The Social Impact of P2P Systems

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Abstract The chapter deals with the social impact of P2P systems in light of a bidirectional connection by which technological developments influence, in a complex and often unpredictable way, the social environment whereas the dynamic evolution of the latter does affect technological progress. From this perspective, the aim is to deepen legal issues, sociological trends, economical aspects, and political dimensions of P2P technology, along with some of its next possible outputs, in order to assess one of the most compelling alternatives to the traditional frame of highly centralized human interaction.

1 Introduction

Although known to computer scientists and networking professionals for decades, peer-to-peer (P2P) systems only became widely popular in the late 1990s with the Napster case and, then, with the U.S. Court's decision in *MGM v. Grokster* in 2005. These developments, of course, affected legal scholars, who have paid increasing attention to P2P systems in recent years. However, their impact goes beyond the law and also raises issues of relevance for economics, sociology, and political science. This is particularly true if we understand P2P systems not only as simple "sharing

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networks", but also, at a more abstract level, as massively distributed platforms for information storage and retrieval.

Therefore, the aim of the chapter is to highlight, in a necessarily non-exhaustive manner, the main research developments in the above-mentioned fields. We suggest that there is a clear bidirectional connection between the technological features of P2P systems and their various social effects. Technological developments influence, in a complex and often unpredictable way, the social environment (i.e., economics, sociology, politics, and law) whereas a dynamic situation in a given social environment also shapes the way in which technological evolution proceeds, favoring certain architectural choices over others. In short, each affects or gives feedback to the other in a continuous cycle. For example, a strongly decentralized and encrypted P2P architecture providing plausible anonymity for its participants will have different social ramifications and effects than those flowing from a weakly decentralized system in which the origin and destination of information can be traced with relative ease. At the same time, the technological developments that make one system rather than another possible will also be affected by the social environment, that is legal frameworks, economic decisions (including public funding), political orientations, and the sociological and cultural perceptions found in the society where the technological research is taking place and its results are diffused.

These inter-related developments are examined in five sections, each of which focuses on a specific field, namely legal issues (Section 2), sociological trends (Section 3), economic analyses (Section 4), political dimensions (Section 5), and, last but not least, some new horizons and perspectives that our society will be forced to cope with in the future (Section 6).

Of course, this overview does not purport to exhaustively discuss all the possible influences of P2P systems over the fields of human action, nor all the ways in which the complex composition of such different elements as law, economics, politics, sociology, and culture, tends to encourage, steer or limit the rate of development of certain P2P architectures over others (or, if one is pessimistic, the development of P2P architectures altogether, as opposed to centralized, one-way communication systems [67]).

Rather, our attempt should be taken for what it is: a humble, but hopefully stimulating, contribution to a better understanding of P2P systems as technological products that cannot actually exist in a vacuum, but in a complex environment with its own set of rules, constraints and possibilities.

2 Legal Issues

Among the most traumatic impacts of P2P systems on the legal field since the late 1990s, copyright issues have undoubtedly taken the forefront for a while. Technology has in fact changed societal behaviors of copying, distributing and, in general, handling information and information-based goods and services, according to a transformation that has deeply influenced legislative initiatives and scholarly

discussions on the topic. Digital copyright is mostly a matter of access and control over information in electronic environments, so that legislators and courts have been obliged to rethink the traditional relationship between creators, producers, and consumers of informational goods. For instance, the U.S. Congress approved both the *Digital Millennium Copyright Act* (DMCA) [39] and the so called *Sonny Bono Act* in 1998 [37]; three years later, the European Parliament and the Council enacted the directive on "copyright and related rights in the information society" [36]. Then, in the U.S., the Congress passed the *Consumer Broadband and Digital Television Promotion Act* (2002), the *Family Entertainment Copyright Act* (2005), and the *Net Neutrality Bill* (2006), while, in Europe, the IPRED saga has been ruling: the first directive on the enforcement of intellectual propriety rights is from 2004 (n. 48), and later the European Parliament supported a new version (IPRED-2) on April 25, 2007.

Courts have been very active, too: the first important decision on copyright and P2P systems was in July 2000, when the U.S. District Judge Marilyn Patel granted the *Recording Industry Association of America* (RIAA)'s request to stop making copyrighted recordings available for download thanks to the Napster services. Even if the San Mateo company did not store any information such as the recordings on its own computers, it was considered against the law to provide the information of the songs available on the computers of the community logged on [39]. It is not enough, in other words, to affirm that the DMCA grants immunity to ISP providers for what their customers do, because this kind of protection does not include "contributory infringers" (as the District Court of Appeals determined in its own decision on Napster, in February 2001).

