

Modeling the Information Society as a Complex System

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Abstract

Considering the Information Society -IS- as a complex system, we use complexity science tools to describe the processes that are taking place. The sometimes troublesome relationship between the new information and communication technologies -ICT- and society, gives rise to different problems, some of them unexpected. Probably, the Digital Divide -DD- and the Internet Governance -IG- are among the most conflictive ones. Being clear that some solutions should be found for these problems, certain policies are required. In this context, data analysis, as well as the construction of adequate physical models is extremely important in order to describe different future scenarios and suggest some control. Indeed, mathematical modelization helps for visualizing how policies could e.g. influence the behavior in a system of social agents. In order to show how this purpose could be achieved we have chosen, as examples, the Ising and a generalized Lotka-Volterra model for DD and IG respectively. We conclude that the social modelization of the Information Society as a complex system provides insights about how the Digital Divide can be reduced and how the a large number of ‘weak’ members of the IS could influence the outcomes of the IG.

Keywords: Information Society, Digital Divide, Complex Systems Analysis

1. Introduction

The intensive usage of the information and communication technologies -ICT- in daily life has given rise to the Information Society -IS- concept, as well as to different problems, some of them unexpected, for which it is clear that stable solutions should be found as soon as possible. Therefore certain policies are rapidly required. Neither their plan nor their regulation should be left to theoretical considerations only, but could be surely much focussed if some primary testing could be made before their implementation.

Due to the global ICT interconnections, information is transmitted almost instantaneously. But different societies and cultures have different reactions to the information received and different times to absorb it. In order to reach a “people-

centered, inclusive and development-oriented Information Society” the World Summit on the Information Society proclaims (WSIS-03/GENEVA/DOC/4-E, 12 December 2003), policies to be applied should be carefully analyzed as they need to fill up at least two different issues: a) to be acceptable for the national society, and b) to be coherent with the external conditions.

Our joint study concerning the Information Society is aimed at contributing to the definition of the most adequate policies that are required to achieve a harmonious IS.

This contribution is devoted to show how social, legal and ethical aspects of the IS can and should be analyzed using the concept of complex systems, as the IS has most of those systems properties, in the sense that societies and economies are interrelated in a nonlinear way and often self-organizing within some general constraints. For this reason the socioeconomic problems which are spread globally need solutions which should be adequate to each society. This is not a minor task: modelization to forecast future scenarios is necessary, as it would give at least a preliminary idea about the consequences of proposed 'solutions', especially when the speed at which interactions takes place in the presently globalized context is quasi infinite, because due to the new ICT, the context operates world wide on line.

Two relevant problems regarding the IS are treated in this contribution: (a) the Digital Divide -DD- and (b) Internet Governance -IG-, both to be further defined and briefly commented upon in Section 2. Up to now, these two problems have been expressed only through the perception of policy makers and social scientists, and there is little data to be analyzed.

On the one hand, measurements on DD demand, to begin with, a strict definition of the concept, and afterwards, careful design of polls and clear specifications about what is to be measured. Unfortunately, the existing data is not fully reliable, as the United Nations agency International Telecommunication Union -ITU- admits it.

“The STAT Unit verifies and harmonizes data, carries out research, and collects missing values from government web sites and operators' annual reports, particularly for countries that do not reply to the questionnaire. Market research data are also used to cross-check and complement missing values” (ITU ICT Statistics Database).

On the other hand, IG is an idea, proposed from a theoretical point of view that is suitable for the interests of corporations that disregard the role of states at the time of defining policies, especially about their regulation.

In this context, data analysis followed by the construction of adequate physical models which are able to describe different future scenarios that can be further discussed, appear to be if not extremely relevant, very much rewarding.

Our starting point is the survey of the ongoing policies and proposals, such as those that can be considered to be the outcomes of the WSIS, for instance, the Internet Governance Forum -IGF-; see Sect. 2.

