AN ANALOGY OF CHAOTIC SYSTEM AND ORGANIZATIONAL SOCIOGRAM

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ABSTRACT

Potential applicability of Chaos theory to social science, particularly to human relations, is still debatable at this time. However, there is a roadmap that leads to the connection of human relations and Chaos theory. The resemblance of human relations, specifically the social connection (or social network) of people inside an organization, to a Chaotic system inspired this exploration.

Thinking that social network inside an organization is simple and linear is an undervaluing of the organization as a whole. Concepts of Chaos theory, such as co-evolution, equilibrium, perturbance, emergence, fractals, attractors and self-organization, are applied metaphorically to explore the complexity of the features of a social network. The construction of sociogram, as a visual representation of the organizational social network, is the prerequisite to the exploration. A hypothetical case about succession planning is built to illustrate the ideas presented in the paper.

Illustrations are shown that learnings from the field of Chaos theory can be applied to analyze the complexity of the organizational social network. An example is that interactions inside the organization can be sensitive to 'initial conditions' (such as the resignation of a clerk might affect the whole organization). Accordingly, examining the dynamism of social networks would be a best practice to organizations (especially to business organizations), since many issues in human relations are complex in nature.

Keywords: social network analysis (SNA), organizational network analysis (ONA), organizational behavior, chaos theory, complexity, interpretive research

INTRODUCTION

Organizations cannot be modeled by just using linear relations such as $y=ax+b$, where a and b are constants. Outputs are not always directly or inversely proportional to the inputs. Organizations are complex entities with many human members (actors) interacting in *nonlinear* manner. Organizations, such as business organizations, are examples of *Dynamical Systems* that continuously evolve through time. This is why organizational and business models commonly use *Complexity theory* as an extension of *Systems theory*. For this reason, applying concepts of *Chaos theory*, as a field under Complexity theory, could possibly help organizations in understanding the behavior of its members and of itself.

The usual word "chaos" defined in the English vocabulary and the word "*Chaos*" (with a capital "C") used in Chaos theory have different meanings (James 1995, as cited in Durham, 1997). The characteristics of a Chaotic system can be summarized as deterministic or non-random, nonlinear, aperiodic, sensitive to initial conditions, has structure in phase space, and bounded (these concepts are discussed later in the paper). As opposed to the Newtonian concept of *determinism* ("a deterministic system is predictable"), Chaotic system, even though deterministic, is generally not clearly predictable (Stanford Encyclopedia of Philosophy, 2003, 2008).

Chaos theory is commonly used in physics, chemistry and biology. There are also researches in finance and industrial engineering that utilize the concepts of Chaos theory,

such as those of Investment Analytics (n.d.), Tan (1999) and Wilding (1998). Some concepts of Chaos theory can also be applied in business management (Rensburg, n.d.), academe (Davis, Smith, & Leflore, 2008), military (Durham, 1997) (Crane, 2007) and sports (Mack, Huddleston, Dutler, & Mintah, n.d.).

Why an analogy? A Metaphorical Point of View

Using *metaphors* in organizational/business theories is a classic habit. In Gareth Morgan's book, this simple premise describes the art of "reading" and understanding organizations:

> *…that all theories of organization and management are based on implicit images or metaphors that lead us to see, understand, and manage organizations in distinctive yet partial ways....The use of metaphor implies a way of thinking and a way of seeing that pervade how we understand our world generally.* (Morgan, 2006)

Metaphors help create an environment for creative interpretation, discussion and development of ideas using an established concept (in this case, Chaos Theory). Some well known metaphors are: organizations are like ships, machines and organisms (McCrimmon, n.d.). Some relate organizational management to a river, chess game, and hunting in a forest (Knapp, 2000). Even Kim and Mauborgne (2005), in their famous marketing book Blue Ocean Strategy, borrow metaphorical ideas – the blue ocean and the red ocean.

Another reason for using an analogy in this exploration is that directly using Chaos theory in social sciences is still debatable. Recognizing if a system is Chaotic or not, using the mathematical definition of Chaos, is not a simple task. There are assumptions that need to be met before a system can be called Chaotic. A Chaotic system needs to be deterministic; but it is still controversial if human free-will is deterministic or stochastic/probabilistic (Durham, 1997). As such, social interactions are not yet proven to be in Chaos. Also, existing methods or models under Chaos theory, such as determining the Lyapunov exponents and fractal dimensions, were developed for highly idealized conditions, such as:

- systems of no more than two or three variables;
- very big datasets (typically thousands or millions of observations);
- very high accuracy in data measurements; and
- data having negligible amount of noise. (Williams, 1997)

It should also be noted that, even though all Chaotic systems are complex, not all complex systems are Chaotic.

Nonetheless, the restrictions stated above did not stop this exploration in using the ideas from Chaos theory to be applied in organizational social network analysis. There are numerous ideas that an organization can learn from Chaotic systems, and these wisdom could not wait for the perfection of the compatibility of social science and Chaos theory. There would be losses in not considering organizations as Chaotic, since there are many managerial implications that can be derived from Chaotic systems. It is like comparing the organization to "nature", which is really Chaotic. Equivalently, it is the same as what some did in comparing marketing strategies to military war, even though market dynamics are not true military war. To consider or not to consider the use of the concepts discussed in this paper lies in the decision makers of the organization.

