about the process of becoming therefore is only implicit in actual forms.

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[16] The major source to the flexibility of assemblages is that the nature of connections among virtual differential elements is topological and not metric.

[17] Beyond multiplicities there are assemblages that still retain partial structure and beyond them there is a continuum of difference with ever diminishing structural content – an open ended 'wilderness' of pure potentiality. See also foot note 25.

In contrast to former metaphysical approaches that are based on ideal essences or categorical species as the basis to identity, Deleuze's philosophy of becoming is a philosophy of individuals. It defines the individual as a structure of relations holding between the virtual and the actual (Williams, 2003, p. 204). This is perhaps the most significant feature of Deleuze's ontology: the individual, be it a phenomenon, a quality, a concept, a person or a species is inseparable from individuation – the process of its becoming, and from its pre-individual dimension – the virtual field of immanent differences. Existence, therefore, is becoming – an ongoing creative expression of difference. The profound significance of becoming is grasped only through fully embracing the individual, its ultimate uniqueness and inherent incompleteness. Identity and resemblance do of course exist but only as superficial secondary effects while their intrinsic differences are either disregarded, or, equalized and distributed in the actual properties and qualities that disguise them (the shape of the mountain ridge disguises the intensive mechanical tensions that brought it forth).

No actual phenomenon is ever entirely determined and thus separated from the virtual. There is always more to the actual than what is observable: a hidden immanent potentiality. Even what may seem to be complete determined identities harbor underneath indeterminate multiplicity[18]. At any instance, certain determined aspects of a phenomenon can be undone due to perturbations of other, less apparent, aspects. Actual structures can lose their coherency while the underlying multiplicity gives rise to novel actualities. This is, as we'll see, an evolutionary selective process.

The philosophy of becoming is a very complex theme in Deleuze's work and the presentation given here is only introductory. Yet, the profound significance of this ontology to the science of complex systems can be captured by the following four complementary ideas/approaches each characterizing an aspect of becoming:

1. Intensive differences
2. Progressive determination (repetition, self organization)
3. Quasi-causation
4. Becoming and virtual connectionism

7.2. Intensive differences[19] (intensities)

The initial understanding of intensity and intensive differences was already given in the overview section (see pp. 9-10). Intensive differences are according to Deleuze the sufficient reason of all phenomena (Deleuze, 1994, pp. 222-223). He writes: "The reason of the sensible, the condition of that which appears, is not space and time but the Unequal in itself, disparateness as it is determined and comprised in difference of intensity, in intensity as difference." The term 'sensible' here relates to anything that can be sensed; not sensed only as in producing an impression for an observer, but in a much wider meaning of producing an effect upon something else. In other words: producing a difference not in itself but for something other than itself. My interpretation

[18] A compelling example is physical vacuum that undergoes quantum fluctuations.

[19] Intensive differences must not be confused with external phenomenal differences which distinguish between fully formed individuals and are based on representational identities.

of the sensible here is reminiscent of Bateson's definition of information as a 'difference that makes a difference'. Deleuze's philosophy of becoming attributes a whole new dimension to this understanding of information.

In very simple terms intensive differences are affective expressions of corresponding virtual pure differences. A series of pure differences may be expressed as a temperature gradient in one system, an electromagnetic gradient in another system, a difference in distribution of organisms over an ecological niche etc. These are examples of a variety of intensive differences. If various systems embed a single pattern of pure differences, the dynamic pattern guiding their becoming will be the same. However, since each system expresses a unique intensity, the actual individuated phenomenon manifested will turn to be entirely unique: the temperature intensity will, for example, drive and redistribute energy and matter of a fluid; the electromagnetic intensity will mobilize electric charges; and the unequal concentration of organisms will produce a migration. Very different phenomena arise governed by the same virtual pattern.