Our main aim is to give *a priori* probable future scenarios, to suggest the more adequate instruments to avoid DD and to design policies for IG. In order to do so we have used two much worked models taken from statistical physics to investigate each case respectively in Sect. 3. For DD we use the Huang's version of the Ising model (Huang) and for IG a multiagent (so called prey-predator approach) system.

2. The Information Society

Beyond the concept of Information Society posed when

“... the OECD acknowledged that the economy of tomorrow will be, to a great extent, ‘information economy’ and the society will become ‘information society’ which means that

information will account for a significant part of added value of most goods and services performed and information intensive actions will become distinctive of the households and the citizens" (WSIS, 1998),

and leaving aside, for the time being, the discussion about whether it is or should be named 'Information Society' or 'Knowledge Society', the fact remains that today this concept involves important social issues, many of them unexpected in the nineties.

2.1 About 'policies'

The meaning here given to the word 'policy' is a course of action or inaction chosen by public authorities to solve, in most cases, an interrelated set of problems (Wolf) derived from the complex nature of the Information Society. One main question is if such problems can be solved by means of policies **for ICT** or whether they should rather be policies **for the Information Society**.

Considering that "the Information Society 'will' affect most aspects of our lives", European policies range from the regulation of entire industrial sectors to the protection of each individual's privacy (i2010). Contemporarily, in Latin America, current programs for IS are likely "to promote public policies for the advancement of development-oriented IS, by aligning policies on the use of ICT for development; to promote transparent and participatory interaction" (e-lac). For different realities, the same need of policies. Moreover, such policies should be both adequate to each society and globally.

2.2 The 'Digital Divide'

Among the problems regarding the IS, and probably the most conflictive of them, is the problem that makes the world to be divided in people who do have and people who do not have access to modern information technologies. This problem is called the Digital Divide -DD-. But, as the examples below show, the DD has no univocal meaning.

In Europe, the problem is considered in terms of 'Broadband gap policy', which is concerned with the geographical aspects of the digital divide among EU regions. In the USA, the DD seems to be analyzed in terms of individual's option:

"a study published by the Pew Internet & American Life Project has found that there is a growing digital divide across America. Whilst a reasonable number of Americans are embracing new technology and Web 2.0, a disturbing number are either not getting the message, or are choosing not to participate." (Riley)

For Latin America, the relation digital divide / social coherence is considered relevant not only by social scientists, but also by international organizations such as CEPAL (Hopenhayn). However, corporations restrictedly analyze the problem in terms of telecommunications infrastructure (OECD). And, in Africa where for most people even making a telephone call is still a remote possibility, cellular phones and Internet telephony are considered as if they were 'taking on the Digital Divide'.

In short, given the reality of today's competitive socio-economic scenario, societies appear to be divided between those who are 'in' -included- and 'out of' -either excluded or not included- the IS. But, beyond the ideas of those that analyze the world as if it were all alike Europe (Derrida, 1987; Foucault, 1984), the DD involves the gap between the educated and uneducated, between economic classes, and the more and less industrially developed nations. The Dependency Theory has demonstrated that the cause of such a dual society is the lack of endogenous growing capability (Cardoso-Faletto, 1969). From another theoretical position, it has also been proved that whereas the developed societies have endogenous growing capability, the

underdeveloped ones lack it (Romer, 1990). So, policies are required to bridge the gap.

2.3 The Internet Governance Forum

From a theoretical viewpoint, it is unconceivable that the Internet, being a global network, should be submitted to the national state regulation of each connected country. Neither should it be submitted to the national state regulation of one given country. In fact, Internet would be an ideal example of an institution that can only be ruled by international law; but it is not. Neither scientific nor political significant efforts are being made in this direction.

On the one hand, the WSIS is committed to governance, a term that corresponds to the so-called post-modern form of economic and political organizations. Governance has, at least, six different meanings: the minimal State, corporate governance, new public management, good governance, social-cybernetic systems and self-organized networks (Rhodes, 2007), most of them focused on legitimating projects of neo-liberal inspiration (de Senarclens, 1998).

