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*** Original Article**

Multribution: interaction and collaboration in network researches

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Abstract
We don't know the protocols to cognitively connect people in a network. Networks with people technologically mediated impose limitations and offer opportunities. On this prospective research we evaluate tools and ways of collaborative work and believe that neither the tools nor the correct methods for a very big number of researchers to interact for cognitive collaboration still don't exist. In a number over around 150 researchers, the capacities of intersubjective communication are overcome, but it's possible that we take advantage of the collective knowledge. The interaction in a virtual environment also allows the stigmergic interaction. Both concepts can be implemented with the help of genetic algorithms, that develop rules and capacities on the network and its knots. To this new form of network collaboration, we have given the name **multribution.**

Keywords
multribution; research collaboration; interactivity; Internet; stigmergic interaction

Introduction

Researches are even more advanced about how to connect machines on a network, than the ones about how to connect people on a network. We don't know exactly how to increase the capacity of a network of human minds. There are no studies about the "protocols" of this type of network.

The network activity imposes limits for people to do things the way they are used to. This happens because it demands a way of working, researching and learning, which has little to do with traditional practices. People, on the relationships they establish daily, collaborate in an instinctive way: they coordinate, cooperate and act in small groups, with no bigger efforts. But

when relationships become more complex, there's a need for the introduction of technologies. This has two apparently contradictory effects:

- On one side, instinctive collaboration becomes difficult. We aren't able to have the same intensity obtained through the collaboration mediated by intersubjective communication, where we perceive voice inflections, facial microexpressions, body gestures... All of this would allow a crucial emotional interaction. The system of mirror neurons, fundamental for empathy and learning of roles through imitation, cannot be used on this case.
- On the other side, the introduction of interactive technologies increases the possibilities of another type of collaboration. Teams of millions of people can collaborate in an effective manner, without the need for hierarchy, centralization or even common and conscious objectives.

In 1950, half of the publication on the field of natural sciences was produced by teams, a number which increased to 80% on the last years. The size of the teams was 1.8 researchers, and today it raised to 3.5 (WUCHTY, 2007).

Advanced scientific research either is collaborative, or doesn't exist. In isolation, a person cannot comprise the diversity of necessary knowledge, even to himself/herself. He/she needs the work of other people. And even if a scientist could create science on his own, he would need the criticism and evaluation of his job. This is also collaboration.

Antecedents

This research is a deployment, in parallel and complementary, of other researches and initiatives from Next, that start with the research about Virtual Communities in Health in 2006. This research, about virtual communities, aimed to take advantage of the particularities of the Internet and interactive technologies as a possibility to put into practice the SUS principles, of democratization and extension of the participation of users on the health system.

Due to the speed of development and innovation, and the amplitude of necessary expertise to comprise Internet, we proposed to constitute a Researchers Network for Internet and Health, building a collective intellectual that would allow to make it viable. For that, we started to build a Virtual Interaction Device as an environment for the construction of this network, which, on the other hand, lead us to the need to discuss the ways that would make viable the collaboration of a very large number of researchers. At first, it became clear for us that the traditional means of collaboration used by small groups of researchers didn`t make viable the collaboration in such a wide scale. Until the present moment, Next has researchers on Rio de Janeiro, São Paulo, Goiás, Argentina and Portugal, but our network tends to be widened to Spain and Venezuela and increase the number of people involved a lot.

Objetivos

The research about cognitive interaction and collaborative intelligence, from the Nucleus of Experimentation of Interactive Technologies - Next, from the Institute of Communication and Scientific and Technologic Information in Health from Oswaldo Cruz Foundation, is part of the research line about "Strategies and Policies for the Implantation of Interactive Technologies in Research, Education and Health", from the Fiocruz Research Group "New Technologies, Culture and Interactive Practices and Innovation in Health". We try to develop efficient means of learning and researching, that allow dozens, hundreds or thousands of people to contribute for one or more objectives, common or diverse, sharing not only drafts, documents or multimedia, but also actions, ideas, questions, answers, doubts, and everything that is necessary in a process of research and learning.