In the process of becoming, qualities and characteristics of actual phenomena are individuated and become distinct by the cancellation of intensive differences and the elimination of the Unequal in its distribution. Moreover, phenomenal change takes place only as an effect of cancelation of difference (Deleuze, 1994, p. 223). This abstract notion of becoming is clarified if we note that the tendency towards cancelation of difference simply reflects the presence of singularities in the virtual multiplicity. According to system dynamics, singularities are points or limit trajectories where some or all of the intrinsic components of the differential vector field become nullified, which literally means that differences are cancelled. Under the assumption of continuity, trajectories tend to diminished differential vectors in the vicinity of singularities.

Inasmuch as each trajectory is the convergence of a virtual multiplicity into a unique actual manifestation, the distinct characteristics of such manifestation correspond to a virtual singularity. The arising of distinctiveness and individuality in actual phenomenon corresponds therefore to the cancellation of differences in the neighborhood of virtual singularities. This is why the distribution of singularities is indeed the significant aspect of a multiplicity as explained before (see Fig 4 for visual example).

Deleuze is careful to affirm that there is no cancellation or equalization of differences in the virtual, only in becoming (Deleuze, 1994, p. 228). The tendency of intensive differences to cancel in the process of becoming is only an external effect. This asymptotic tendency of equalization is the mechanism by which differences bring forth identities as a secondary effect. An identity is nothing but an effect concomitant to cases where intrinsic differences are not relevant or not effective. In other words, we grasp identities not by re-cognizing in them an essential or categorical element but by selectively disregarding differences that make them unique incomparable and unqualified instances[20]. The only effect that becoming has on the virtual plane is that of

[20] To characterize something as black we must disregard indefinite number of shades and nuances and the indefinite relations these may hold in perception to shades and nuances of other colors etc…

hiding the rich heterogeneous structure of multiplicities underneath its individuated products.

In the case of non-equilibrium open systems, intensities are never cancelled or even get close enough to a state of cancellation. Such systems manifest *actual productive processes* where the process of becoming is observable (externalized). Such observable productive processes are characterized by *partially individuated* phenomena that can hardly be categorized or modeled in terms of even approximate representational identities. Turbulence and other chaotic behaviors of far from equilibrium systems are examples to such phenomena.

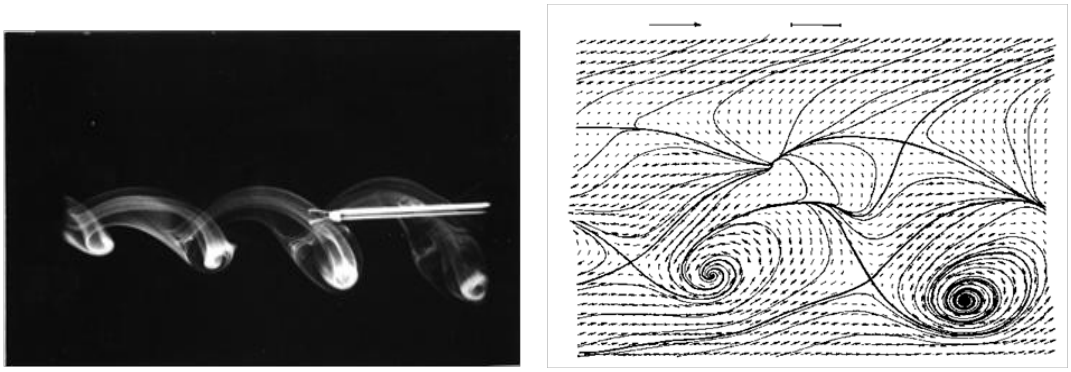

Figure 4: A smoke wake (left) illustrates an intensive process and the corresponding implied multiplicity immanent in it (right). [Images from http://www/mech.unimelb.edu.au/fluids/, Credits: (Perry & Lim, 1978), (Perry & Tan, 1984)]

7.3. Progressive Determination

Becoming is a morphogenetic process. Virtual elements become progressively determined and by that are being actualized as measurable extensive properties and qualities of distinct phenomena. In terms of the systemic understanding of multiplicities, becoming is a progressive determination of a trajectory within state space. In very simplified terms it is represented by the mathematical integration of the multiplicity's vector field resulting in actual trajectories. Philosophically, it means that becoming can be understood as a spontaneous computational process that produces information. For the majority of cases, however, besides the extremely simple systems, the computational process involved is intractable and does not yield to reductive algorithmic or procedural representations. The process is too complex and can be described mainly in qualitative terms using models based on vastly simplifying assumptions that disregard much of the inherent indeterminacy that is involved.