THE EXPLORATION

This exploration specifically aims to metaphorically and subjectively relate the concepts of qualitative Chaos theory to organizational social network analysis (or simply *organizational network analysis*). This exploration hopes that organizations will learn from the metaphors by incorporating such to their *strategic planning exercises*. The ideas generated can be used as additional tools in attaining *organizational/business intelligence* towards a sustainable development. According to a study, the existence of Chaos and complexity depends on the number of employees (Dietz, 2005); but this does not hinder small organizations in using the ideas discussed in this exploration. In fact, a small organization can inhibit a complex nature due to the complexity of the behavior of its members.

The exploration focuses on the social network (interaction among the members) inside an organization, particularly inside a business organization. The method of social network analysis is best if external and internal environment scanning, and scenario or "what-if" analysis are also applied. Note that even though the universal set considered in the exploration is the set of human actors inside the organization, it does not mean that the organization is detached from the outside environment.

Moreover, the exploration uses a Gestalt theoretic approach, which is *anti-reductionist*. Though reductionism is not an inferior tool in analyzing organizations, it is assumed that "the organization, as a whole, is greater than the sum of its members or groups of its members", which is a concept from Systems theory.

Social Network Analysis and the Sociogram

Sociogram is a visual representation of the social network, and is used to expose patterns in the interaction among actors. It is sometimes called as social x-ray or social architecture. Construction of sociograms is a basic part of social network analysis (under the field of Sociometry/Sociography), and is very much utilized in *Knowledge Management* (especially in maximizing information flow). Detailed discussion of social network analysis is not the focus of this exploration, but the basic steps are enumerated as follows (Hart, 2005):

1. context setting and planning;
2. survey design;
3. survey communication and distribution;
4. preliminary analysis and interpretation;
5. work analysis; and
6. communication of results.

Steps number 2 (survey design) and 4 (preliminary analysis and interpretation), will be touched in the discussion. Survey design requires construction of questions. The nature of questions varies depending on the need. Here are sample questions that can be asked in constructing the organizational sociogram:

- With whom do you work closely?
- Who helps you grow in your career?
- From whom do you get data and other resources in order to finish your job?
- To whom do you submit your job results? or Who uses your job results?
- To whom do you go for advice regarding work?
- With whom do you discuss company strategies?
- Who are the people that you interact with everyday?
- With whom do you discuss non-work related matters, such as personal issues, inside the organization?

- Who are the members of your "barkada" (group of close friends) inside the organization?
- Who are the people inside the organization that you do not go well with?
- Who are the people that hinder you to achieve your career goals?

The existing organizational chart can be the starting point for the construction of the sociogram. In connecting the *nodes* of the sociogram, it is advisable to assign weights or values at the *edges or ties* (a non-uniform graph). Interaction inside the organization is not simply "connected or not" (binary) but it is also "fuzzy". For example, if closeness between two people is being measured, then *Fuzzy logic* (a many-valued logic) can be used in order to identify "how close is close?". Moreover, not only healthy relationships can be included, but also those negative connections as exemplified by the last two questions above (these connections can be represented by negative weights).

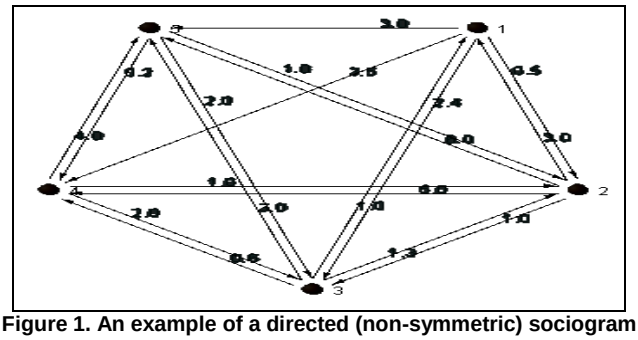

Figure 1. An example of a directed (non-symmetric) sociogram

In the preliminary analysis and interpretation, concepts of *Graph theory* can be applied. Essentially, knowledge of Graph theory is very useful in social network analysis. There are open freewares, such as Agna, Pajek, Ucinet, NetDraw and Keyplayer1, which can be used in social network analysis. Some elements that are commonly identified are as follows (Benta, 2003) (Borgatti, 1996):

- *Shortest/Geodesic Paths*. These are possible paths of minimum length between all pairs of nodes in the network.
- *Diameter*. This is the length of the longest geodesic path to be found in the network. This measure can show the nominal size of the network.
- *Eccentricity*. This is the length of the longest geodesic path originating from a node.
- *Clusters or Subgroups*. Examples of subgroups are the *components* (sets of nodes that are mutually reachable), *cliques* (maximally "complete subgraphs"), and *factions* (optimal partition minimizing in-group distances or maximizing in-group ties). Clustering may not only give information on who's who are similar, but it also gives the organization an opportunity to learn from the differences of the subgroups.
- *Measures of role, position and structural equivalence*. These measures can show how similar are the actors inside a subgroup. These can also reveal inter-subgroup similarities.
- *Centrality indices* such as closeness, farness and betweeness.
  - *Closeness index*. This is the inverse of the sum of the geodesic distances from a node to all the other nodes.
  - *Farness index*. This is the sum of the geodesic distances from a node to all the other nodes.
  - *Betweeness index*. For a given node *i*, this index is computed as the sum of the ratios of the number of geodesic paths between all possible pairs of nodes *j* and *k* involving node *i* to the number of all geodesic paths between j and k.

General centrality index can also be computed to know how centralized or decentralized an organization is.