Today we have sophisticated tools such as Google Wave, social networks, *wikis*, etc. The problem is not knowing how they work, but discover how to take possibilities out of them besides the ones already proved and recognized. For that, we cannot move to a network the work means we used to use until now. It's not about overcoming what seems to be their limitations. Many of them cannot be overcome, and, in reality, from other logics, they are valuable resources. It's about taking advantage of network characteristics - such as absence of distance, decentralization, dislocation, absence of hierarchy, automation of processes, redundancy, multiplicity of knots and "centers", possibility of anonymity, sensorial limitation - and, by exploring them, to establish new forms of collaboration.

Method

It's a prospective research planned so that data are collected as soon as the events under study are observed. We are researching and using tools such as discussion boards, *blogs, wikis,* documents and collaborative searchers, Google Wave, etc.; concepts related to collaboration established on a network, such as stigmergy, *crowdsourcing* and collective knowledge; and experiences such as Wikipedia, the algorithm for Amazon recommendation, the Google "Page Rank" algorithm, that can show us methodologies to develop network researches.

Tools for collaborative research in networks

The most used collaboration tools by researchers, at the moment, are those with specialized functions: social markers, wikis, blogs, collaborative documents... Even when there are "complete" solutions ("packages") that offer all possible services, they aren't much popular, since the teams of researchers and workers have been developing processes that involve not only a single tool, but many tools: mail groups, *wikis, blogs*, *feeds* readers, collaborative documents. As much as "packages" seem to allow a flexibility and customization, they end up gaining a specialized character, due the imagined use by the ones who developed their programs. Their several functionalities are more or less developed due to their objectives and, this way, the option to combine and couple several tools seems more advantageous, developing this or that functionality that is most useful due the objectives it intends to develop.

On the other hand, we can distinguish between two types of tools: tools that take to the Internet only the traditional collaboration forms; and tools that take advantage the Web particularities and establish new forms of interaction and communication. Most tools use metaphors of the individual work environment in a PC, that, on the other hand, uses metaphors of the work forms of daily life, such as work areas, documents, files, mail, etc. This resource, which can be useful at first, becomes a barrier if worked in scales that go beyond the possibilities of immediate collaboration offered by intersubjective communication. In the end, these tools allow to use only one of the Internet characteristics: the absence of distance to communicate with people from different locations. It's the case of the Microsoft Office Live Workspace (http://workspace.officelive.com/) ou BSCW (http://public.bscw.de/).

Some other tools take advantage of some new forms of collaboration that the Internet provides. It's the case of tools that provide access to a network of contents and contacts, according to the researcher's interest. It's the case of Mendeley (http://www.mendeley.com/), CiteULike (http://www.citeulike.org/), Google Reader (http://www.google.com/reader/), among others. Some look for new operational forms of collaboration: this was the case of the late Twine (http://en.wikipedia.org/wiki/Twine), Shareflow (http://www.zenbe.com/shareflow), turned to companies, or Google Wave (https://wave.google.com/wave/), a total communication tool that will no longer be developed by Google, but will continue under development by the Apache Foundation.

Our team has decided to use the following tools:

- Wiki from Next (http://www.next.icict.fiocruz.br/wiki/). It shows the Next activities and allows anyone to participate. It has been shown particularly efficient for the group of researchers to have fast access to the group of team activities and the production of reports and collective planning, where each one adds their contribution due to their particular expertise and specific activities they develop. It also serves to the collective production of articles and projects. For example, the draft for this article can be consulted at (http://www.next.icict.fiocruz.br/wiki/index.php/Multribuição)
- Moodle Server (http://www.next.icict.fiocruz.br/wiki/). It constitutes the axis of the Virtual Educational Environment (with capacity to activate its other services) that allows the execution of EAD courses from Next and to develop the activities of the EAD Course Incubator, which will be offered to researchers from Internet and Health Network to develop courses and other graduation activities.
- Internet and Health Network (http://www.next.icict.fiocruz.br/social/). It can substitute the mail lists, Wiki and part of the Moodle activities, since it offers these possibilities.
- Next website (http://www.next.icict.fiocruz.br/), which is being rebuilt to fulfill the role of Next's institutional presentation and access to all services on its Interaction Device
- Delicious (http://delicious.com/nextfiocruz). It allows to share links
- YouTube Channel (http://www.youtube.com/nextfiocruz). It allows access to recordings of the Next activities and share videos related to its researches and activities
- JustinTV Channel (http://pt-br.justin.tv/nextfiocruz). It allows to access live the activities developed by Next.
- Mail lists in Google Groups. One of them (Virtual Communities on Health), is public, where people can share and discuss about topics of interest in the field of Internet and Health (http://groups.google.com.br/group/comunidades-virtuais-na-saude)
- Twitter accounts (http://twitter.com/nextfiocruz) from Next and several of its researchers. Another channel to divulge activities and subjects of interest.
- Personal accounts in Google Docs. To elaborate articles and documents among the Next members.
- Personal accounts in Google Reader. To read and share Internet contents
- Personal accounts in Mendeley. To share academic contents and access what other researchers have been doing in common fields. Under experimentation
- Personal accounts in Google Wave, under experimentation
- Google Coops searcher about Health. Under experimentation. (http://www.google.es/cse/home?cx=014839754898499767985:k0ndeooeglg)
- Personal accounts in Aardvark (http://vark.com/home). Under experimentation

Besides using the habitual inter-personal communication tools: profiles in social networks (Facebook and Orkut), Google email, Google chat, Skype, and other tools with very specific functions (Yuguu, Adobe Connect Now, Mindmeister, Google Books). Many tools have common functions, and, little by little, some are more used that others. Meanwhile, Elgg network, Wiki, Twitter, Justin TV, mail lists, Google Docs, Reader and Skype are the most used tools (not always used in all their functions). They basically constitute, through their coupling and articulation, on the Virtual Interaction Device (DIV) from Next.

Our habitual work process is as follows: researchers access the content of their accounts on Google Reader and other information services more connected to their activities, and share with others through mail lists, Twitter and Elgg network what they think to be of collective interest, or to some researchers. The website offers the Next activities, uses embed from YouTube, Justin TV, and makes connection (links) to other channels. Twitter does a parallel work. The Elgg network offers the Next activities, creating work groups and allowing anyone to add ideas, and tends to be the central DIV instrument. Scientific articles can be worked on the Elgg network *wiki* or on Google Docs. Besides, the Next educational environment turns viable and gives support to graduation activities.

These tools only intensify the possibilities of a person to person collaboration, but Delicious, Google Reader and Mendeley go beyond that. Google Reader offers contents suggestions: according to the users' activities; the more it's used, the better this will be done. Delicious allows to research through *tags* and use the intelligence of all users to search for contents of interest. And Mendeley does all that specifically with researchers, but still doesn't have a critical mass.

Collaboration tools have distinct usage scales: the public mail list has 93 users (October 1, 2010); on Google Docs the normal is an average of eight people collaborating in specific works; all Next members have Google Reader accounts that are shared among us. With a larger number of people, these tools would be useless and would create an overload of information. And we aren't only facing an operational problem (of the tool itself), but facing a cognitive problem of our species.

According to the size of their neocortex, simians form groups with bigger or smaller number of individuals. For the size of the human neocortex, according to varied estimates, the interaction-direct relationship is viable up to around 150 individuals. This is also, in general, the size of the humans relationship networks, the cognitive limit of stable social relationships, that a human being can keep. In order to make viable a larger number of relationships with coherency, a pyramidal structure of organization and authority is used (DUNBAR, 1998). In order to work in researches with teams larger than this number, the hierarchy resource is used. In fact hierarchy, in general, is present in all researches. It is only shown when results evaluated in pairs are published in prestigious magazines that are accessible for a much bigger number of researchers.