“Governance can be seen as the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences” (UNDP).

On the other hand, some authors maintain that the cyberspace shows a somehow feudal character that emerges from the hierarchical privatization of its government associated with the granting of Internet domains (Yen, 2001; Elkin-Koren, 2004). That's why the Internet's government, like that of a feudal society, is highly fragmented (Yen).

In the Tunis phase of the WSIS -November 2005-, governments asked the UN Secretary-General to convene a Forum, with the mandate to discuss the main public policy issues related to Internet Governance in order to foster the Internet's sustainability, robustness, security, stability and development. (WSIS-05/TUNIS/DOC/6(Rev.1)-E). The Inaugural Meeting of the Internet Governance Forum -IGF- took place in Athens, in November 2006 and in November 2007 a Second Meeting took place in Rio de Janeiro.

The different criteria for listing participants (see Provisional Lists) in both meetings prevent us from making an accurate comparison. It can be said, however, that companies, trade associations and non profit organizations fully committed to the Internet made, in both of them, a wide majority among the ‘Entities’, a somehow ‘private sector’ category that seems to be supposed to represent the ‘civil society’. But, such organizations can also be found among “International Organizations”, provided they have any kind of international activity –ISOC Italy being an example of this statement-.

Leaving aside the current discussion on state or non-state regulation (de Souza Santos-Rodríguez Garavito, 2005), there is no doubt that there must be some kind of regulation regarding the Internet, and that such a task demands

“the full involvement of governments, the private sector, civil society and international organizations” (WSIS, Tunis Agenda, 2005, 2).

“In addition, there is a need to consider the following other issues, which are relevant to ICT for development and which have not received adequate attention: ...Activities on ICT-related institutional reform and enhanced capacity on legal and regulatory framework” (WSIS, Tunis Agenda, 23, j).

The Chairman's Summary of the second meeting provides good material to analyze the debate regarding the legal aspects involved. The document shows, among several

appeals to self-regulation and soft law instruments, a consistent demand of state regulations. An ECLAC document (Newsletter N°4) informs, however, that

“Representatives of Brazil introduced a variety of proposals about how to reform the ICANN, restricting its function to that of a coordinating organization. There was an extensive discussion about the future of the ICANN and its relationship with the USA Department of Commerce, whereas Brazil recommended the creation of a new international agency, composed by representatives of the civil society, to rule the access”.

The Chairman’s Summary alludes to this debate, but records neither authors nor proposals.

“Other points covered the relation of governments to ICANN and whether it was appropriate for the Government Advisory Committee (GAC) to have only an advisory role as opposed to fuller powers in terms of international public policy. While one panellist argued that the participation of governments in the GAC was one of ICANN’s most important features, another put forth that the current model with GAC as part of ICANN was not a stable model.”

2.2.a Introducing Non-State Actors

“A vast literature has developed over the last few years that theorizes and empirically studies novel forms of governing the economy that rely on collaboration among non-state actors (firms, civil organizations, NGOs, unions, and so on) rather than on top-down state regulation. ... From this viewpoint, the solution lies neither in the state nor in the market, but rather in a third type of organizational form –collaborative networks involving firms and secondary associations-” (de Souza Santos-Rodríguez Garavito).

The long quotation above is intended to show its direct correspondence with the following words.

“The international management of the Internet should be multilateral, transparent and democratic, with the full involvement of governments, the private sector, civil society and international organizations” (WSIS, Tunis Agenda, 2005, 29).

This is merely one of several similar paragraphs that can be found in WSIS documents. Such seemingly horizontal and democratic statements hide the fact that, apart from state and market, only the elites or members of the middle-class with the economic and cultural capital shall be stakeholders in the IG (de Ortúzar-Olivera-Proto, 2007).