- *Measure of reciprocity*. This determines if the edges are directed or not. This can detect hierarchies in an organization.
- *Density*. This is the sum of all edge weights divided by the number of all possible edges in that network. A network which is not dense or having many disconnected components is called a sparse network.
- *Cohesion index*. This is the number of mutual connections in the network divided by the maximum possible number of such connections (weights are ignored).
- *Emission degree of a node*. This is the sum of all weights corresponding to the edges originating from a node. High emission degree may mean that the person is influential. By using this index, the span of control or the number of people the manager directs can also be determined. This measure is similar to the "outdgree" of a node.
- *Reception degree of a node*. This is the sum of all weights corresponding to the edges incident to a node. High reception degree may mean that the person is illustrious. This measure is similar to the "indegree" of a node.
- *Number of outsiders.* This is the count of the isolated nodes.
- *Sociometric Status*. This is the sum of the reception and emission degrees of a node, relative to the number of all other nodes in the network.
- Statistics of the indices generated such as minimum, maximum, mean and entropy.

An aspect of the network that is very important to be identified is the set of *keyplayers***.** The optimal set of key nodes in a sociogram represents the keyplayers. Keyplayers can be the people which when removed from the network would cripple the network, or the well-connected people who are likely to be significant or influential to others (Borgatti, 2003). These are people which can likely help in the organizational development, such as when applying interventions or doing innovations. They can be good candidates to be "change agents". According to Community Analytics (2008) there are some named keyplayers such as:

- *Trusted Advisors*. These are the people preferred by most of the workers to be their advisers, maybe because of their ability to brainstorm new ideas or solve problems effectively.
- *Connectors*. These people provide the shortest path for many individuals to reach other workers.
- *Cross Connectors*. These are the people who create the shortest path for many individuals from different work units (e.g. other departments or staffs) to reach one another.
- *Bottlenecks*. These people possess the organization's resources such as valued information. Many people may tend to go to these people frequently; thus create clogs, and lose efficiency. (Other workers might assume some of the responsibilities of the bottleneck employee to minimize people jam and maximize information flow).

Organizational network analysis can be used to determine the state of the "social capital" and human relation systems, e.g. grievance systems, of an organization. It can be a good business intelligence tool to help the management create well-informed speculations about a situation, such as knowing "why a person is disconnected to a person who is supposedly connected to him?" or "why is the connection of two employees weak?". There are many approaches to network analysis; and the kind of approach to be used depends on the need. The network can be a *whole network* (representing the whole organization) or an *egocentric/personal network* (representing the network of certain employee/s or business owner/s).

Chaos Theory and Related Concepts

One of the most important characteristics of a Chaotic system is being *deterministic*. This means that the system follows a certain rule and is not randomly generated. However, from this deterministic state, "disorderliness" (wild fluctuations) would come out (Williams, 1997). That is why Chaos is sometimes described as "*orderly disorder*" (Wilding, 1998). The random-like behavior arises from the design of the system itself (Williams, 1997). According to Durham (1997), Chaos is a state of disorderliness masquerading as randomness (even though the model and the inputs are deterministic!). In studying Chaos, it is therefore important to determine the system's level of *entropy*, which is the degree of disorderliness or disorganization. Figure 2 shows the distinction between usual determinism, deterministic Chaos, and randomness.

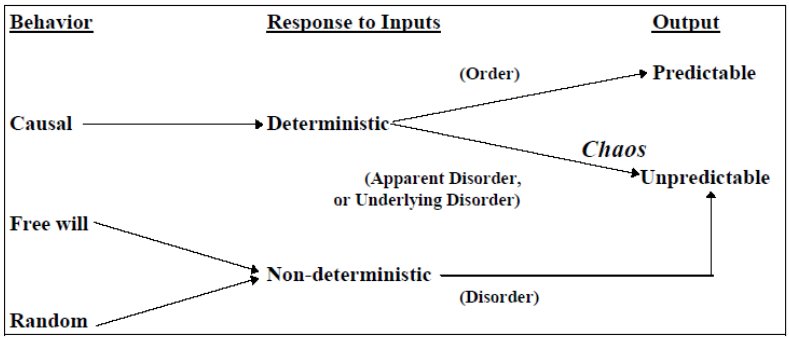

Figure 2. Generalized Post-Chaos World View (DeBlois, not published, as cited in Durham, 1997)

The equation $x(n+1) = 3.95\ x(n)\ [1-x(n)]$ is an example of a deterministic model (i.e., given an $x(n)$, $x(n+1)$ will be derived). However, when the $x(n+1)$'s or the outputs will be graphed in an n-$x(n)$ plane, a Chaotic plot will result. (Liebovitch, 2004)

Another important characteristic of a Chaotic System is being *sensitive to initial condition*. This idea resulted from Edward Lorenz in the 1960's while he was simulating weather patterns and drastic changes in the output occurred when his initial inputs just differed by decimal points. The "*Butterfly Effect*" is the offshoot of that experiment, which has a popular public anecdote about the effect of the flapping of wings of a butterfly in the tornado patterns in Texas (Rosado, 2003). In management point of view, this means that a small change in input may dramatically and unexpectedly affect the organization in large scale; thus making long term planning difficult (Sussman, 2000). It is then possible that a stable organization can become unstable because of such sensitivity. Fundamentally, it is said that the future of a Chaotic system is defined by its initial condition (Williams, 1997).