Four years later, it was the turn of the U.S. Supreme Court in *MGM v. Grokster* to consider P2P systems, such as Streamcast or Grokster, as a form of technology promoting the "ease of infringing on copyrights," so that its producers "can be sued for inducing copyright infringement committed by their users." Notwithstanding this unanimous holding by the Court, the legal consequences on further developments of P2P technology remained unclear. The Supreme Court justices were indeed divided in their arguments, between the need to protect every technology "capable of substantial non infringing uses" as they declared in *Sony v. Universal City Studios* from 1984, and the necessity to provide remedies against new ways of copyright infringement. So far, in the U.S., the problem is to determine whether software is creating "shared files folders" to make "available for distribution" that very information protected by copyright that would be shared via those folders [40].

In *Elektra v. Barker*, (see [33]), for example, Judge Kenneth Karas from the Manhattan federal court rejected the RIAA's "making available" theory in January 2008, even if he admitted the sufficiency of the allegations of "downloading" and "distributing", giving accordingly RIAA an opportunity to reformulate pleadings. Whereas Karas' idea is to represent the issue with the legal hypothesis of "offering to distribute for purposes of redistribution," it seems more fruitful to remark that the suit, in *Elektra v. Baker*, was based upon a report of an Internet investigator who claimed to have detected the "illegal files folder" we presented above.

In fact, the process of investigating alleged copyright infringements by P2P networks raises another central legal issue besides copyright, that is privacy. In the quest for new tools to help their fight against illegal file sharing, both the movie and music industry have posed serious dilemmas to Internet users, as it occurred some years ago with a highly controversial decision involving an American ISP, Verizon, and, again, the RIAA. The reason is that "the privacy of Internet users participating in P2P file-sharing practices is threatened under certain interpretations of the DMCA [as] a new form of *panoptic surveillance* that can be carried out by organizations such as the RIAA." [26]

Again, this privacy deadlock took place in summer 2007, when the *Motion Picture Association of America* (MPAA) asked and, according to federal judge Florence-Marie Cooper, it should have obtained the IP addresses of those connecting to TorrentSpy files via their service in the U.S. Forced to enable server logging against its own privacy policy, it is noteworthy, however, the different conclusion of the case: TorrentSpy, which servers are physically located in the Netherlands, announced its decision to stop doing business in the U.S. on August 27, 2007.

Despite the general tendency to reach harmonization in copyright law, there is indeed a clear difference of approach to P2P-related privacy issues between the U.S. and the European Union [49]. If a property standpoint prevails in the former legal system, privacy is widely considered as a fundamental right in the latter, as proclaimed by both the European Convention from 1950 and the EU Charter of Nice in 2000, let aside the specific constitutional traditions of each Member State. Conceived as a matter of protection, access and control over personal data, the traditional concept of privacy as the "right to be let alone" has evolved due to the same technological revolution that has conducted from traditional copyright to digital copyright. Thus, digital privacy has become one of the most relevant legal issues debated in recent cases, insofar as, at least in Europe, access and control over information allegedly reserved to copyright holders must respect P2P users' personal data.

For example, this is what took place in Italy in 2007 with the so-called "Peppermint" case. Although the legal reasoning of the court is rather complex [11–13] it is possible to summarize some key elements of its decisions in order to show the central role played by data protection laws. The facts are technically (but not legally) simple. A German record company (Peppermint Jam Records GmbH) suspected a large number of Italian users were downloading, without proper authorization, music from its catalogue via P2P networks. Hence, the copyright holder commissioned a Swiss company (Logistep AG) to monitor the activities of all the computers connected to those P2P networks. Logistep used a "crawler" which was able to connect to any P2P network as a normal client; but rather than simply exchanging digital files with other clients, Logistep's program recorded in its database additional data – including the IP addresses as well as date and time of the connection – of all the users who were sharing a file. Consequently, we have a twofold problem.

First, it is not entirely clear whether Logistep has been monitoring only users who were uploading (or rather, making available) Peppermint's songs on the Internet, or whether it was checking those who were downloading as well.

Secondly, it is likely that the database created by Logistep was, and still is, hosted in Switzerland, which raises a set of major legal issues insofar as the data "travelled" outside Italy and, so, outside the European Union.