3. Mathematical modelizations of the Information Society

A mathematical modelization would help us to visualize if policies could influence the behaviour in a system of social agents or not. In order to attain this purpose we have chosen the Ising model and a multiagent (prey-predator-like) model.

3.1 The Ising model approach to Digital Divide

The Ising model is one of the pillars of statistical mechanics. When developed by analogy toward sociophysics one considers that the world is composed of sites at which are located agents (originally magnetic moments); they “interact” with others in their neighbourhood; each site (agent) can have two values i.e. +1/-1; for simplicity we will consider that the underlying site network is a square lattice. Here we use it as a neighbour behaviour model. As in the Ising original version, the present model is analyzed in terms of two parameters: the temperature of the system and the external field. The simulations have been made using the method developed by Caiafa and Proto (2006).

In our description, the temperature is associated to the *degree of interest* or relevance concerning a given situation, in this case to be ‘in’ or ‘out’ of the IS, while the external field(s) represent(s) the *applied policy(ies)*.

We intend to show how policies (the external fields) are able to accelerate the arrival at a desired situation (in the present case to have more agents ‘in’ than ‘out’ the IS). For simplicity, here below we take the temperature to be the same in all the simulations.

The lattice, which represents a given ‘society’, has 100 x 100 agents. The initial situation in each simulation is taken at random, between +1 or -1 for the initial agent values. The evolution in time (arbitrary units/iterations) without an external field, is considered to be a situation without policies. If we apply an external field (let us say, $H = 1$, arbitrary units), that represents a certain policy, and it is possible to follow the evolution within the ‘in’ and ‘out’ agents (Fig. 3). Finally, we apply a more adequate policy (external field $H = 2$ arbitrary units). The images and plots of the evolution of number of agents with value +1/-1 is shown, indicating that the appliance of adequate policies would drastically reduce the evolution time required for the society under analysis, in order to arrive to more ‘in’ than ‘out’ agents situation. Comparison between figures show that if an external field is not provided, (i) a lower number of agents shall be found ‘in’, and (ii) it takes around three times longer for the same evolution range.

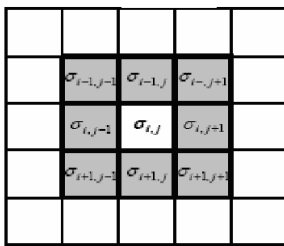


Fig. 1
Neighbor structure, each agent has eight neighbors with whom to interact.

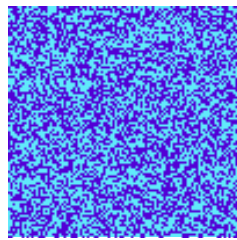


Fig.2
Bidimensional plot showing initial situation of each agent. Blue dots are the ‘in’ agents (+1) and cyan the ‘out’ (-1) ones, as in the following draws.



Fig.3
Bidimensional plot showing the ‘stable’ situation of each agent without an external field (without policies)..

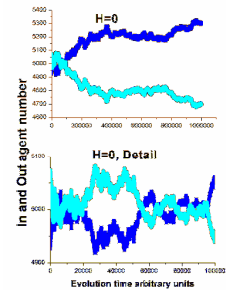


Fig.4
The number of ‘in’ and ‘out’ agents, plotted versus time/iteration. (without policies)..



Fig.5
Bidimensional plot showing the ‘stable’ situation of each agent. An external field ($H = 1$, arbitrary units), certain policy, is applied.

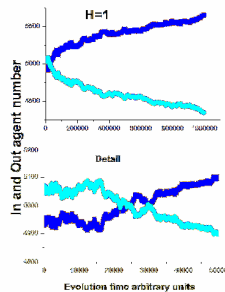


Fig.6
The number of ‘in’ and ‘out’ agents, plotted versus time/iteration, for $H = 1$.



Fig.7
Bidimensional plot showing the ‘stable’ situation of each agent. An external field ($H = 2$, arbitrary units), strong policy, is applied.

