A SYSTEMIC APPROACH TO LANGUAGE AND SYMBOLIC REPRESENTATION

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ABSTRACT

In the scientific worldview it is common that we ask our-self how to label the objects and concepts with an appropriated name that describes, defines and diagnoses the thing than we are talking about. In this everyday effort the International Council on Systems Engineering (ICSE) and the International Society for the Systems Sciences development the endeavor "Common Language for Systems Praxis Project" (IFS, 2012).
As part of this common language in the ICSE they identify, explore, and understand the patterns of complexity across next views: 1) The source of the systems thinking or Foundation of the System Science, 2) The systems science theories and 3) The Representation of the System Science (IFSS, 2012).
The present proposal is a contribution to Foundation of the System Science and has been based in the Semiotic view of complex phenomena through the graphs and networks tools of Representation of the Systems Science.
In the First part It is describes why the use of complex science tools in social field. Next it has explained how is the link between Network Theory and Semiotic. Third part presents the results of an application of the approach. Finally it is show some brief conclusions.

1. THE REPRESENTATION OF SOME COMPLEX SYSTEMS OF SYSTEM SCIENCE ACROSS A NETWORK MODEL

What is a Network? A network is a directed graph showing a relation between a set of actors and their binary links (Xij), which can be considered as a state of change that transforms slowly (Snijders, 2009).
In the field of Systems Science, everybody comming from natural sciences knows who introduced the concept of graph. He was Leonard Euler when he tried to solve the Königsberg problem (Barabási, 2002). However, I will give a brief explanation for those who come from the social sciences and don't know the subject. Who first introduced the concept of *link* and *graph* was Leonard Euler across the formal proof by the Königsberg problem. This problem consisted to demonstrate if there was a way to cross the seven bridges that linking the village of Königsberg without stepping two times the same bridge. The town of Königsberg was rounding by three plots of land, two of the lands have two bridges each one, and one of them has three bridges to joint them all. The answer to the problem was *no*, and the demonstration was conducted with Euler's diagram, called directed graph (Barabási, 2002).

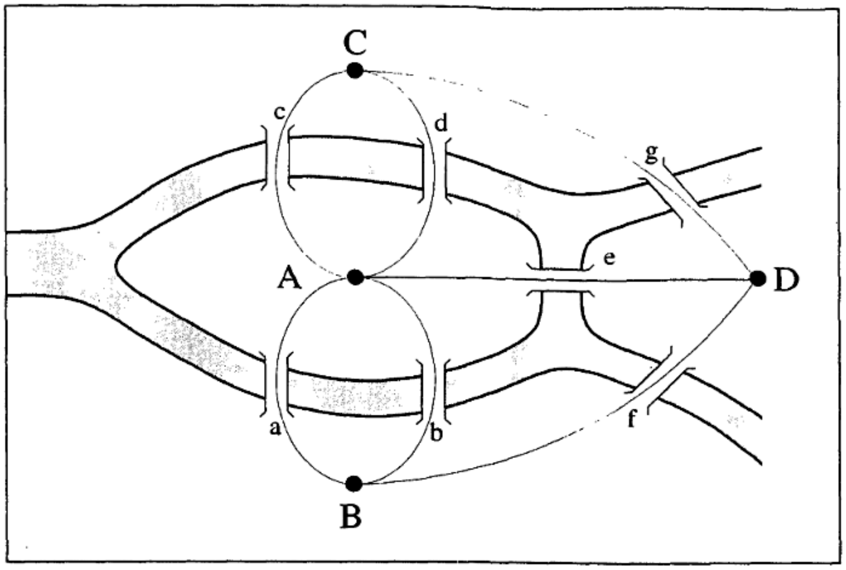


Figure 1. The diagram used by Euler for his demonstration. Source: Barabási, 2002, p. 11 "Königsberg Bridges".

Hence, the Graph Theory (GT) birth with Euler's diagram. Initially the GT focused on data structures such as Euler's scheme, that is an example of a regular graphs. But in the past century when the Complex Networks Theory began to be studied, first with the representations of GT, and next with a new data structure of an idealistic idea of network, GT included a new quality named random graphs. Who formalized this kind of analysis and models were the Hungarian mathematicians Paul Erdös and Alfred Reniy (1959).