Scientific knowledge is based on a method of observation in which a system is put in a carefully designed experimental setup made to create more or less sterile circumstances for the system. In such circumstances, if successful, the virtual dimension of the studied phenomenon is almost entirely neutralized in that that it is forced to produce a very narrow variety of trajectories in the studied system's state space. From such trajectories inferences regarding the general dynamics of the system are made, but such inferences

are useful mostly for very simple cases. This is the only way experiments can be faithfully reproduced and reproducibility seems to be necessary for credible scientific results. This method, however, seriously limits the domain of possible scientific knowledge. In reality, irrespective to any experimental setup, multiplicities are meshed together into a continuum and their structure is affected by the opportunistic assemblages they form with other multiplicities. They can and do in fact produce a vastly larger span of phenomenal effects than what can be possibly captured by inferences from trajectories that explore only very limited territories of the virtual plane.

It is important to note that becoming is inherently complex and intractable because it is a *progressive* determination. This means that determination of trajectories does not take place all at once but in a succession of determining events. Every such event is selective in the sense that subsequent paths and events are indeterminate before the event took place (see DeLanda's definition of multiplicity P. 20).

The first level of determination in the process of becoming is the individuating field. At this level, virtual differences are incarnated as intensive differences; that is a pattern of difference expresses a sensible effect. The sense - the difference that is made (following Bateson) implies (the structure of) the virtual dimension immanent in it and sets the individuating context, for example: a meteorological pressure system, imbalance of prices in a stock market, new specie within an ecological niche etc. A multiplicity will produce entirely different kinds of phenomena in different intensive setups that incarnate it.

The individuating context also includes the determination of the assemblages involved: These assemblages bring forth capacities of affection and interaction which are not determined by the structure of a single multiplicity. For example: the assemblage a human anatomy creates with the ground selects capacities such as walking, running, crawling or just sitting or laying. These are entirely different from capacities such as swimming or diving selected by an assemblage a human anatomy creates with water[21]. The intensive setup plus the assemblages involved, together determine the field of individuating activities within which further determinations of a multiplicity are to take place.

Subsequent determining events driven by intensive differences take place within the individuating field. As already mentioned, not everything is determined at once and therefore becoming, though it is a process that follows necessary lawful determinations at any given instance, is inherently non-deterministic; its outcome cannot be predicted in the general case[22]. That is why becoming is both productive and creative: every trajectory is a novel actual expression of a virtual multiplicity.

The trajectory forming determining events are of two major categories. The first category includes transition and bifurcation events. Transitions and bifurcations are

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[21] These assemblages imply of course the meshing of multiplicities at the virtual dimension.

[22] Additionally, certain events can introduce new intensities and involve new assemblages and by that dynamically modify the individuating field (a man runs into the water and starts swimming).

usually associated with the presence of critical differences; they are best understood in terms of the underlying structure of multiplicities. It was already mentioned that multiplicities are topological structures rather than metric. This means that distributions of singularities that are symmetric under topological transformations such as bending, stretching and deforming are considered equivalent and therefore constitute a single multiplicity. A transition event is an event where the structure defined by the distribution of singularities undergoes a phase transition into another, topologically *nonequivalent,* distribution of singularities. A bifurcation event is where nested multiple layers of the multiplicity's vector field are exposed and the system 'selects'[23] which branch of the bifurcation it will follow. Every such branch is characterized by a unique distribution of singularities and the selection determines which sets of trajectories become further accessible to the subsequent process and which are eliminated from the current instance of actuation. Bifurcations are cases of symmetry breaking in regard to the structure of the multiplicity and the patterns of becoming immanent in it. (DeLanda, 2005, pp. 18-20) The branches coming out of a bifurcation are distinct from each other and the selection of a single branch makes the whole system less symmetric than it was before. In a cascade of bifurcations, each selection makes the system more specific as the shape of trajectories is progressively determined.