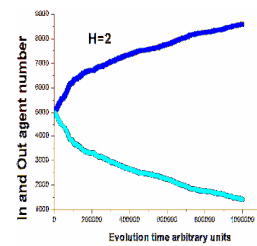


Fig.8
The number of ‘in’ and ‘out’ agents, plotted versus time/iteration, for $H = 2$.

Taken as example an interacting agents society (Fig.1) in which some agents are in, and others out, distributed at random (Fig.2), and leaving the system to evolve alone – this is, not adding any policies- the ‘in’ and ‘out’ agents nucleate -form two definite

fields- and the population of both categories is more or less the same and seems to be bound to stay still. This is a DD state (Fig.3). Now, by means of applying certain policies, the analyzed society acquires more mobility. The agents offer resistance against the policy, what is shown in the strong transitory with rises and drops (Fig.4-6). Finally, some of them move slowly from ‘out’ into ‘in’, but the final result of such movement, being faster, is not much different. A policy aimed to impel ‘in going’ decisions has been adopted, but its outcome has not proved it to be efficient. The ‘in’ field has made a significant progress in Figs.7-8. What has happened? It seems that the particular society under analysis has been provided with the required induction. In other words, the policies here adopted have proved to be more adequate than the previous ones.

3.1.a Some results of actual policies

For example, in 2006, in Sao Paulo 54% of the entrepreneurs had access to Internet, but only 47% of their firms had at least a personal computer, and that access was used for on line bank and governmental services and e mail in an 83% (SEBRAE, 2003). On the other hand, the Argentinean firms in GBA not only had the equipment in the assets -93%- but also access to Internet -90%-, but made poor use of it -62% procedures, 49% on line banking services and 80% e mail- (UNLP, 2005). Why is it that Brazilian entrepreneurs did such an intense and dynamic use of ICTs, even ‘outsourcing’ the access to Internet? The answer might be in the policies the Brazilian government adopted.

In Brazil the Information Society -e government being a part of it- is a state policy (Wilson, 2004), not ‘one government’s’ policy. Consequently, successive governments have developed a strong program based on early decisions aimed to discourage physical presence when on line procedures are possible. It seems that Brazilian policy makers have found the adequate external field –policy- in order to accelerate the arrival at a desired situation -agents’ dynamic interaction using ICTs, even by means of someone else’s equipment-.

3.2 The Internet regulation as a multiagent system: The Lotka-Volterra model

To give a more concrete exemplification of the discussion on state or non-state regulations, and particularly to enhance the importance of the participation of non-state actors, it is adequate to appeal to a simple semiempirical modelization of the problem at hand. We develop the model introduced by Lotka (1925) and Volterra (1931), and applied it further herebelow to model the competition between web sites (Maurer - Huberman, 2000) and in hung scenarios in sociology (Caiafa - Proto, 2006). The set of N differential equations (Maurer - Huberman) of the model is the following:

$$\frac{df_i}{dt} = \alpha_i f_i (\beta_i - f_i) - \sum_{i \neq j} \gamma_{ij} f_i f_j$$

where $\frac{df_i}{dt}$ means the time derivative of f_i , and indexes $i, k = 0, 1, \dots, N-1$. The f_i , is the *weight of the i agent opinion*, at time t , with summatoria the f_i equal 1. The parameters of the model are: α_i , the growth rate of the agent i , β_i , the saturation value of the agent i -agent. In order to introduce the effect of the ‘size’ of the agents we have modified the growth rate parameter α_i according to Economo et al (2005) as:

$$\alpha_i = \left(\frac{a}{b_i} \right)^4$$

where a is the *selection pressure* which is, for simplicity hereby taken to be equal for all the agents living in the same environment (here the Information Society) and b_i is the parameter which reflects the *inverse of agent competitiveness*, for example, in organizations theory it is associated to the ‘cost to do something’ (Porter, 1980). In our case, the competitiveness should be understood as the cost imposed to the agent’s ideas/interests to be accepted in the regulation of the Information Society. This modification of the growth makes it possible to take the agent’s ‘size’ into account as suggested by Economo et al (2005).