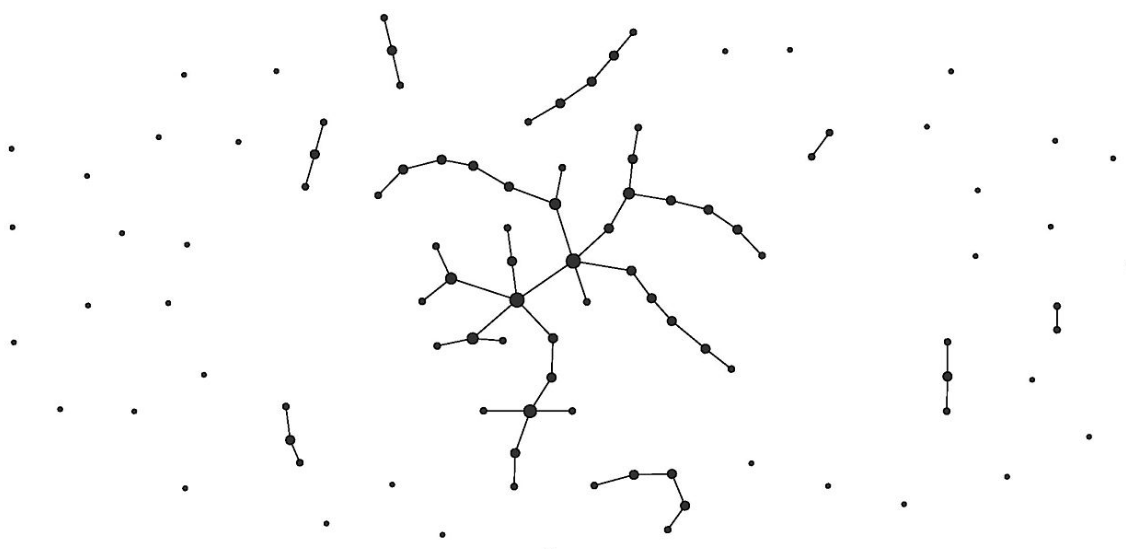


Figure 2. It is a view of a random network. Source: http://en.wikipedia.org/wiki/Erd%C5%91s%E2%80%93R%C3%A9nyi_model

Consequently, since 1950 new data structures form large networks with no early apparent design were described as randomized graphs or random network (Albert & Barabási, 2002:

2). In the late twentieth century Reka Albert and Albert- László Barabási (2002) showed that real networks have some **organizational principles**, contrary to random network or the model of universe of Reniy-Erdös. According to the Barabási-Albert's model, these principles must be encoded in some level of the network. But if the scale of observation of the system has changed the roles of nodes and edges could be different. The nodes can be objects and processes depending the scale of observation. Thenceforward the most important qualitative characteristics of real network was to found if the organizational principle is the connection between their nodes and edges, because the new representation began to characterizing dynamic elements of the system. This feature makes the analysis more complex for statistical models of random networks. Subsequently new conceptual tools were developed to describe the patterns of order and control that arise in real random networks (Barabási & Albert, 1999).

As it can observes in this brief description about the general conceptual class of network theory, that the development of network concepts to represent some complex systems of the System Science has to be changed the aim and objectives of study.

The first representations was among directed graph and they were thinking to model local and static or dynamic and lineal phenomenon with nodes and edges well defined. The second stage was to imagine a random universe where there is not a clearly pattern, so the nodes and edges are not local and are not defined. And the third stage draws a world where the phenomenon occurs in a multilinear and simultaneous time-space. Such an embodied and dynamic phenomenon arises by depending on the observation scale. These last ones are the real networks.

In the realm of evolution *No Living Systems*, *Living Systems* and *Conscious Systems,* according Lázlo (1987: 55) and Wilber (2000), in the first stage of theory networks it were developed tools like local networks, random networks and graphs to achieve aims and objects that concerns predominantly the transformations of matter *m,* energy *e* or No Living Systems. In the second stage they developed tools like small world networks, scale-free networks, random Boolean networks to achieve aims and objects that concerns primarily transformations of matter *m,* energy *e* and information *i* or Living Systems. And in the third stage they are developed tools to achieve aims and objects that concerns mostly the flow of information *i,* between human mind and social behavior in human activity systems.