Remarkably, transitions and bifurcation events are symmetrical in the sense that a process can progress through such points in both directions. Specifically, in bifurcation, the system can progress from the branched side to the unified side, which means from a more determined state to a less determined and more symmetric state. Such transitions have a special place in Deleuze's philosophy and are called 'lines of flight' (DeLanda, 2005, p. 225). These are trajectories by which a system escapes a highly individuated state into a less identified and more fluid state (i.e. away from an actual manifest and closer to the virtual plane). Such escape processes which designate disintegration of order and identity are part of the process of becoming as well and are called in some places counter-actualization processes.

The second category of determining events is the development of an actual trajectory within a specific layer of the multiplicity. Such processes lead either to subsequent bifurcations or into one of the basins of convergence that are shaped by the distribution of singularities. Settling into a basin of convergence is associated, as already mentioned, with reduction in the degrees of freedom of the system (self organization) and with the cancellation of (at least some of) the intensities that drive the process. The actual product in such cases is a characteristic asymptotic stable state of the system, or alternatively, any conceivable pattern of repeating periodic or quasi-periodic behavior.

In cases of non equilibrium systems, there is no such convergence and there is no cancellation of intensities. Such systems usually go through an indefinite series of bifurcation events that usually manifest as chaotic phenomena. Chaotic phenomena express an inherent structural instability of the virtual multiplicity immanent in it. In

[23] 'Select' is only partially appropriate here because there is no selective criterion involved. This is rather an intractable chance event.

other, even less structured cases, the trajectories are not chaotic but are driven in and out of the given basins of convergence and would settle neither on steady state nor on periodic behavior displaying irregular complex trajectories.

The progressive determination of trajectories guided by multiplicities and driven by intensities is what becoming is all about. Besides a very small class of systems in very strict and temporary circumstances the trajectories are developing indefinitely and always include an unpredictable aspect which is no other than the yet unexplored territories of the virtual multiplicity. Since assemblages, being part of a greater individuating field and a greater expanse of the virtual plane, are themselves dynamic, a change in active assemblages may always perturb the system enough to leave its current trajectory and embark on another, or alternatively reach a transition point, bifurcate etc.

7.4. Quasi-causation

The process of becoming cannot be understood in terms of chains of causes and effects like those characterizing actual processes. The dynamic relations holding between the virtual and the actual and bring forth the individual are said to be intensive and expressive but never causative per se. Virtual patterns *guide the becoming* of actual phenomena; *they do not cause* actual phenomena. There are a few reasons for this profound observation that invites a further investigation of the unique nature of becoming.

The first reason is that cause-effect relations are based on identities. In order to establish a cause-effect relation, both the cause and the effect must have clear and distinct identities. On the virtual plane and in the process of becoming, partial identities are involved that simply do not have clear and distinct identities. These are elements in the course of determination which in principle is never complete. Clearly, such elements do not fall under what we may normally consider as proper causes or effects. It can be said that insofar as partial identities are considered, causes and effects are meshed in such manner that they cannot be distinguished. This state of affairs is very well known in complex systems with high interconnectivity and interactivity among components such as organic neural networks. The dynamics of such systems often presents distinct behaviors that cannot be reduced or associated with distinct chains of causes and effects. According to the philosophy of becoming, this irreducibility is not merely empirical but rather ontological. Partial identities are real elements, and the becoming of actual phenomena is therefore not causal in the strict sense. When it comes to becoming, an alternative to causative explanations is needed.

From a different perspective, while the actual is populated by distinct elements that may hold proper causative relations between them, the virtual plane is populated by multiplicities that are causally sterile; they cannot cause anything to happen and nothing in them is an effect. The reason multiplicities are causatively sterile is because they are pure forms independent of any particular mechanism. Each multiplicity can be actualized by an indefinite number of diverse systems of intensive elements which cannot possibly share any causative resemblance to each other. Yet, in each particular case it is the virtual pattern that governs the becoming of actual effects and forms. The

virtual is always precedent to the actual. This is not a temporal or causative precedence but rather the precedence of difference to identity and of the non determinate to the determinate. The problem that becomes apparent here is how distinct actual effects develop from virtual causally sterile differences? If the virtual lacks any affective powers whatsoever, there is a doubt whether it is anything more than a mere abstract model.