One irony about sensitivity to initial condition is that not all initial conditions have an effect. Sometimes, huge events or interventions do not move the organization. Sometimes, the effect will only show after introducing many small initial conditions. There are only selected inputs which create what is called "bifurcation". This means that the management must scrutinize the effectiveness of their organizational development techniques prior to their application in order to minimize cost and unwanted consequences. Initial conditions should be placed at the right place and time. Sensitivity to initial condition is illustrated in this literary work:

> *For want of a nail, the shoe was lost; For want of a shoe, the horse was lost; For want of a horse, the rider was lost; For want of a rider, the battle was lost; For want of battle, the kingdom was lost!* (Rosado, 2003)

Bifurcation is the drastic change in the pattern of a system (Williams, 1997). It is related to Malcolm Gladwell's "tipping point" (Gladwell, 2000). Mathematically, it is the instance of splitting identical entities and making the divided parts take very distinct paths, possibly in an exponential manner (Williams, 1997). This is instigated by the system's sensitivity to initial conditions. Bifurcations are the starting points to the possible "evolution" of the system.

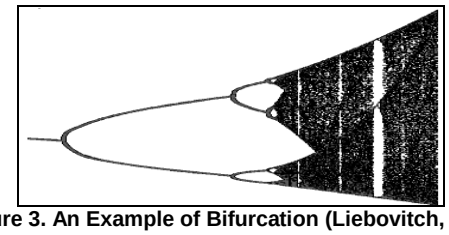

Figure 3. An Example of Bifurcation (Liebovitch, 2004)

Other concepts related to bifurcation are the Noah and Joseph effects, which names are inspired by Bible stories. *Noah effect* is the occurrence of a sudden discontinuous change in the pattern of a system immediately after the occurrence of the cause or "perturbance" (Oech, 2007). An example of this is the drastic change in the stock prices after the broadcast of a bad news. On the other hand, *Joseph effect* is the occurrence of an unexpected change in the pattern of a system long after the occurrence of the cause or "perturbance" (Oech, 2007). An example situation of this is "a bank persisted for a while but afterwards filed bankruptcy months after the declaration of a mortgage crisis in the country".

In an organizational point of view, it is critical to know when will be the occurrence of the possible bifurcation after the occurrence of a possible cause so that the management will know the starting point of the organization's possible evolution. Nevertheless, if it is impossible to predict the occurrence of a bifurcation after the identification of a possible cause, then at least the organization could prepare for the bifurcation's possible occurrence. Consequently, determining the "route to Chaos" or the pre-Chaotic patterns can help in the anticipation of the occurrence of Chaos (Couture, 2007). It is said that bifurcation will likely to exist if the *Feigenbaum number* (4.6692…), which is the limit of the ratio of the lengths of successive constant *period doubling*, is approximately attained (Williams, 1997).

Organizations are exposed to the internal and external environment. As the environment changes, organizations must *co-evolve* with it to survive. With this co-evolution, *disequilibrium* will take place; and the source of this disequilibrium is called perturbance (Reigeluth, n.d.). *Perturbation* (non-mathematical) is the change in the environment that causes bifurcation. With disequilibrium, organizations mostly persevere to attain stability; however, the idea in Chaos theory is that a state of constant equilibrium is the death of the organization (Wheatley, 1999, as cited in Reigeluth, n.d.) and living organizations can only approach stability asymptotically. Instead, organizations must look for disequilibrium that causes evolution than striving for equilibrium that causes sterility. For a system to be healthy, it must experience challenges. Facing challenges could make the organization's current weaknesses to be its future strengths.

During the process of struggle between disequilibrium and stability, *emergence* will occur. Emergence is the tip of the evolution or transformation. It is where a new system emerges to replace old ones (Reigeluth, n.d.). Emergence is not about piecemeal change per department, but is about overall organizational change; and it requires long-term evolution. Most organizations that underwent the process of emergence usually evolve to a more complex and higher-level system (Rosado, 2003). However, the process of evolution may result to self-organization or self-destruction, which can be determined by the initial condition.

Self-organization is one of the significant characteristics of a Chaotic system. Its main idea is that without external assistance an organization can still evolve in its own. Organization, with synchronized efforts from its members, mutates in order to survive and progress. Self-organization is commonly seen in *Complex Adaptive Systems*. The continuous cycle of self-organization is called *Panarchy* (Holling, 2001).

Learning or open organizations are the ones that allow self-organization rather than plotting the development by strictly planned and controlled change. Business organizations grow more by self-organizing rather than pure rational planning (Morgan, 2006). Rational planning only takes few minds, but learning organizations take efforts from all actors. Learning organizations allow constant upheaval and stress in their system (perturbance), so that evolution will occur. Organizations must get out of their comfort zones, so that, through struggles, creativity will occur. However, it is sometimes more challenging to handle a learning organization than which is not. The necessary element for self-organization is the kind of leadership applied.

Autocratic and bureaucratic leadership styles cause sterility of an organization. Bureaucracy even delays flow of information. Holling (2001) call such hierocracies as "rigidity trap". Organizations need sufficient enablers or those who are called *transformational leaders*. These enablers are the ones who practice "participatory leadership". Mechanistic approaches to organization are applicable only to "mechanistic" jobs; and these approaches have dehumanizing effects on the employees. Even Saint Paul avoided autocratic form of leadership so that self-organizing, self-governing, adaptive communities will evolve (Ascough, 2002). Furthermore, participatory leadership could help in the unearthing of the employees' talents.

According to a study, too much rules and too few rules (represented by an inverted U-shape scheme, as shown in Figure 4) cause unproductiveness (Davis, Eisenhardt, & Bingham, 2008). Transformational leadership and a well-balanced number of rules are the necessary ingredients for self-organization. It is not good to leave an organization with no rules; it would result to destruction. Even "nature", which is Chaotic, has rules called the "physical laws".

