The Paradox of Elegance –
A Very Short Introduction to the Topology of Complex Social Systems and the "Small World"-Paradigm in the Realm of Law

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Abstract. This paper aims to follow up the proposal of the AISB'09 Convention organizers in order to promote the interchange of knowledge and methodologies between the "multi-agent systems"-analyses and the "social network" perspectives. The idea is, first of all, to summarise ten years of research on the "small world"-paradigm and to present the most recent work on the topology of complex legal systems. In light of the extraordinary discoveries achieved in this field, we then stress limits and open problems, both at theoretical and practical levels, of the new paradigm. Law seems, indeed, a good field in which scientists can deepen that fundamental interchange of knowledge and methodologies we need in the study of contemporary social systems.

1 INTRODUCTION

In order to promote the interchange of knowledge and methodologies between the "multi-agent systems"-analyses and the "social network" perspectives, this paper comes in four sections.

First, we summarise ten years of research on the "small world"-paradigm and, hence, we recall some work on the topology of complex legal systems.

Secondly, we present our own research and results over the last three years on some possible applications of the paradigm to extremely hot legal issues of today's debate as it happens with privacy and copyright.

Thirdly, we mention some other possible applications of the paradigm to the "multi-agent systems"-approach as in the case of the development of legal ontologies.

Finally, we stress both limits and problems of the "small world"-perspective. Notwithstanding its merits in current legal research, Gregory Chaitin's paradox on the "elegance" of computer programs recalls why we cannot demonstrate to have find out Leibniz's (and even Gödel's) characteristica universalis. Law is indeed a good field in which to test that interchange we need among different theoretical outlooks that deal with complex social networks.

2 THE LAST DECADE OF THE "SMALL WORLD" PARADIGM

Since the idea of small world-networks first appeared in the pioneering work of Stanley Milgram and later with the sociological research of Mark Granovetter, in few years it has become one of the key words of contemporary scientific research by fostering a large set of empirical studies on the topology of complex systems. Of course, significant effort has been made in order to structure analytical models able to capture the nature of small world-networks. Here it suffices to mention only three of these. The first one was proposed by Watts and Strogatz [1998]: they suggested to rewire randomly a small fraction of the edges belonging to a low-dimensional regular lattice in order to prove that the degrees of separation in the network would exponentially decrease. In fact, the peculiarity of the small world-model depends on the apparent deviation from the properties of both random and regular networks since, like random networks, small world-networks present a short characteristic path length but, like regular networks, they also have high clustering coefficients. This model considers social networks as a structured and ordered world with nodes in the graph tending to be linked each other when they share one or more neighbors. Moreover, random links can determine some shortcuts to distant nodes, thus limiting the diameter of the network.

However, this first small world-model is not easily applicable from an "algorithmic" perspective: Milgram's experiments, as well as everyone's experience in ordinary life, prove not only that shortcuts exist, but that people in a social network are able to find them, with some approximation. This means that if we want to define the behavior of a rational agent living in a small world, we can also assume that he/she can reach a distant point in few steps using local information and without a global "bird's eye view." Hence, distant nodes are not simply linked in a random way, like the small-world model suggests, because connections are biased toward closeness or similarity criteria. Kleinberg [2000] extended the model in order to capture this effect observed in real life networks.

On the other hand, the third work we need to mention is Barabási's research [2002]: Indeed, he noted that most real world networks grow by continuous addition of new nodes whereas the likelihood of connecting to a node would depend upon the node degrees. In other words, this sort of special attachment in a growing system explains what Watts and Strogatz apparently missed, i.e., the power-law distribution of the network in a topological scale-free perspective. This means that most real small world-networks are characterized by few nodes with very high values and by most nodes with small degree. So that the presence of hubs, i.e., a small fraction of nodes with a much higher degree than the average, is the key to comprehend why small world-networks in the real world can be both highly clustered and scale-free when small, tightly interlinked clusters of nodes are connected into larger, less cohesive groups.

To shed further light on the new paradigm let us introduce its legal applications by considering two studies from 2005. The first work is by Seth Chandler [2005] who built an electronic map of 26000 decisions issued by the U.S. Supreme Court from early 19th Century till now. He assumed each case as a node of

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the network and each citation as a link while links between nodes are intended as directional arrows rather than simple lines. The result is a network with very low density that nevertheless also has a main core. In fact, only 258047 out of 365 million possible citations really exist but there also are decisions among the large group of weakly connected cases that are both well cited and interdependent. These decisions are the hubs of the network and, not surprisingly, Chandler claims that this main core substantially concerns "rights of free speech and association under the American constitution." [2005, 20; and Pagallo 2007, 205] More particularly, we have got 122 nodes each with 28 or more links to the other cases of the main core so that the density is more than 500 times greater than the density of the network as a whole. By grasping these cases as hubs of a small world-network, it becomes then easy to understand why any First Amendment decision would reverberate more readily through law than a decision made in any other field. In a nutshell, hubs offer the common connections mediating the short path lengths between other nodes in the network.