According to the idea of the realm of evolution, which conceptual tool could be use by a science like Anthropology? The research groups use the same models of Living Systems to characterize phenomenon from Conscious Systems. One of the tools that can be useful to characterize the symbolic universe of human is the power law to embody the social behavior. Hypothetically a coefficient like a power law could show the scale invariance of a symbolic system (Apostel, 1957).

But how do we do? They are two types of networks: simple networks and complex networks. The type of the networks will depends from the structure, the form of recollection and the interpretation of data.

In such way, a research about "silverware", from Physical Sciences focuses on the nature of mathematical relationships that joint the atoms of the spoons. The important core of a physic research will be in the features of matter and energy represented by a formal model. In another sense an anthropologist will take like fundamental basis of his analysis the social relationships that make real the tool development in a Society and the impact for example in the culinary behaviour. In the social view, the core of the research is the transformation of

information across objects and behaviours. The important thing in both approaches is that the object is the same, but the method to understand and the scientific representation of the object arrives to different answers.
The researcher can deal with simple data structures in such cases schemes of directed graphs are useful; the reverse occurs when dealing with complex data, which can be derived, in complex characterizations of reality.
However, to charactering a phenomenon with a network model, it must comply with the following properties (Albert y Barabasi, 2002):

1. The system reflects a topology graph, i.e. there are nodes and links defined by the connectivity and information flowing parts.
2. The topology is an evolution of connectivity is reflected through a share exchange.
3. The topology of the network has a clustering coefficient, and then it can know how much connected is a node of a graph with the other nodes.
4. Eventually emerge subgraphs and/or new properties in the Network. These are defined by the clustering coefficient, so that the graph may have behaviour of open cycles (in tree form) or in closed cycles.
5. The emergence of subgraphs defined connectivity and distance (maximum and minimum) between nodes, so it can estimate whether the size of the clusters is independent of the size of the network or the network defines the size of the cluster.

2. COMPLEX SCIENCE TOOLS APPLIED TO A SEMIOTIC EPISTEMOLOGY

From the perspective of semiotics of Charles Sanders Peirce (1931) a sign is determined by a real object or *state of things* the macrocosms, and a mind-brain that across an idea called *interpretant* use a vehicle to communicate the sense (or meaning), the vehicle to communicate the microcosms is named *representamen* or symbol. This process uses at least three entities and two or more links to joint them, it is show in Figure 3.

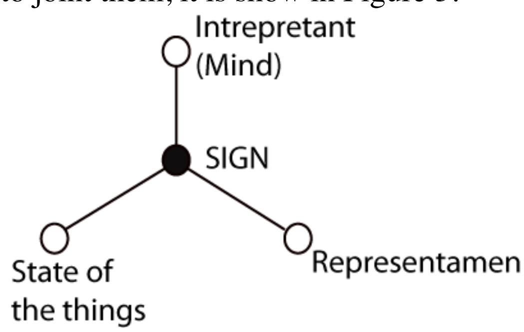


Figure 3. The components that determine a symbolic representation have a special relationship with *matter m, energy e* and *information i*. The state of the things or objects correspond to the order to the *material m*; someone's mind idea the *interpretant* is based in neurochemical reactions to generate, store and discern objects, corresponding to the order of *energy e* and the relationships with *matter m*; finally the use of symbolic representations correspond to the social systems of signs or *represetamen*. In the interaction of these three parts is emerging the sign.

From a semiotic perspective the connectivity of a network on the social behaviour could be found in interconnections between the compound of signs, *objetcs, interpretants, representamens*; and the form to being-there of the sign, *firstness, secondness, thirness*.

Charles Sanders Peirce developed a Category System to denote the logical relationship between the Classes of Signs. Consequently, the data of any problem could be expressed by means of these kinds of class of signs and their categories. In this way it was possible to express synthetically the transformation rules and the resulting expressions of meanings through a logical notation (Peirce, 1931).
In principle for this author there are three ways in which a Being or Entity manifests its-self, these include: firstness, secondness and thirdness. Firstness corresponds to the positive quality of the possibility of becoming, Secondness are currents facts, and Thirdness to the law governing the facts in the future. These three ways are the three basic categories of Peircean thought the author usually listed as 1, 2 and 3 (Peirce, 1931).

The design of the Sign of Peirce combining the three general Categories and the relationships with objects, interpretants and representamens, a matrix of signs is obtained with probabilities of the basic combinatory it is show in Table 1.