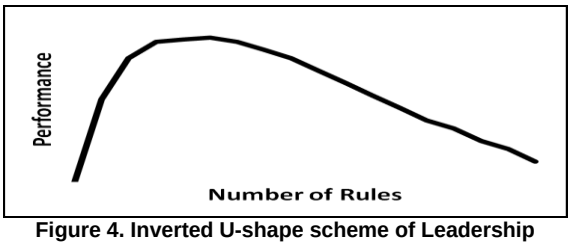

Figure 4. Inverted U-shape scheme of Leadership

Usually self-organization can only be successful if there is enough number of *mature* members who are capable of handling evolution. By *Pareto's principle* (an example of *Power Law*), on the average, 80% of the transformation can be attributed to the works of the 20% of the members.

Positive feedback is important in self-organization. Feedback is used as a constructive learning tool by correcting the mistakes of the past; thus, leading to good decisions for the present and future. Feedbacks can either maximize or minimize the disorderliness and "noise" in a system. *Noise* can have positive or negative effects (e.g. consequences of having grapevine). Communication among the actors, in any rank or position, is necessary in giving feedbacks. The positive feedbacks can be the next input as the initial condition. In addition, being *proactive* is a significant trait that needs to be cultivated, rather than just being reactive.

Time and patience are necessary in self-organization. Keyplayers should not haste self-organization by inducing canned assessments or "cook-book" solutions to problems, to avoid temporary, immature or ineffective transformation (Hilburt-Davis, 2000). Management should look for the *edge of chaos*, which is the best environment for flourish change and growth. Edges of chaos usually occur when there is adequate order to maintain the organization, and sufficient Chaos to allow for diversity and innovation (MacGill, Complexity: A new perspective for the 21st century, n.d.).

In the process of transformation, transient phenomena exist. Transient motion is "the motion that has not yet settled down to a steady and regular pattern" (Durham, 1997). The auxiliary element for this phenomenon is the *attractor*, which acts as the system's identification card. Common attractors are point, cycle and strange attractors. The strange attractor is the one that brings the system to the edge of chaos. These attractors are like magnet – drawing elements near it. It can also magnetize behavior, causing it to be repeated (Hilburt-Davis, 2000).

In an organization, attractors can be the people, ideas, styles, schemes, opinions, emotions, mission, vision, stories, processes, or beliefs that attract people. An example of this is the "brand story" of DMCI Homes, where most decisions are based on the character of "Alfonso" (the story can be read at www.dmcihomes.com/brand_story.php). Humans respond to symbols and stories; that is why members of organizations are attracted by these types of "branding" initiatives. Attractors are important since these promote collaboration, cooperation and unity among members, no matter how diversified and resistant they are. Attractors create self-reference on core ideas, values and beliefs that give the organization an identity (Reigeluth, n.d.). These attractors identify similarities among members or groups inside the organization; and these similarities can be of any dimension (e.g. physical or behavioral).

Attractors are mostly in *fractal* forms. "Fractals are patterns that recur at all levels of a system, called self-similarity" (Reigeluth, n.d.). Any segment in a fractal that is magnified in whatever scale appears identical to the whole fractal (scale invariance) (Williams, 1997). In management analogy, fractals may exist in the organizational design – different work-units may exactly or approximately resemble other smaller or larger work-units. In a society, social structures can be examined at the macro and micro levels by looking for similarities.

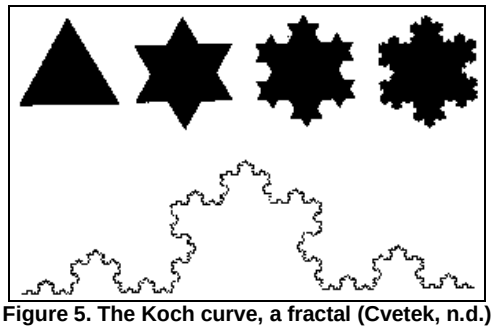

Figure 5. The Koch curve, a fractal (Cvetek, n.d.)

Attractors have influence to most of the members of an organization. Hence, attractors are powerful tools in developing core competencies. Fractals are similar to what Dawkins and Blackmore call as *memes*, which are social "genes" (Dawkins, 1998 & Blackmore, 1999, as cited in MacGill, Complexity Theory as a possible mechanism for the progression through the stages of social evolution as described by Spiral Dynamics®, n.d.). Like in physical genes, some memes survive while some become extinct. These memes can be the shared ideas and cultural beliefs of a society which can be the cause of the current situation of that society. For a meme to become strong, it must be shared out widely to the whole populace.

Unlike random system, Chaotic system has structure in phase space (low dimensional) (Liebovitch, 2004). *Phase space* or *state space* exposes the patterns, even the hidden ones, in a Chaotic system (Williams, 1997). Phase space can reveal a portion of the system's structure. There are multi-dimensional phase spaces that can be explored to reveal such patterns. The axis of a phase space can also be translated or rotated to look in a different point of view. Looking at phase spaces depicts the different perspectives of the actors in an organization. Business owners, managers, employees, customers, etc. may have diverse views regarding a certain situation. This implies that it is helpful to consider the different perspectives, in different dimensional level, when studying the organizational network. It is sometimes helpful to think "outside the box".