In any case, the story went on partially as in the aforementioned TorrentSpy case. The plaintiff had indeed required before a section of the Tribunal in Rome to get from the Internet Service Providers responsible for collecting the IP addresses, the identity of the subscriber(s) using a specific IP address at a particular time and date. The tribunal of Rome accepted the request twice, therefore forcing the relevant ISPs to disclose such identities. So that, in spring 2007, a Bozen law firm representing Peppermint could send to every of the 3000 identified subscribers a "personalized" letter in which it was required a sum of EUR 330 for settling the case as a "partial compensation for damages, legal and technical expenses."

Nevertheless, a subsequent decision by another section of the same Court changed the whole picture on June 16, 2007. In a nutshell, the court affirmed that claims of the plaintiff, i.e., of the copyright owner of the songs being exchanged on P2P networks, should be duly balanced against the rights of P2P users, namely by protecting personal data as a fundamental right. Again, legal technicalities of the court's reasoning remain complex as they involve an analysis of the legislation on data protection, copyright and telecommunications, both at the Italian and European Union levels, along with various considerations on procedural safeguards which were not respected by allowing a private company to perform what amounts to be a full-blown police investigation. Still, the core element of this new decision seems evident: while personal data protection has been recognized by the Italian Constitutional Court's jurisprudence as a fundamental right, it is not admissible to conceive copyright protection as a justification for extremely invasive monitoring techniques.

In order to confirm how data protection laws are extremely relevant when defining cases on P2P file sharing systems, let us finally recall a recent decision made by the European Court of Justice in the "Promusicae" case (C-275/06) on January 29, 2008. In fact, the court was asked by a Spanish tribunal to clarify whether national law was compatible with the law of the European Union, because it did not seem to oblige ISPs to disclose identities of their subscribers for alleged violations of copyright law (as Promusicae, an association of Spanish music producers, was claiming). Indeed, the Spanish court was not asking the European Court of Justice to take a decision on the specific facts of the case, for it would simply have gone beyond the ECJ jurisdiction. Rather, it demanded the correct interpretation of EU law on this matter, pursuant to article 234 of the EC Treaty.

Put it shortly, the decision has been a double one: on one hand, it states that it is not required for any legal system of EU Member States, such as Spain, to make such disclosure compulsory. But, on the other hand, such a compulsory disclosure would not be incompatible with the law of the European Union. As the European Court of Justice affirmed, "when transposing those directives, the Member States [must] take care to rely on an interpretation of them which allows a fair balance to be struck between the various fundamental rights protected by the Community legal order. Further, when implementing the measures transposing those directives, the

authorities and courts of the Member States must not only interpret their national law in a manner consistent with those directives but also make sure that they do not rely on an interpretation of them which would be in conflict with those fundamental rights or with the other general principles of Community law, such as the principle of proportionality."

So, the conclusion is that a delicate balance must be found here, insofar as P2P systems do not only involve private claims about possible copyright infringements, but also privacy concerns about data protection in digital environments. If we stressed how legal scholars still discuss, in the U.S., on the possibility to ascertain whether P2Ps are a technology capable of substantial non infringing uses, it is thus clear that, at least in Europe, such a copyright protection must go along with the fair respect of P2P user's personal data. A different constitutional approach to the informational nature of human beings and their relationships in digital environments leads in fact to a divergent way of understanding the most relevant legal issues created by this technology. As a first striking example of that bidirectional connection remarked since the introduction, the social impact of P2P systems involves different legal outputs that shape the very evolution of this technology.

3 Sociological Aspects

The legal misadventures of Napster and its ruin in 2002 are a good standpoint to introduce the sociological aspects of the analysis on P2P systems. Indeed, Napster was a centralized P2P network with a number of servers keeping information on the peers – namely, the files that each peer made available for distribution over the Napster network which answered to clients' searches for a particular file.

As we saw in the previous section, it was in fact this architecture to be considered illegal by the Courts: The operators of the central server(s) used to index each peer's files so that they could have intervened to stop copyright infringements. Of course, it can be questioned that the simple exchange of a file would automatically imply copyright infringements, therefore ignoring all of the defenses afforded by "fair use" and other similar doctrines. However, the point is to remark how the following generation of P2P systems has moved toward a more massively distributed way of sharing and exchanging information on the Internet.