A third and even more subtle and difficult aspect of the same problem is to explain how virtual multiplicities affect each other. As was already mentioned (see p. 22) multiplicities communicate through two or more series of difference that correlate or resonate via a third series of differences of differences. Intuitively, such mediating series must embody a certain correlating or invariance relation between the two series. Such invariance would imply however an identity that underlies the interaction. In relation to this Deleuze writes: “The most important difficulty, however, remains: is it really difference which relates different to different in these intensive systems? Does the difference between differences relate difference to itself without any other intermediary? When we speak of communication between heterogeneous systems, of coupling and resonance, does this not imply a minimum of resemblance between the series, and an identity in the agent which brings about the communication? Would not 'too much' difference between the series render any such operation impossible?” (Deleuze, 1994, pp. 119-120). Deleuze is careful not to reintroduce identity in the back door into his ontological construction of the virtual and by that jeopardize his whole project. His attempt culminates in developing a new concept that will resolve the apparent problems. This is the concept of quasi-causation.

It is beyond the scope of this work to follow in detail the intricate development of the concept (see for example: (Deleuze, 1994, pp. 117-120)), but a few highlights are in place, again, for their significance to systemic thinking. Quasi-causation must embody a mechanism of affection without the presumption of identity neither of the affecting nor in the affected elements and most importantly not in the relation between them. Interestingly, Deleuze does not propose a philosophical principle that will replace causation in the case of incomplete identities. On the contrary, he offers a variety of mechanisms: “…As we shall see, given the variety among systems, this role [of quasi-causation] is fulfilled by quite diverse determinations. The question is to know in any given case how the precursor [the quasi-causative operator] fulfils this role”. In simple terms, influences from one series of differences to another are themselves products of individuation. Causation as we come to know it in actuality is therefore an individuated product of becoming; it is not a manifest of a pre given principle. Remarkably, this would mean that even actual cause-effect relations cannot be considered invariant. They are subject to variations since they too have a virtual aspect.

A quasi-causal operator, no matter its particular system dependent implementation facilitates a transfer of information from one series of differences to another via a second order series of differences. Following the definition of intensity given above, every (second order) mediating series can be considered as an intensive difference that (in this case) mobilizes information. The quasi-causal operator is if so an intensity that mobilizes information. As such, it can be understood as a (symmetrical) communication channel (DeLanda, 2005, pp. 76-77), (Deleuze, 1994, p. 120). In the mathematical sense

which is of help here, a communication channel has nothing to do with the signs being communicated, it sets however reciprocally determined probabilities between the communicating variables (in this case series of differences). This is a description that implies of course an underlying multiplicity[24].

What this comes down to is that the effect of mobilization of information between series of differences can facilitate quasi-causal relations at all levels of becoming and such facilitation is consistent with the primary ontological status of virtual differences: identity remains an effect, a product of individuation and not a pre-condition. Additionally, this association of quasi-causation and information channels opens a research avenue towards the possible construction of models and simulation of the process of becoming.

7.5. Becoming and virtual connectionism

Dynamic connectionist models occupy an important if not central place in understanding complexity (Ciliers, 1998). It is worth to explore in brief how Deleuzian ontology and the process of becoming may be described in connectionist concepts.

The virtual plane being a continuum of pure differences is a vast multiplicity where everything can be said to be interconnected. This is however not the case of distinct elements being distinctively connected as one imagines a network but rather the case of virtual elements that are never entirely distinct from each other[25].

It is consistent with a Deleuzian view of existence, to describe the state of affairs of existence at any instance as follows: The actual dimension is the sum total of all virtual connections that become explicit at that instance, while the virtual depth underlying the actual is the rest of the connections which though virtually existing with more or less distinctiveness are hidden and only implicit.