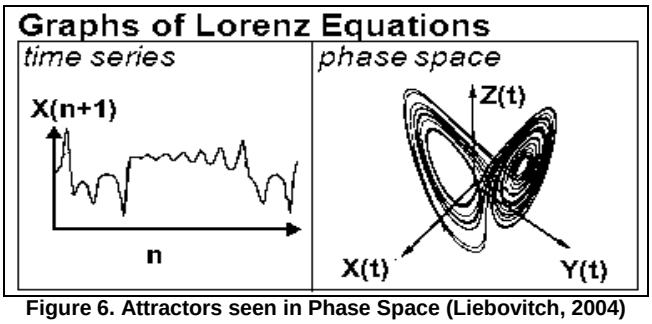

Figure 6. Attractors seen in Phase Space (Liebovitch, 2004)

A Chaotic system is *aperiodic*. Aperiodicity means "history never exactly repeats itself". Patterns may exist in a Chaotic system, but a certain state will never exactly repeat twice (Wilding, 1998). Moreover, Chaotic systems entail time irreversibility; thus making a Chaotic system noninvertible. Noninvertibility means that it is difficult, usually impossible, to retrieve Chaotic system's history, because the records about the initial condition is commonly irretrievable (Williams, 1997). This implies that when reviewing the history of a "Chaotic" organization, great efforts might be done to look for the causes of a certain event.

When studying a Chaotic behavior, it is imperative to look at the *trajectories* or patterns of points that iteratively traverse in a route. *Foldings* are the radical changes in the direction of the trajectory making its graph non-monotonic, having different slopes. The trajectory will reverse itself and go back near the place it traversed previously, with the attractor as its gravitational force (Williams, 1997). Studying the "trajectories" (e.g. processes) and "folding" (e.g. events) in management will help managers determine the patterns of behavior and the possible occurrence of Chaos.

Another characteristic of a Chaotic system is boundedness. A *bounded* system stays in a finite range and does not approach infinity (Wilding, 1998). It only operates in a finite set of states. Outputs or consequences lie only within the boundaries. Past behaviors are never repeated exactly but may reoccur within a certain domain. For example, weather patterns, which are proven to be Chaotic, have limits within a finite horizon. (Wilding, 1998)

Because of being sensitive to initial condition, long-term predictions are mostly impossible. Patterns can be seen in the system, yet forecasts are good only for short-term period. However, it still makes forecasters lucky, since *Chaos is more predictable than randomness*, and more "exciting" than the usual deterministic system because of less predictability.

Unlike randomness, a *Chaotic system can be controlled* in some way. It is occasionally possible to drive a system into Chaos or prevent Chaos from occurring (Durham, 1997). When a Chaotic behavior is mistakenly considered as random behavior, we lose the opportunity to make predictions and control the system (Durham, 1997). If organizational behavior is considered as Chaotic, then there can be possibilities that the

future (ideally short-term) behavior of members and of the whole organization can be as well predicted and controlled. There are ways, such as manipulating the initial conditions and the perturbance, that can control a Chaotic system. Attractors can also be controlled. It is possible to create or destroy attractors by perturbation, through a change in the initial condition.

Chaotic systems, which are normally *dissipative*, have friction; thus lose energy (Williams, 1997). Chaotic systems, such as those "Autopoietic systems", demand constant flow of energy to keep the system in continuous motion. Empowerment and motivation from leaders should accompany the organization because journeying the way of evolution takes a lot of resources and strength.

However, one thing that is very important to be remembered is this: if there are unwanted or unnecessary complexity or disorderliness in a system, then maybe there are things that need to be shed off from the system. It is still better to work in a simple environment than in a complex one.

The Convergence: A Hypothetical Example

Usually, organizational network analysis use typical steps in investigating social interactions inside the organization. But this paper proposes supplementary steps and questions to ask in the analysis. The following is a simple example of incorporating the concepts of Chaos theory to the organizational network analysis. The network was randomly generated using *Ucinet*, and the analysis was done in *Agna*. (In reality, the creation of sociogram is deterministic, i.e., the connections among the nodes are not randomly generated.)

Profit Corporation is an advertising company, and practices a collegial type of management. The team leaders and the top management decided to create an organizational sociogram as a tool to visualize and analyze the interaction among its employees. They believe that it is necessary to dig down their social network to discern how they can make their organization evolve and their succession planning initiatives thrive. After doing the necessary procedures in social network analysis, the following organizational sociogram was created:

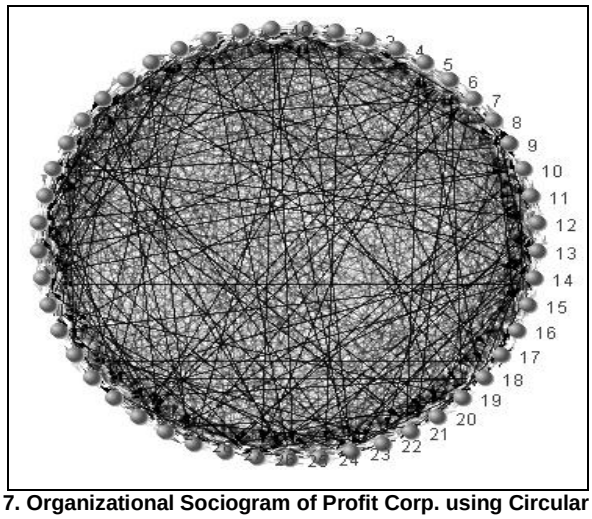

Figure 7. Organizational Sociogram of Profit Corp. using Circular Layout

The survey questions are confined (bounded) only to the work-related interactions of employees (although in reality the more personal questions can be included). The weights of the edges represent the extent of their interaction (e.g. dependence to each other). As a

note, to make a clear reading of the sociogram, it is helpful to focus only the survey design to specific features of the organization, depending on the need of the decision makers. The generated network is a weighted and directed graph, having the following sociometrics:

Table 1. Sociometric Output from Agna using Profit Corp.'s Organizational Network

METRICS	DETAILED STATS	VALUE
Number of Nodes	Count	49
Number of Edges	Count	2,020
Number of Outsiders	Count	0
Diameter	Value without weights (binarized)	2
Eccentricity	Mean without weights (binarized)	2
Density	Value without weights (binarized)	0.86
	Value with weights	1.99
Cohesion Index	Value	0.74
Emission Degree	Max	117
	Min	76
	Node with max outdegree	23
	Node with min outdegree	35
	Mean	95.53
	Standard Deviation	9.47
	Relative Entropy	0.13%
Reception Degree	Max	118
	Min	76
	Node with max indegree	40
	Node with min indegree	34
	Mean	95.53
	Standard Deviation	7.9
	Relative Entropy	0.09%
Determination Degree	Max	18.24
(Reception – Emission)	Min	-32.16
	Node with max determination degree	27, 39 & 40
	Node with min determination degree	23
	Mean	0
	Standard Deviation	12
Sociometric Status	Max	217.92
(Reception + Emission)	Min	157.92
	Node with max sociometric status	40
	Node with min sociometric status	34
	Mean	191.04
	Standard Deviation	12.96
Centrality Index	Freeman General Coefficient	0.09
(using Bavelas-Leavitt)		
Closeness	Max	0.02
	Min	0.016
	Node with max closeness	7, 12, 16 & 24
	Node with min closeness	41
	Mean	0.88
	Standard Deviation	0.04
	Relative Entropy	0.03%
Farness	Max	51
	Min	61
	Node with max farness	41
	Node with min farness	7, 12, 16 & 24
	Mean	54.78
	Standard Deviation	2.48
	Relative Entropy	0.03%
Betweeness	Max	8.32
	Min	5.08
	Node with max betweeness	16
	Node with min betweeness	28
	Mean	6.78
	Standard Deviation	0.72
	Relative Entropy	0.15%
Transitivity	Value	0.63

Rather than just getting the sociometric measures and just analyzing these measures using traditional ways, Chaos theory will also be used. The large number of edges (2,020) can be the effect of being a collegial/participatory type of organization. The values of the diameter and eccentricity show that people can reach other employees through at most one mediator; thus, information can flow easily. The high values of the density and cohesion

indices indicate that the network is relatively complex. The relatively high transitivity index means that the organization is not bureaucratic, which is true.

The employee representing node 23 has high emission degree, and probably can be a bottleneck when there are delays in his work (since more people need him). Moreover, the employee representing node 40, having high reception degree, might be a company executive; but if he is not an executive then it should be questioned why he is receiving many of the connections (for information security purposes). He could be a trusted advisor, or he could just be receiving plenty of tasks given by other employees. Actually, node 40 has also the highest sociometric status. Nodes 23 and 40 are candidates for being keyplayers in the organization.

Another candidate for being a keyplayer is node 16 for having the maximum betweeness index. He can be a good "connector". In addition, all employees are connectors in their own sphere of influence, since the minimum betweeness degree is greater than zero, and because of relatively high transitivity index. This means that it is hard to "cripple" the network, since each node is connected to more than one node (i.e., if one node is removed, the other nodes connected to the removed one would still be connected to the network). However, the low centrality index indicates that there is likely no keyplayer-attractor in the organization.

When the network is binarized, the employee who represents node 7 is the most connected (i.e., emitting to 45 nodes and receiving from 46 nodes). Probably this employee knows most of the employees. He has also the maximum centrality index. Node 16 and 7 are among the best candidates for being good "connectors".

The candidates for being keyplayers, as enumerated above, are the possible members of the "20%" who can deliver 80% of the transformation (Pareto's principle). In addition, there are open-ended questions that can be asked after looking at the sociometric measures. These are the sample follow-up questions: What is the level of entropy or disorganization?; What are the possible initial conditions that would create perturbance and bifurcation?; What or Who are the attractors?; Are there any procedural or cultural similarities among the departments that can be regarded as fractal; Are we comfortable with the status quo or do we want organizational evolution?; Who are the possible change agents?; Where and when is the best place and time to intervene?; What other points of view can we consider (phase space)?; What short-term plans can we create out of the generated organizational network?; and If a person would resign, who are the people that will be affected? (The last question can be answered by doing a simulation.)