Table 1. A Matrix of "Signs divided into Ten Classes", from Charles Sanders Peirce.

OBJECT	REPRESENTAMEN	INTERPRETANT	SYMBOLIC REPRESENTATION	FEATURES
1	1	1	Mode of apprehension sign	Sensitive knowledge -aesthetic-
2	1	1	Mode of introduction to Object Immediate	An object that represents the sign
3	1	1	Current mode of Dynamic Object	Object in its current form
3	2	1	Relationship between the sign and its Dynamic Object	Knowledge by observation. Development of current experience
2	2	1	Mode of introduction to Interpretant Immediate	The effect of the Interpretant in the sign
2	2	2	Current mode of Dynamic Interpretant	Interpretant as development of current experience
3	2	2	The relation between the Sign with the Dynamic Interpretant	The effect of the sign in the mind
3	3	1	The Nature of Interpretant Normal	The posterior effect of the sign in the thought
3	3	2	Relationship with Interpretant Star Average	Current Effect of the sign in the normal Interpretant
3	3	3	The triadic relationship of the Sign with its Dynamic Object and its Normal Interpretant	Symbolic Representation

Charles Sanders Peirce uses another representation to show the combinatory of class of signs named interpretant, representamen and its object; it is show in Figure 4.

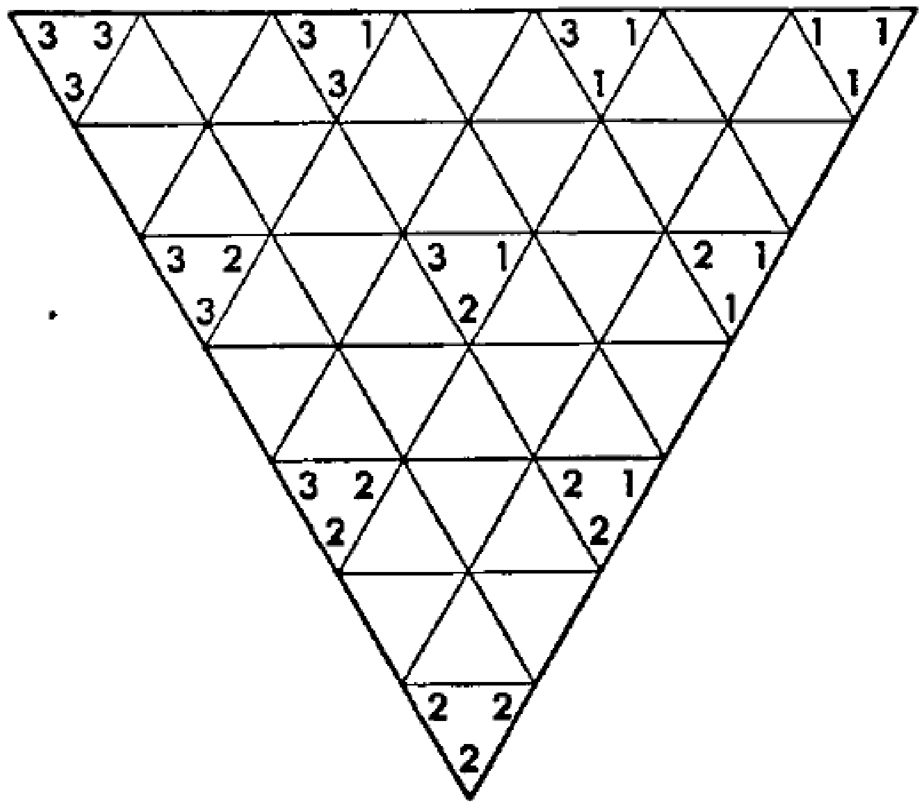


Figure 4. Scheme of "Signs divided into Ten Classes", from Charles Sanders Peirce. The number above to the left describes the Object of the Sign. That above to the right describes its Interpretant. That below describes the Sign itself or Representamen. Numbers describes *firstness, secondness* and *thirdness* (Peirce, 1931).

The same data can be structured in the way of Euler-Venn diagrams; as these are show in Figure 5.