In our model we have introduced two kinds of agents:

- a) The ‘well-established in the Information Society agents’; let us call them Old (O) they are e.g. ICANN -the gatekeeper of the Internet-, software companies, Internet providers and NGO involved in the development of communications and the Internet. These agents presently lead the ‘*de facto*’ management of the net. We call them stakeholder.
- b) The agents that are trying to find a seat in the Information Society Governance. These are ‘civil society agents’, like NGO, individuals, SME and the like. We can also include in this category several governments that still haven’t definite policies about IS, or more specifically for an egalitarian KS. We call them New (N), or participant.

3.2.a Simulation results

For the present work, in order to illustrate the analysis, we consider only ten agents, keeping $a = 1$ equal for all agents which means that we assume that all agents, living in the Information Society, are equal supporting equal *selection pressure*, defined above. This means that, ideally, all the agents have the same rights as regards the *policies for the sustainability of the Information Society*. So, we only vary the agent competitiveness, to look at the evolution and determine the long term *weight* (importance of its opinion) of the i -agent, f_i . Also for simplicity we keep $\beta = 1$. The γ_{ij} values are fixed and all equal to +1 or -1. The O agents are in competition among themselves, through their γ_{ij} sign (-1) which is the same in all the simulations. In Figs. 9 to 12 we show the evolution of f_i for a situation where there are 40% O agents (each having a different $b_i = 0.10, 0.11, 0.12$ to 0.13) and 60% N agents with each having a different b ranging from 0.41 to 0.46, differing by 0.01 (0.4, 0.41, 0.42, 0.45, 0.46). The initial condition on f_i for both, the O- and N- agents is equal to 0.1. The simulations show that when N do not cooperate among themselves (Fig.9), their weights remain always below all the Old’s weight, so, their opinions remain not relevant or do not count faced to the O’s opinions. In such a scenario, “governments, the private sector, civil society and international organizations”, that are not well established actors in the Information Society yet –in other words, mere PARTICIPANTS-, shall not have any chances for their demands, as regards as the Information Society’s regulation, to be attended. But, we have also found that, when N agents cooperate among themselves, the weight of the opinions of O and N get closer and closer and that there is even a chance for the opinions of N to win (Fig.12) when all of them are in a cooperation scheme.

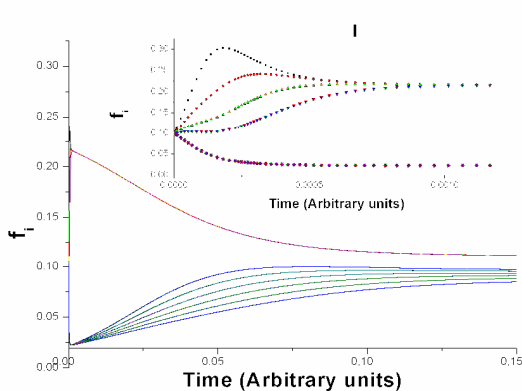


Fig. 9

New agents do not cooperate and Old agents compete among themselves. Blue line Old agents (superimposed behavior) I: Transitory regime. Violet line: New agents (superimposed behavior). Black, red, green and blue Old agents. As before, some curves are superimposed.

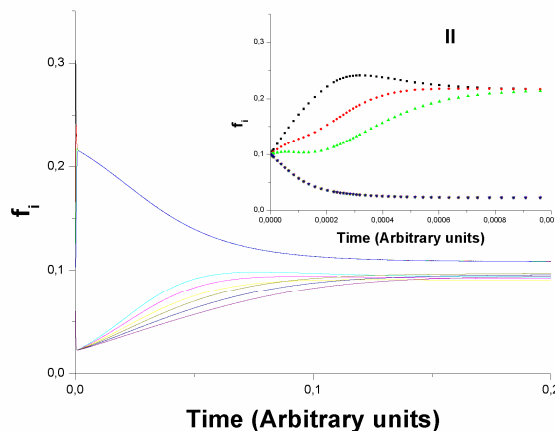


Fig.10

Fifty per cent of the New agents cooperate and Old agents compete among themselves. II: Transitory regime, colors as in Fig. 9.