By looking deeply at the organizational network and sociometric measures, some observations and suppositions can be derived:

- By inspecting the sociogram, it seems that the network is disorganized. However, the computed relative entropies are relatively low. The main reason for this is even though there are many tangling connections, every node resemble each other (has similar structures). Actually, the indices of each node are nearly identical. This can be the result of a collegial type of management and the working environment they have (e.g. employees continuously brainstorm ideas to enhance creativity since Profit Corp. is an advertising company). The initial perception of a disorganized network turned out to be organized due to a near fractal formation; thus perhaps making the organization easier to manage. Profit Corp.'s organizational sociogram resembles a "small world network".
- The current organizational network may be perturbed by introducing the following dynamics in the initial conditions (examples):
    - Changing the organizational design (e.g. decentralization);

  - Changing some business thrust (e.g. from print advertising to TV advertising);
  - Rationalizing a department (e.g. outsourcing some processes of the finance department);
  - Rewiring the connections by controlling the interactions;
  - Having a number of non-cooperative employees (due to issues in human relations);
  - Resignation of an employee (the new hired employee may not immediately cope up with the complex interactions among employees; however, extra effort from old workers may offset this problem);
  - Having high employee turnover (the company must co-evolve with the environment, e.g. if competitors offer better compensation, then the company must improve the salaries and wages of the employees to prevent high employee turnover); and
  - Introduction of a keyplayer-attractor, since there is no keyplayer-attractor.
- If the company would experience high employee turnover because of competition (the initial condition), then it is still possible for the company to self-organize. The company could hire new employees, and from these new employees the company could gather new ideas (which are very important in an advertising company). This can be the start of the evolution, expectantly desiring for a better organization. Positive feedback can be the auxiliary factor for this evolution (e.g. applying the lessons of the past).
- If the aim is "emergence", then locating the attractor is important. However, according to the previous analysis, Profit Corp. does not possess a keyplayer who is an attractor; hence, it is hard to locate a transformational leader. It is now imperative to locate the non-human attractor, which magnetizes the people and their behavior (e.g. brand story, mission-vision of the company and organizational culture). If there is an attractor, then it can be used as the transformational tool. If there is no attractor, then it is time to introduce one. It is better that the attractor will be a fractal; such that the similarities are seen in any level of the organization (e.g. mission-vision statement is well evangelized to all employees).
- Since Profit Corp. follows a collegial type of organization, floppiness in the performance of employees may arise. Constant checking of effectiveness and efficiency of their work is needed. There should be a well-balanced number of rules. Too much autonomy is bad. Employees should sometimes get out of their comfort zones to be challenged, and then evolve.

Assuming that Profit Corp. has a keyplayer-attractor (let say the CEO), there is a possibility of having a crisis (when the CEO retires) if the attractor will not be replicated. Answering "yes" or "no" to the simple question "are we going to mentor people so that they can assume position afterwards?" may drastically affect the future of the organization. The successor should be equipped already by making him an attractor, too. This would avoid gaps during the transition of positions. However, it should be noted that usually it is better to develop the non-human attractors, since people are more temporary.

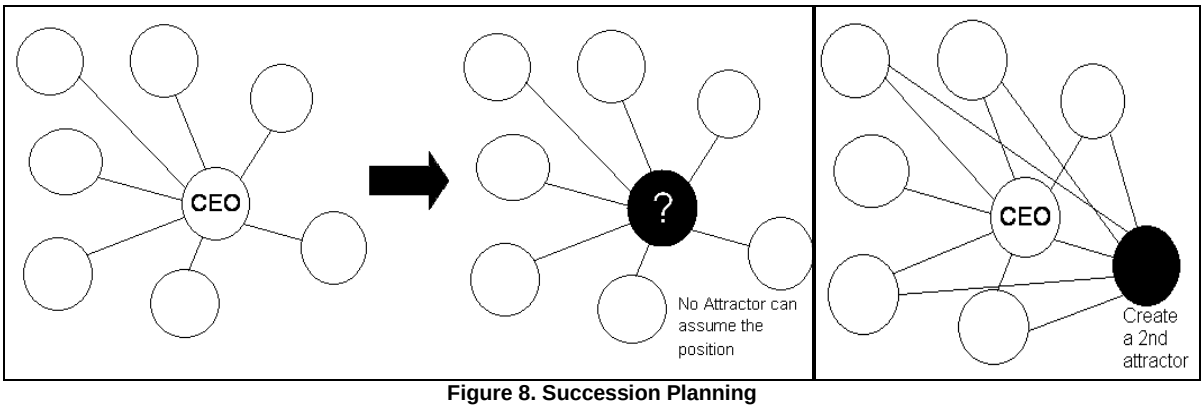

Figure 8. Succession Planning

It is mostly impossible to predict the future of an organization; however, it is possible to plant the necessary elements that would increase the probability of making the organization grow.

CONCLUDING REMARKS

The organizational network may change very fast due to the dynamism of interactions. Constantly updating the network may require more resources, but will help a lot in "mining" and understanding the complexity of an organization.

There are ethical elements that need to be considered in making a sociogram. Oversimplification, survey error, and indirectly manipulating the networks may affect the social network analysis. Moreover, knowing the interactions among organizational members may give the management omniscience. This could be used to politically target individuals and deter human rights.

Decision-makers might be hesitant to use the metaphors discussed. Sometimes, they still prefer using the traditional and "safe" methods. However, there can be opportunity losses in not considering the organizational network as "Chaotic". Understanding the transformation processes is very significant in the appreciation of Chaos. "Thinking chaotically" is a philosophy, and mostly only those people who are conscious enough and who have the "sixth sense" can understand what it can provide.

According to John Maxwell, only true leaders can employ the concept of evolution. The Law of Navigation states "anyone can steer the ship, but it takes a leader to chart the course" (Maxwell, 1998). Change agents should discern/filter the concepts to be used to include only those which are applicable.

The approaches presented in this exploration remain as a topic in an open-ended discussion. This is good, so that the approaches would continue to evolve to near perfection. In addition, researches in qualitative Chaos theory can be extended to include concepts of Catastrophe theory.

> *"Making a pact with chaos gives us the possibility of living not as controllers of nature, but as creative participants."* (Briggs & Peat, 1999, as cited in Lyster, 2005)

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