The dynamism of becoming is such that from instance to instance certain connections that were hidden become (more) explicit constituting distinct identities (thus sensible), while other connections that were distinct become less so - more implicit, diminishingly distinct and eventually disappear into indistinctiveness. This dynamic relation between the actual and the virtual is such that while the virtual dimension provides the creative potential (what connections are available and at what level of determination and distinctiveness), the actual dimension of existence is the selective element in the dynamism of becoming (determining what connections may become more or less

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[24] The communication of the series is an effect of a determination of trajectory in the multiplicity that underlies the mediating series.

[25] The concept of unilateral determination of differences is particularly powerful in that that it allows the virtual plane to include *all potential connections* but in various degrees of distinctiveness. The continuum of distinctiveness never falls into the ultimate static condition of 'containing all possibilities': Distinct features (connections) can differentiate from an indistinct ground while they can also disappear into a featureless ground. The profound meaning of difference is exactly this: a metaphysically dynamic and creative existence.

explicit). Virtual multiplicities guide the determination of trajectories in the course of becoming; the structure of multiplicity specifies the options for relations among differences to become more or less determined (in the vicinity of singularities, for example, they generally become more determined). Yet, as already explained, the structure of virtual multiplicities is implied from actual phenomena. This is how actual phenomena through the mediation of multiplicities are selective in the process of becoming.

The significance of this perspective besides being conversant with already established approaches to complexity is that it alludes to a powerful metaphysical evolutionary principle. Deleuze develops this idea in his brilliant interpretation of Nietzsche's concept of eternal return (Deleuze, 1994, pp. 297-301).

8. Complexity and the philosophy of becoming

The holy grail of classical science was always to come up with one elegant simple theory that will account for all phenomena. Unity and simplicity in unity were and still are the landmarks of scientific understanding in most fields. The power of a theory is measured by the variety of phenomena it is capable to subordinate under the same principle (i.e. the one identity). Such landmarks that guide scientific endeavors are grounded in the Platonist and Aristotelian systems of thought that offer identity, immutable essences, and transcendent laws as first principles. These principles also allude to a deeply rooted belief in a single creator or creative principle which is *outside* creation and also to a single unified observer, always located *outside* the scene of observed happening. They certainly resonate with man's dream of having complete knowledge and consequently complete control over nature.

The discovery and investigation of complex phenomena dealt a shattering blow to the worldview sustained by these principles. It is quite clear by today that most phenomena, with very few exceptions indeed, can hardly be tamed by this philosophical paradigm and the science it engenders. In this sense the emerging science of complexity is far from being just another field of scientific research; it is rather a paradigmatic shift in scientific thought and the philosophical principles that underlie it. The significance of complex phenomena is not in the general and universal principles that bring it forth but rather in the heterogeneous and unpredictable expressions of these principles. It is not the unity and uniformity which is interesting in complexity it is uniqueness, variety and the manner individual phenomena emerges. In this context it is easy to see how the philosophy of becoming provides for the science of complexity the ontological foundation it is missing.

System theory – the major conceptual tool of tackling with complexity, was developed within the ecology of thought of the 20th century where ontology and its importance to the foundation of science were of little interest if not totally rejected by most prominent

philosophers (Carnap, 1996)[26]. The theory was developed therefore as a tool of abstraction – a representational system that abstracts away physical matter and shifts emphasize from the study of phenomena towards studying idealizations of phenomena. Models are created to resemble the behavior of physical systems and their success is measured in terms of resemblance and identity. The differences between the model and the real system are considered only as disturbing the established similarity; as such they need to be either eliminated by refining the model or disregarded as unimportant. The exclusion of difference is not a mere technicality, it is paradigmatic and in full conformity with the Greek philosophical roots underlying classical Newtonian science. The attempts to establish an independent philosophical ground to system theory mostly culminated with extreme relativism and constructivist theories (Heylighen & Joslyn, 1992) (Maturana, 1988) that only reinforced the abstract idealistic nature of the theory.