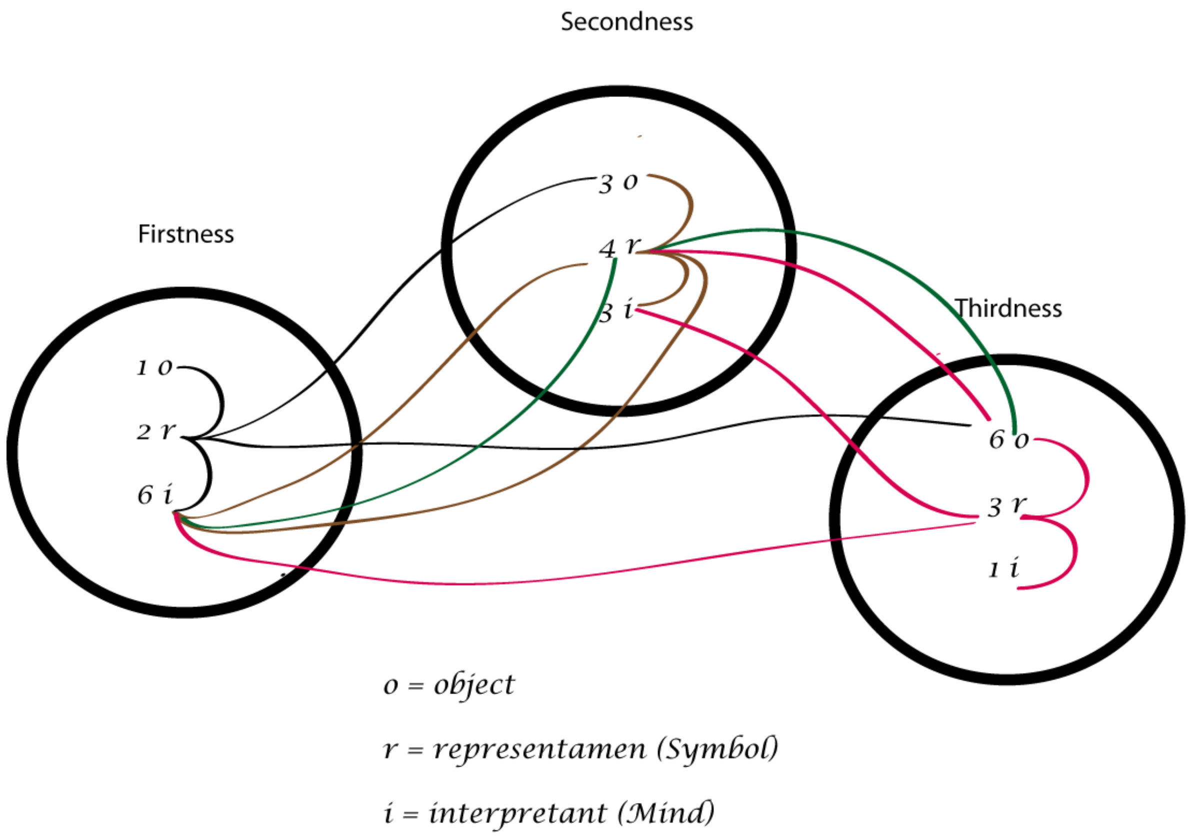


Figure 5. This is an adaptation of the Euler-Venn diagrams; it is shows the components of the Sign (object *o*, interpretant *i*, and representamen *r*) in a very simple representation as a topological space. This is a compound of subsets that are called open sets and meet each of the three logical properties of sets: the Empty set, the Intersection and Union.

In a Network model the scheme of Signs divided into Ten Classes can be characterized with a mathematical approach, first with an undirected graph, second with a Network, and third through the numerical features of the Network, it is shown in Figure 6, 7 and Tables 8, 9 and 10.

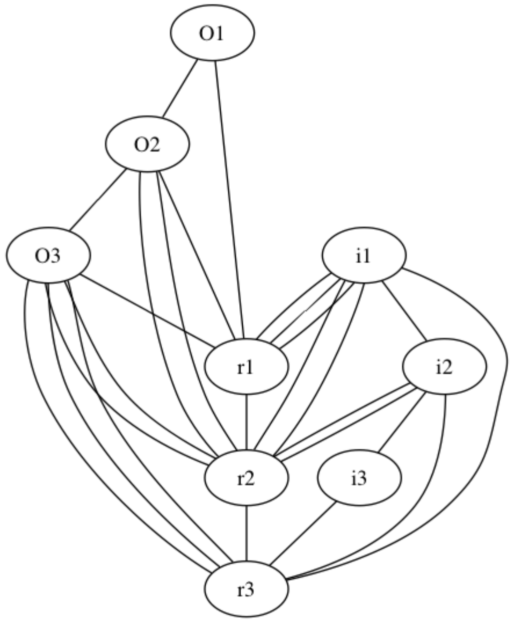


Figure 6. An undirected graph was generated using Graphviz Software. This scheme of an undirected graph shows the different paths from objects o, interpretants i and representamens r according to the Signs divides in Ten Classes in Peirce.