Cognitive collaboration needs a network of individuals (people). A network must allow communication among its knots (people), and not necessarily among everyone to everyone. And, for that, they must share at least one objective and rules for the contact and decision making. When we talk about research collaboration, we have to distinguish three levels:

- Coordinate research, where researchers decide which topics to research and who will research which topic. When institutions share sponsorships and grants, they are coordinating the research. The network can be centralized and little connected. The number of knots can be too big.
- Cooperative research, where researchers divide tasks for a common objective. The work obtained is the sum of the works performed by each knot under collaboration. It requires a coordination by one or more knots. The network is centralized to allow coordination, but it's interconnected for sharing of information. The number of knots can also be too big.
- Research that implies cognitive collaboration. The cognitive collaboration involves the collective resolution of tasks of cognitive type. This type of collaboration is a challenge, and this is the one we research. The traditional forms of collaboration need intersubjective communication, which limits the number of participants or demands hierarchy and defines the collaboration.

In order to understand the implications of this network cognitive collaboration, let's present some concepts.

Crowdsourcing

It is the act of giving a task to a third party, traditionally performed by a hired employee or contractor, delivering it to a numerous group or a community. The concept can also be used in research. This way, the amateurs astronomy uses *crowdsourcing*. Thousands of amateurs with their telescopes research the skies, divided into areas distributed among them, in spite of the discovery been done by one single person.

On *crowdsourcing*, only one can have the solution and not need the others. The objective can be reached by a single knot. The network is centralized from the knot that places the problem. It is a coordinated or cooperative research. But amateur science already exists for a long time, and the new *crowdsourcing* concept does not provide anything new, and only its translation on the economic and technologic field.

Collective knowledge

It's the fact the average common knowledge of a numerous group is better than the knowledge from specialists. But in order for this to exist, it's necessary diversity and independence of opinion, decentralized local knowledge and aggregation of individual answers. And data, some data.

Ronin Hanson and other economic and political scientists believe that the predictive markets (an efficient implementation of collective knowledge), where the mass votes and risks their money, can be used to guide scientific research (ARROW, 2010). In Brazil, we have http://www.mercadodeprevisoes.com.br/, an initiative that is sponsored by the Center of Enterprises of the Institute of Information Technology of Federal University of Rio Grande do Sul.

In order for knowledge to work, heterogeneity is very important. This doesn't work well with the research specialization. Another problem is that each person has to think and act in the most independent form as possible, but media influences people's ideas. With Social Internet, it's the virtual flow next to each person that provides data and the great medias lose value when facing personal recommendations. This sounds good for mass intelligence. And researchers have the so called "methodological individualism", that can assure independence.

Stigmergy

A concept created by French researcher Pierre-Paul Grassé. It's a spontaneous, indirect coordination mechanism, on which marks done by agents, on the environment, stimulate the development of a subsequent action, for a different agent or for the own agent. Through this mechanism, complexes and apparently intelligent structures, without planning, control and even direct communication among agents.

Ants as example

Ants have few capacities as individuals, but their collectives seem to have intelligence. An anthill is a network of ants that share objectives, capacities and rules. If we had a team of people with the objective of looking for food in a big area, in order to maximize our effort, we would have to imagine very complex capacities and rules. But ants do that with very simple capacities and rules.
Next, let's take what could be five of these capacities:
- To move and leave a trail of pheromones (that loses intensity).
- To identify pheromones from partners.
- To identify what is food.

- To identify what is the food storage.
- To be able to get the food.
And the network would follow four rules:
- To follow the strongest pheromones trail.
- If there is no trail, advancing at random.
- When finding food, get it and come back by its pheromones trail.
- When arriving to the food storage, leave it there and come back through its pheromones trail.