It is in the light of this that the significance of Deleuze's philosophy of becoming is clearly apparent in *providing ontological grounding* to system theory and the investigation of complex phenomena. It provides a coherent and plausible path towards a realist holistic worldview; one that accommodates difference, variety, heterogeneity and process of change at the ontological level. This new kind of realism brings both the creative process and the observer back into existence. Embracing the philosophy of becoming, we rediscover the *idea* as a creative element immanent in matter and not as the transcendental immutable element it is according to classical philosophy. Ideas, according to Deleuze, are multiplicities[27]. We discover the *idea* as multiplicity in its inexhaustible manners of actual expression in our perceptions and thoughts. Thought[28] emerges through diverse interactions with actual phenomena and not by a presupposed privileged and unified observer by means of a privileged access to a divine mind or a plane of pure ideal essences. Moreover, distinct concepts are individuated products of ideas. While ideas (as multiplicities) are dynamically shaped by actual phenomena, concepts are actual expressions of ideas through becoming. However, with ideas being their virtual aspect, concepts are never complete final products.

The abstract concept of system as structure independent of specific implementation is not eliminated but radically transformed into the concept of multiplicity. Its externally imposed structural rigidity (as described in the 2nd section) is eliminated and it gains instead a much needed ontological status that accounts not only for the lawful behavior of actual phenomena but also for their inherent heterogeneity, incompleteness and unpredictable creative potential, all of which are characteristic of complexity. System theory, thus grounded in the virtual, will then be *presenting* existence instead of dealing with *representations* of existence. This is the core value of the paradigm shift spelled by the philosophy of becoming.

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[26] Carnap and the Vienna Circle that operated in the 1920's had a tremendous influence on the scientific paradigm during the 20th century.

[27] This has many profound philosophical implications that are not discussed here.

[28] This involves of course a profound critique on the famous 'Cogito' with implications on the nature of 'self' and 'I': the thinker is individuated in thought always fragmented and incomplete.

It is clear that Deleuze's work thus abridged is a valuable contribution to the foundations and philosophy of system theory and scientific thinking. An objection that is often raised against this case is that Deleuze's work is obscure and basically anti-scientific. While the focus of science should be on explicating things and bring to light the hidden principles that govern the world of phenomena, Deleuze's ontology makes the case for a dimension of existence which is intrinsically hidden and implicit. The virtual cannot be explicated and cannot be brought to the light of understanding, processes of becoming which drive the individuation of phenomena will always have an obscure aspect. Such approach cannot possibly support and benefit scientific thought. This objection fails to grasp the most fundamental thrust of Deleuze's work: the replacing of identity with difference as the primary ontological element. The Platonist and Aristotelian ontologies were constructed under the presumption that the elements of existence or at least a more or less faithful copy of them can be *entirely* grasped by the intellect. This presumption secures the primacy of representation and reductionism as vehicles of scientific thought: it is possible to understand the world of phenomena in terms of representations of its elementary constituents. Deleuze's ontology of difference is not anti-scientific in claiming that the ontological elements of existence are ungraspable differences. It does expose however the unwarranted presumption at the basis of scientific thinking and therefore the serious limitations of representation and reductionist methods. By that it convincingly suggests the need to reform and expand the foundations of science. Science as a paradigm is also the product of becoming- there must be more to it.

The fields of research that might be most impacted by introducing the concepts outlined here are obviously those were the failure of representation and reductionist methodology are most apparent. Also, the kinds of complexity in systems/processes that produce novelty are highly interesting candidates for application. These include dynamic and highly connected complex systems that are difficult to model such as evolutionary processes, developmental processes, cognition, economic and social systems, quantum computing and many others. It remains for further research to find out whether the application of the philosophy of becoming to these fields will indeed yield new insights and novel methods of research.

Finally, in the context of how systemic thinking applies to human affairs, a short remark on the ethical aspect is in place: realism, individuality and process, the metaphysical watermarks of this philosophy, carry with them profound ethical implications that diverge significantly from mainstream thinking. In the fast changing complex world we live in with the acute problems and the far reaching opportunities it presents, the philosophy of becoming rephrases the perennial question of how one should live into another one: how one might live? (May, 2005, pp. 1-25) In that, it highlights an experimental and open-ended approach as a cure for dogmatic fixation in thought and action.

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