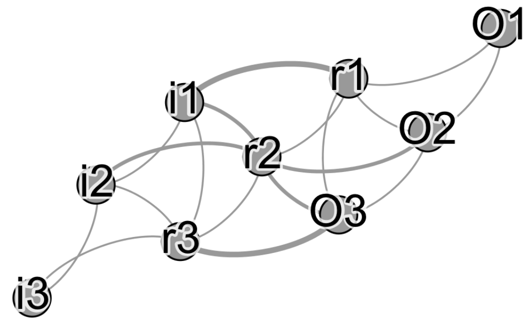


Figure 7. A local network was generated using *Yi Han Fu algorithm*, in Gephi Software. This is a local Network representation to the Signs divided in Ten Classes. The thin lines denotes one link, bold lines denotes two links and double bold lines denote three links. The categories of being-there are with numbers 1, 2 and 3; the components of the sign are with letters *object o, interpretant i*, and *representamen r.*

Following the topological properties described by Albert & Barabasi (2002) the Signs divided in Ten Classes, reflects a topology graph through the nodes and its links, defined by the connectivity and information flowing parts. The nodes are the compounds of the sign: *objects o, interpretants i* and *representamens r*.

A mathematical representation in formula (1) can be useful to define the **network density** in formula (2) this feature describes the portion of the potential connections PC in a network that have actual connections AC, and a “potential connection” in formula (1) describes a connection that could potentially exist between two “nodes”.

(1)[*] $$PC = \frac{n(n-1)}{2}$$

(2) $$\frac{AC}{PC}$$

[*] PC= potential connections, AC= Actual connections, ND= Network density, n= Nodes

According to Peirce, the basic Ten Classes can be computed in a permutation relationship whit the three categories (*firstness, secondness* and thirdness) in the form: $3^{10} = 59{,}046$. The permutations computed replace the portion of potential connections *n* in the formula (1) and it can be obtained the maximum potential connections of a semiotic phenomenon, Peirce named *semiosis ad infinitum*.

(3) $$PC = \frac{(3^{10})(3^{10}-1)}{2}$$

(4) $$PC = 1{,}743{,}362{,}676$$

(5) $$ND = \frac{\frac{(3^{10})(3^{10}-1)}{2}}{AC}$$

In the individual performance to generate a meaning of anything is the variability of actual connections AC and the hypothetically relation between AC and PC will show an evolution of connectivity reflected through a share exchange or the Network Density ND. The anthropological tools to get the AC data are the ethnography methods. Consequently the observation of the social event must be focus in the egocentric network relationship of the individuals and the objects around they. An example of this method is in the work of Kazuyasu Ochiai (1984).

At this time, the tools of complexity, only let us know the space of equiprobability; but in a real process of meaning the topology of the network must show a **clustering coefficient**. "*The clustering coefficient, C(V), measures the connectivity amongst the neighbours of a vertex V, and can be defined as the number of edges among V's neighbours, divided by the total possible number of edges if all the neighbours were connected to one another. The average clustering coefficient of a network characterizes the general tendency of vertices to form clusters*" (Zhang and Roth, 2009).

(6) $$C_i = \frac{2n_i}{k_i(k_i-1)}$$

Where n_i is the maximum potential connections (3) of links connecting the k_i of node i to each other in this case k_i in the case of the basic Ten Classes k_i is equal to 10.