The algorithm with this capacity allows ants to optimize their activity and choose the shortest path to food. Rules are statistical (they tend to something). It's not only about a process that admits mistakes, but needs mistakes. Rules work as an algorithm, an algorithm that replaces very complex rules to obtain an optimal solution, for simpler rules that reach a solution, but need more time.

People

The oldest human system, that serves to collaborate, is based on the mirror neurons (KEYSERS *et al.*, 2010). The mirror neurons allow to transmit operative knowledge very easily, and also allow empathy, which is not conscious. Do we have a system to transmit another type of knowledge? Yes, language. The collaboration forms on humans are marked by their evolutional history, since we are social animals. The groups we form reach, in average, as said, 150 members. This is the limit number of people with whom we can have an intersubjective relationship. But human collaboration groups are much smaller. On human groups, adult males collaborated on hunting and adult females on collection.

Ants and other insects that use stigmergy are all similar. All have the same capacities and follow the same rules. Humans don't have the same capacities and may follow different rules. Meanwhile, stigmergy is used to treat relationships between insects or software. Humans don't use stigmergy, we use our "superior" communicative capacities, but there are cases where these capacities aren't the best. When we overcome the Dunbar number, these capacities are no longer useful (when groups turn into a mass, we act as instinctive animals: panic, for example). The Internet is a new flow where many actions performed by people work with this principle: users interact by local modifications of a shared virtual flow. Folksonomies are an example of stigmergic algorithm for the creation of categories. The Google algorithm for Page Rank is also partially stigmergic. We can consider that as examples of cognitive maps: marks left in the middle by individuals (agents) of a community to communicate (stigmergy) among themselves, which offer an information plan in the middle that the other agents can interpret (RIPEANU *et al.*, 2007).

The possibility of stigmergic collaboration networks

A stigmergic network needs objectives, capacities and rules. The rules can only be checked through statistics (they are tendencies, as said), and the process really needs mistakes to be reliable. In order to create a stigmergic network, we have to know the capacities of knots (people and devices) and decide which rules to follow. Even better, to know the people's inner rules, to enjoy them as much as possible or replace them if necessary. The Internet capacities depend on the application: electronic mail, Twitter, Google Reader... Rules depend, in part, on the application, but also on the person. We can also optimize a network process by increasing the number of capacities. It is here that we have to develop algorithms that can get, like the ants, that the result obtained is much bigger than what would be done by people alone.

Humans privilege their communication capacities through language in their relationships for collaboration. But, in certain cases, these capacities aren't the best ones. When selecting the path in a network, millions of people aren't better than millions of ants. Today, stigmergy is

used for common tasks, such as how to organize and recover pictures or products by qualities perceived, tagging them, which is a type of indexation. In reality, until then, it's nothing beyond an individual's attitude. The question is if it's possible to imagine rules and capacities that allow the emergence of properties or results that go beyond individual capacities. This is what we call stigmergic intelligence, which is beyond collaborative intelligence: "the stigmergic intelligence seems to reside not only in and among the agents in their totality (the traditional notion of collective intelligence), but on the interactions among the agents and the dynamically shared environment" (PARUNAK, 2005).

The evaluation system of scientific works by scientific references is a stigmergic system. The environment is the ecosystem of scientific magazines. The marks are the references. The result evaluates not only magazines with a bigger impact, but also works with the biggest impact. And this knowledge needs all scientific community to get known. A good example of stigmergy is the one on which the knowledge obtained is superior to the knowledge anyone can reach. A irrelevant research in a field can be very important in similar areas, and the specialized researchers don't notice that.