These results were (partially) confirmed in June 2005 by Thomas Fowler and Sangick Jeon who presented the network of 30,288 U.S. Supreme Court majority opinions from 1754 to 2002 (actually, they also accounted for the decisions of the Supreme Court of Pennsylvania contained in the first volume of the U.S. Supreme Court Reporter). Again, each case is considered as a vertex or a node of the network and each citation as an arc or a link. The total number of links to and from the node represents its degree (in and out). The overall result is a list of all of the cases that are connected together by 220,500 citations according to the power-law distribution of a small world-network. From this viewpoint, it is not only possible to highlight the "good hubs" (well cited) as well as the "good authorities" (most interdependent nodes) of the network. We are also able to follow the rise and fall of a precedent's importance in a continuously evolving legal system such as the U.S. common law. While the most authoritative cases before the American civil war involved freedom of contract, namely the contract clause, after the war and until the end of the 1930s with the New Deal, the main core became balance of power in order to regulate commercial issues in a federal system. Whereas this perspective confirms Chandler's conclusions – in that the contemporary main core of the U.S. Supreme Court jurisprudence is given by rights of free speech as Justices shifted their focus towards civil liberties – Fowler and Jeon also back up our network perspective. "In particular, the power-law tail in the degree distribution of inward and outward citations in the precedent network suggests that there is something systematic about the evolution of law that mimics the evolution of other network phenomena." [2005, 33]

3 LEGAL TOPOLOGIES

There are two main applications of the "small world"-topological approach to complex legal systems.

First, it is possible to deepen the analysis of some fields of artificial intelligence and the law concerned with the study of legal reasoning and argumentation through computational methods as in the example of case-based legal reasoning, of knowledge discovery in legal databases, or of legal information retrieval [see Pagallo, Ruffo 2007a]. For instance, we can determine which are the most connected cases, i.e., the hubs of the network in the double perspective of good hubs that cite many good authorities and good authorities cited by many good hubs. By quantifying the grade by which some decisions accelerate the transmission of ideas in the legal network, we obtain two kinds of precedents, i.e., well founded in law and influential. From this further standpoint, electronic maps permit not only to determine and quantify the authority cases of the legal network while comparing them with expert rankings, in that the small world paradigm also fits several other realms of law. We have electronic maps built on the articles of the U.S. federal commercial code, on the network of legal decision-making both at Capitol Hill and in Stockholm, but even on scholarly publications [as shown by Th. Smith 2005].

However, there is a second possible realm of applications due to our network approach: Indeed, after Barabási's work on the Internet and the Web, several scientific papers have demonstrated the existence of small world-patterns and power laws-distribution of information that characterize any peer-to-peer system at different levels. For example, there is a significant evidence of spontaneous clustering of users by content distribution in, say, both Gnutella and Kazaa systems as shown by Iamnitchi et al. [2004] and Ruffo et al. [2008]. Whereas different models can be used in order to detect this phenomenon like "data-sharing graphs" or "affinity networks," what is striking is the fact that the topology remains the same of such complex networks as the U.S. Supreme Court jurisprudence or the Web studied by Barabási: notwithstanding the nature of the system or its peculiar constituents, the probability that a vertex in a complex network is connected to other vertices decays according to a power law. So, it is possible to exploit these topological properties of the network in order to get some interesting applications on recommender systems, digital privacy, and copyright.

On one hand, our work shows how hubs can be considered as vectors for exploiting all the very opportunities of this technology in order to protect personal data. As we illustrated in previous work [i.e., Pagallo, Ruffo 2007b], it is still Gnutella's small world-features that suggest to adopt a decentralized recommendation scheme based on spontaneous affinities. By exploiting partnership degree and users relationships it is not necessary to get user profiles and users are not required to give feedbacks to a data collector entity. In other words, we do not need to trade off personal data for digital personalization and data protection on the Web, because there is a brilliant way to update Amitai Etzioni's [2004, 45] dichotomy between "liberalizing technologies" and public protective ones. On the other hand, it is not a mystery that hubs may be intended as simple targets in order to break these spontaneous networks and, hence, these new emerging digital communities. As a matter of fact, legal troubles of P2P systems prove, among other things, that the topology of these systems can be (and has been) exploited to develop new methods for attacking copyright infringements [as discussed in Pagallo 2008a-b].