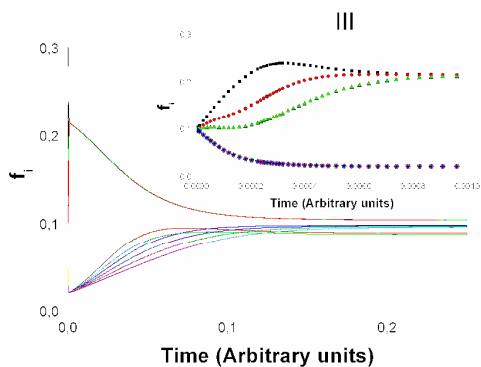


Fig. 11

Sixty six per cent of the New agents cooperate and Old agents compete among themselves. III: Transitory regime, colors as in Fig. 9.

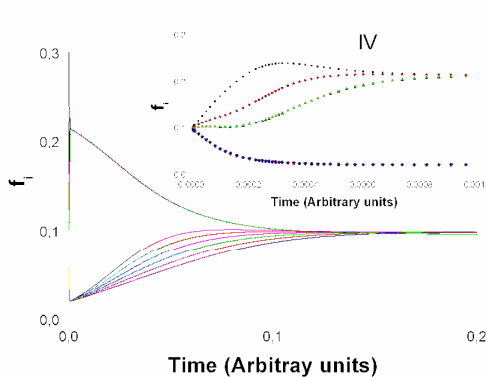


Fig. 12

One hundred per cent of the New agents cooperate and Old agents compete among themselves. IV: Transitory regime, colors as in Fig. 9.

In these figures cooperation allows New agents to become more and more powerful.

3.2.b Interpreting policies in the light of the model

Coming back to the Internet Governance context, in the Chairman's Summary we read:

“There was a clear convergence of views that governments had an important role to play in creating a solid regulatory framework and making sure that the rule of law was well established and respected”.

We can ask convergence of whose views? And, looking for an answer, revise the figures above and wonder whether it was a convergence of views of individuals, of organizations or of contributors. We can also question in whose benefit has such a demand been posed?

As the simulation results show, there is a chance to achieve a scenario where, by means of cooperation among N agents, their demands are attended. There are many weak agents among the N, but there is also China, Brazil and some relevant independent NGO. From such a further developed scenario might emerge the rules

for a widely comprehensive and satisfactory government of the Internet-. It might also set the basis for the legal and political frames of the Information Society.

Conclusion

Numerical simulations with the Ising model let us see that the appliance of adequate policies reduces drastically the time required for the society under analysis, to arrive at, almost, all 'in' agents. If external field is not provided, a lower number of agents shall be found 'in', and it takes around three times greater evolution range. Thus we have learned that, in many situations –countries, regions, social groups-, defined policies should be implemented in order to encourage people to move 'in' the Information Society.

Through the multiagent system, we arrive to the conclusion that to attain an active role in the Information Society, and therefore participate in policies decisions, the N agents should cooperate among themselves (See Figs 10-12). We have even some indication of the order of magnitude of the number of necessarily cooperating N agents in order to overthrow the O opinion/attitude/ and how long it takes (see Figs. 10-12).

In both cases simulation results lead to solutions which are clearly equivalent to the consequences that some social scientists have forecasted, in terms of theoretical explanation of phenomena that are actually comparable to those that are taking place within the Information Society.

In summary, the social modelization of the Information Society as a complex system provides insights about how the Digital Divide can be reduced and how the huge majority of 'weak' members of the IS would influence the outcomes of the IG and, in so doing, allow the Internet Governance to "be multilateral, transparent and democratic".

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