The problem with this system is that people have conscience of it and can interfere on it, transforming "marks" on the environment in conscious signs. It's like an ant were interested that its path were the most used and increased the deposition of pheromones. Therefore, a problem of human stigmergy is that individuals have conscience of the process and can interfere on it, transforming what has to be an index into false indexes, symbolic signs that perform the role of indexes. But when we work with large numbers, this type of procedure tends to become rare. The virtual environment allows the uniformity of the individuals' capacities and the production of reliable marks (indexes).
Johnson (2003) defines five rules for the construction of a system where there is macro intelligence.

1. There should be a critical mass of actors to generate a global behavior. And it's only through observation of all work system that it appears.
2. Development and intelligence are global. It's better to have many simple than a few complex. The question is if emergent systems are possible when their components are too complex.
3. There should have a certain randomization on the performance of rules, some mistake degree. Without the possibility of chance, the colony wouldn't be able to adapt to new environmental conditions or seek new sources of food.
4. The frequency of signs has to be measured. It's not only yes or no, but how much and when.
5. The network is locally connected, and has interaction with what's closer. But the ants move and increase the chance to connect to each other.

Stigmergy is possible using very complex elements, if they only use limited capacities and rules. The reference system, for example, is very simple. The marks (references) can happen or not, and their intensity depends on the flow they are produced (magazine). That's all.

The proposal

In order to find stigmergic rules that allow humans to develop results beyond their qualitative cognitive capacities, an intelligence beyond human intelligence is necessary. But... will we be able to recognize results beyond our capacities? We think so, our limitation is to create rules. So, we could develop rules in a manner extremely equal to nature, through proof and mistake. The problem is that this would take too long, since we would need to wait for the results of each group of rules.

To advance, we could use human models to make the process faster; create computer models of human collaboration in virtual environments and develop algorithms to research rules. This could make possible to find stigmergic alternatives, beyond our qualitative capacities.

The problem is that we have to model human capacities, and these are still beyond the computer capacities. One possibility is to try these models, even if they are imperfect, and then validate with human teams.

In order to develop algorithms, the most appropriate would be the path used by nature. But not as "*ant algorithms*", since they only seek solutions based on capacities and refined rules. We suggest the evolutional genetic algorithms, with a mixed system: people with their natural capacities and robots that follow rules provided by algorithms, to avoid the possible manipulation of humans (using evidences as signs). The objective would be to complement people with robots, developed with capacities and rules provided by genetic algorithms that compete among each other.

Genetic algorithms have the following computer advantages:

- They are intrinsically parallel. They can evaluate many possible solutions at the same time.

- They work well in environments where data and noises are mixed, and there are "optimum locations". They allow to find the best solution. In order to use genetic algorithms, we need to formalize population, the distinct environments (Internet), the objective (bigger yields in researches) and how the algorithms are reproduced (how they evolve).

The concept of *Multribution*

We call this type of emergent collaboration based on collective intelligence, that uses stigmergy in a virtual environment, with rules developed by genetic algorithms, of *multribution.* This new concept emerged in talks between one of the authors of this text and Guido David Núñez-Mújica, creator of the LavaAmp project (http://www.lava-amp.com/) and Next researcher. On this project, a fundamental task is to create a network of researchers that collaborate on biotechnology the same way they collaborate on the development of *open source software.*

Conclusions and new perspectives

For collaboration in small teams there are already great tools, but still little used. For bigger teams, it's necessary to develop resources with the help of stigmergy, considering collective knowledge.

A preliminary version of this text was discussed during the XI National Research Meeting in Information Sciences - XI ENANCIB 2010. This experience allowed an important feedback for the writing of the present article: no studies considering the existence of networks with multiple and several objectives were found, which means, decentralized networks are not considered, organized to perform several objectives from initiatives of several and dynamic groups, that are developed inside a collective movement. The research goes on, incorporating this finding. The provisory results show that developing all possibilities of collaboration through the Internet implies on a change of cultural habits, making new collaborative processes viable. And, still, that is necessary to develop sophisticated procedures that must go beyond the ones already known.

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