Yet, the panoply of all possible applications, pro or contra privacy, pro or contra copyright, does not imply that technology should be considered as something "neutral," i.e., a simply means to obtain whatsoever end. Rather, it is important to remark the mutual interaction through which technology reshapes both legal concepts and their own environmental framework, while political decisions influence or attempt to

determine possible developments of technology. After all, legal troubles of P2P systems with both copyright and privacy interests illustrate some peculiarities of the U.S. legal system as well as some key differences between U.S.- and EU-law determined by the same technology.

4 LEGAL ONTOLOGIES

One of the most fruitful ways to produce formal descriptions of knowledge is currently the development of "structured dictionaries" and research efforts on formal ontologies. For example, Gianmaria Ajani and his research group have shown many interesting applications, including a tool based on an ontology designed to recover legal information and build conceptual dictionaries. Avoiding as much as possible the polysemy of legal terms as well as terminological and conceptual faux-amis, an experiment has been conducted on taxonomy, where "terms are supported by a clearly identified concept inserted in a knowledge structure of a text and related to the other concepts that belong to such a structure." [see Ajani, Ebers, 2005] From a technical viewpoint, it is quite interesting to stress the "bottom up fashion" starting with legal terms defined by scholars. Actually, a traditional "top-down approach works well for the topmost level, where the basic conceptual primitives are precisely defined (concept, relation, role, qualia, processes, etc.), and the representation instruments are put at the disposal of those who build the ontology." [Lesmo et al. 2007] But, alas, a lot of problems arise when core ontology level is involved.

From our perspective, it would be very interesting to shed light on the topological aspects of these experiments by considering the semantic hubs of the network since it is not unlikely that further electronic reconstructions of legal networks as, say, in the case of ECJ jurisprudence or, in Italy, of the Constitutional Court would present some known features: high clustering coefficients, short diameter, main cores. So, we have three different applications.

First, at a national level, it would be easy to compare hubs within a same legal field of the network, in order to highlight both affinities and discrepancies of different national legal systems. While a semantic approach to legal ontologies has to select terms, a topological approach indicates which terms are fundamental for comparison, confronting, for example, authority scores with expert rankings.

Secondly, a linguistic field as legal science evolves, so that a topological approach would make it possible to follow the semantic evolution of the network. For instance, by taking into account the jurisprudence of the European Court of Justice, it might be very interesting to investigate how the main core has changed throughout the decades, measuring the authority score of, say, its first fundamental sentences in institutional cases (as in the paradigmatic example of the Kompetenz-Kompetenz issues).

Finally, it is still the topology of our system that obliges us to concentrate on the hubs of every taxonomy. Indeed, even in the case of linguistic systems it is highly probable to find determinate clustering coefficients that go along with a diameter shorter than that of regular networks. The set of nodes with highest degree could represent the main core of the taxonomy in so far as our empirical research would conduct us, with fair probability, to the shortest average distance-concepts with their specific grades of "betweenness." This means that these special hubs will probably be the nodes mostly tested by scholars in order to check the quality of the taxonomy. In scientific research, this outlook really offers a good way to think about our own "trials and errors."

5 THE PARADOX OF ELEGANCE: A CONCLUSION

We gave you a short account of the research on the small world paradigm and the topology of complex legal networks over the last ten years. Its outcomes are remarkable: we do know that this is the case of various complex social networks as the Internet and the Web, the jurisprudence of the U.S. Supreme Court and the network of legal decision making both at Capitol Hill and in Stockholm, the articles of the U.S. federal commercial code and the information shared via P2P systems on the Internet. These topological properties have been exploited in several different ways. Think of it as electronic maps in order to describe the semantic structure and evolution of legal networks, or as recommender systems to avoid overloading information and to guarantee privacy on the Web. In any case, it is always as if we were witnessing "something systematic about the evolution of law that mimics the evolution of other network phenomena." [see again Fowler, Jeon 2005, 33.] So, could we have found Leibniz's (and Gödel's) characteristica universalis via the small world-paradigm?

We do believe this is not the case for a couple of reasons.

First, there is a practical explanation that concerns Friedrich Hayek's classical distinction between cosmos and taxis, i.e., evolution vs. constructivism, spontaneous orders vs. human (political) planning. In a nutshell, Hayek's idea was that the informational complexity of cosmos should not be reduced by any taxis and, furthermore, orders spontaneously evolve from such informational complexity. This means that any constructivist approach as some multi-agent systems-perspectives suggest cannot cope with all the complexity of contemporary legal systems; moreover, even if you deal with cosmos complexity through a small world-topological viewpoint, it is certainly possible to describe and follow how complex social systems evolve but, alas, you cannot foresee or determine their evolution!