(7) $$\mathrm{C_i} = \frac{2\left(\frac{(3^{10})(3^{10}-1)}{2}\right)}{10(10-1)}$$

(8) $$\mathrm{C_i} = 53{,}144.1$$

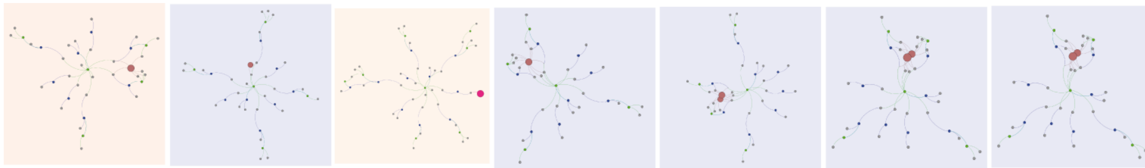
According to Albert & Barabási (2002) the clustering coefficient is a key to understand the emergence of subgraphs and/or new properties in the Network. In this case, according to (7) and (8) in the semiotic process it is a 53% of probability to consolidating meanings.

APPLICATION

The application of the network-semiotic hypothesis was toward the structuring of meanings of The Mexican Day of the Death Ritual, under a Complex Systems approach. In other paper (Valle, et. al., 2014) it is explained how was build the data structure of the research and how were construing the axiomatic entities which are in place of links and nodes.

The Network building of the ritual characterizes the states of transformation of different objects; the example that we take is the flower of the dead (*Tagetes erecta*).

In this way we expect to know, more deeply and based on formal testing, the consolidation of meanings and symbols.



State 1. Ego and his sons and nephews goes to the cementery and collected the flower seeds

State 2. Ego sun dry the seeds in his house

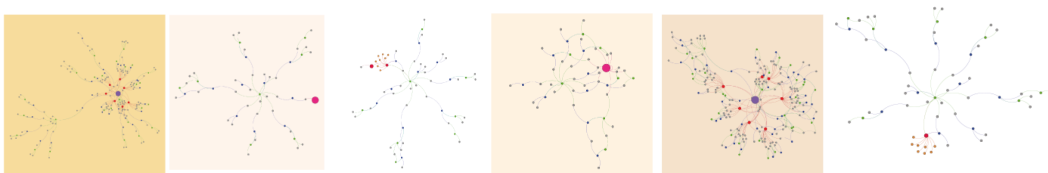
State 3. Ego keeps the raw material in the kitchen

State 4. Ego and his sons, grandsons and brothers germinate the seed in their fields or house

State 5. Ego and his sons, grandsons and brothers sow the seeds in their fields and other fields

State 6. Ego and his brother, sons, and nephews transplanted the first flower bud of the germinated seed

State 7. Ego and his brothers harvested flower



State 8. Ego takes its products to sell on the market

State 9. New NetEgo keeps the flower in the home sanctuary space

State 10. Ego and her grandchildren make a road of flowers from the sanctuary to the street

State 11. Ego and her grandchildren put the flower in the sanctuary

State 12. Ego and her family goes to the cementery and floral arrangement the graves

State 13. The Dead parents (in orange) come across the sanctuary objetcs

Therefore Network Density (ND)numbers are the average between the maximum potential connection and actual connections described in (3). To know the *clustering coefficient* in this state, it is substituted the k_i of formula (6) by the Network ND *and* n_i is the maximum potential connections defined in (9). According to formula (10) in the first state of the flower seed network there is a 56 % to of probability to consolidating meanings.

(10) $$C_i = \frac{2^{\frac{(3^{10})(3^{10}-1)}{2}}}{19(19-1)} = 55{,}941$$

Following the reasoning it can be obtain next data:

State	Probability to consolidating meaning	Network Density in a specific moment
1	58.9	.056
2	58.9	.051
3	58.9	.039
4	58.9	.066
5	58.9	.066
6	58.9	.062
7	58.9	.062
8	59	.016
9	53	.039
10	58.9	.034
11	58.9	.048
12	59	.016
13	58.9	.034

Based in the network analysis it was found that the probability to consolidating meaning is approximately the same in all the states. But the new qualities in the network and emergent patterns only can appear if the growing of the network is slower than the growing of the cluster coefficient. For example the states 12 and 8 have a network density thinner than the other states of the network, following the reasoning, in this states (the marketplace and the cemetery) new conditions of sense and meaning in the signs could appear.

PRELIMINARY CONCLUSIONS

To have a concrete conclusion is necessary get more data from others ritual. The next step in the research will be these and make adjustments to the formal model. However it is important to start with something:

1) In this case the aim was joint an epistemological conceptualization from semiotic view to a complex representation like undirected graph and networks.
2) The idea is that hard sciences and social science can be together in a systemic, holistic and rich image of the cultural and social world.

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