The second reason is theoretical and formalizes the very connection of information and complexity in contemporary legal systems. It may be summed up with Gregory Chaitin's thesis [2005, 125] on why you cannot prove that a program is "elegant," i.e., the smallest possible program that produces that particular set of theorems you have to deal with when analysing the informational complexity of the legal cosmos. In fact, if there were such an algorithm, we could always use it to find all the elegant programs!

This paradox of elegance, of course, recalls us the best epistemological output of the debate in the 1900s, i.e., "falsificationism."

In this context, however, we would like to stress another provisional morality: Both for practical and theoretical reasons, even (good) scientific results do not authorise to assume a close and self-referential perspective. This is why we believe work on social topology and small world distribution of information in (social and legal) complex systems should remain open and

ready to promote the interchange of knowledge and methodologies among some of the most interesting and promising fields of contemporary scientific research.

REFERENCES

[1] Ajani, Gianmaria and Ebers, Martin (eds) [2005]. Uniform Terminology for European Contract Law. Baden-Baden: Nomos Verlag.

[2] Ajani, Gianmaria et al. [2007]. The Multilanguage Complexity of European Law: Methodologies in Comparison, edited by G. Ajani, G. Peruginelli, G. Sartor, and D. Tiscornia, Florence: European Press Academic Publishing.

[3] Barabási, Albert-Lázslo [2002]. Linked: The New Science of Networks, New York: Perseus.

[4] Chaitin, Gregory [2005]. Meta Math! The Quest for Omega, New York: Pantheon.

[5] Etzioni, Amitai (2004). How Patriotic Is the Patriot Act? Freedom versus Security in the Age of Terrorism, New York-London, Routledge.

[6] Fowler, Thomas and Jeon, Sangick [2005]. The Authority of Supreme Court Precedent: A Network Analysis, on line at http://jhfowler.ucdavis.edu accessed 20.12.2008.

[7] Iamnitchi A., Ripeanu M., Foster I. [2004]. Small-world file-sharing communities. In Proc. of the 23rd Conference of the IEEE Communications Society (InfoCom 2004). Hong Kong.

[8] Kleinberg, J. [2000] The Small World phenomenon: An algorithmic perspective. In Proceedings of the 32nd ACM Symposium on Theory of Computing (STOC 2000), pp. 163-170.

[9] Lesmo, Leonardo – Boella, Guido – Mazzei, Alessandro – Rossi, Piercarlo [2007]. Multilingual conceptual dictionaries based on ontologies: analytical tools and case studies, in The Multilanguage Complexity of European Law, op. cit., pp. 179-194.

[10] Pagallo, Ugo [2007]. "Small world" Paradigm and Empirical Research in Legal Ontologies: a Topological Approach, in The Multilanguage Complexity of European Law, op. cit., pp. 195-210.

[11] Pagallo, Ugo [2008a]. Let Them Be Peers: The Future of P2P Systems and Their Impact on Contemporary Legal Networks, paper for the Infosoc meeting on "The Future of… Conference on Law and Technology" organized by the European University Institute, Fiesole, Florence, on Oct. 28-29, 2008, at http://www.one-lex.eu/futureof/ and to be published in a special edition of the European Journal of Legal Studies (EJLS).

[12] Pagallo, Ugo [2008b]. Ethics Among Peers: From Napster to Peppermint, and Beyond, paper for the 5th itAIS Conference on "Challenges and Changes: People, Organizations, Institutions and IT" organized by the Italian Association for Information Systems in Paris, France, on Dec. 13-14, 2008, at http://eventseer.net/e/7947/ and to be published by Springer, 2009.

[13] Pagallo, Ugo and Ruffo, Giancarlo [2007a]. P2P Systems in Legal Networks: Another "Small World" Case, in "Eleventh International Conference on Artificial Intelligence and Law", Acm: Stanford, CA., pp. 287-288.

[14] Pagallo, Ugo and Ruffo, Giancarlo [2007b]. On the Growth of Collaborative and Competitive Networks: Opportunities and New Challenges, in Ethicomp Working Conference 2007, edited by S. Rogerson e H. Yang, Yunnan University, pp. 92-97.

[15] Ruffo, Giancarlo and Schifanella, Rossano [2008]. A Peer-to-Peer Recommender System Based on Spontaneous Affinities. in ACM Transactions on Internet Technology (TOIT), ACM Press, New York, NY, USA. (forthcoming).

[16] Smith, Thomas A. [2005]. The Web of Law, San Diego Legal Studies Research Paper No. 06-11. Available at SSRN: http://ssrn.com/abstract=642863 or DOI: 10.2139/ssrn.642863.

[17] Watts, Duncan and Strogatz, Steven [1998]. Collective Dynamics of "Small-World" Networks. Nature, 393, pp. 440-442.