Instead of a hierarchical network in which one central hub still represents its vertex, the horizontal nature of post-Napster P2P systems makes it difficult to impose centralized controls over the dissemination of information, reflecting, in some ways, the original design for the Internet. Besides, this horizontal architecture creates wider opportunities, both in scope and quantity, for the production of information on the Web. Yochai Benkler calls this process "commons-based peer production" to define collaborative projects such as free software [8–10], while Michel Bauwens proposes to interpret it as "the relational dynamic of distributed networks" where hubs may exist but are not obligatory as it happens with the Internet [7]. From a sociological viewpoint, however, it is important to stress, first of all, that

several scientific papers have demonstrated the existence of so-called "small world" networks at various levels of any P2P system.

This new research relies on and deepens previous sociological work by such luminaries as Stanley Milgram [44] and Mark Granovetter [24, 25] on small world-social networks, or Friedrich Hayek's research [29] on spontaneous evolution of social systems. In fact, as in Milgram's "small world problem," the degrees of separation between nodes are significantly reduced in P2P systems, so the diameter of the network is quite shorter than that of a typical regular system. The reason was anticipated by Granovetter's seminal work on "the strength of weak ties," insofar as a small number of random links reduces exponentially the diameter of the network. If you consider for example a regular network with twenty nodes, each of which has four links, nodes would require an average of five steps in order to reach each other. But, it is sufficient to randomly rewire three nodes to decrease the degree of separation from five to three. This means that in a system of six billion people as contemporary world can be represented, it is enough to have only two random links out of ten thousand regular connections to determine the degree of separation in the network as small as eight. When random links increase from two to three, the degree of separation reduces from eight to five, i.e., something very close to Milgram's first approximation more than forty years ago!

This paradoxical property of small world-systems with clustering coefficients higher than those of random networks, and diameters shorter than those of regular ones, characterizes the spontaneous evolution of many complex networks. Let aside biological corroborations, as in the case of the C-Elegans' neural network studied by Duncan Watts and Steven Strogatz in 1998 [62], this occurs with the Internet as shown by Albert Làzslo Barabási in 2002 [6], or with both the jurisprudence and the majority opinions of the U.S. Supreme Court analyzed by Seth Chandler [14], James Fowler, and Sangick Jeon in 2005 [21], or, last but not least, with contemporary research that has found significant evidence of spontaneous clustering of users according to content that is distributed in P2P systems such as Gnutella or KaZaA [46, 47].

Furthermore, this latter research on P2P systems proposes several methods that can be used to detect the small world-phenomenon in various networks, including "data-sharing graphs" as in [31] or "affinity networks" as in [54]. The reason why lots of real complex social networks are spontaneously developing this way, can thus be understood according to Hayek's ideas on cosmos [29] with the dynamics and evolution of spontaneous orders, for high clustering coefficients and short diameters are the key parameters to understand how the distribution of the information is optimized in complex social systems (see [45]).

Yet, we are still missing a fundamental point. In Barabási's terms [6], real networks like the Web present a power law distribution that goes along with its characteristic "long tail" of information. It is in fact a tiny fraction of nodes extremely connected in the network, namely its hubs, that produces a peculiar scale-free effect dubbed as the "rich gets richer"-phenomenon, or, in Barabási's jargon, the "anti-democratic" nature of the hubs. This way of distributing information in a network has partly been confirmed by the aforementioned work on the U.S. Supreme Court

jurisprudence, and on P2P systems as well. As the topological research of all the papers published in the history of U.S. legal journals confirms, most of the articles are scarcely consulted even by their authors, and only a very small percentage of essays is massively quoted by scholars! So, as it occurs with the phenomenon of globalization, the legitimacy of the hubs depends on the clustering coefficients of the network. What P2P systems obtain, most of the times, spontaneously on the Internet, is precisely what contemporary globalization lacks: shortening the diameter of the network via its hubs does not mean you have got higher clustering coefficients in the system [48].

However, some other scholars claim that proper P2P systems do not need any "subcenter," hub, or Super-peer, as it occurs with decentralized P2P networks, index authorum, or the jurisprudence of the U.S. Supreme Court. The idea is that only the relational dynamic that arises in distributed networks can properly be called "peer-to-peer" (see [7] 2.1.A). This is not, of course, a simple matter of definition or of fantasy, in a world with no "authoritative" nodes anymore. Rather, it is entwined with the evolution of collective intelligence [41, 63], cognitive capitalism [16, 60], and even netarchy [7].

So, after "spontaneous evolution" of P2P systems with their legal problems, between cosmos and taxis in Hayek's phrasing, it is time to shed further light on such a topic of classical philosophy via the economic analysis of P2P systems. The idea is in fact to deepen both the impact of this technology in contemporary society and the dynamic situation through which social environment shapes the way technology evolves, insofar as it was just economics, after all, the first field in which Hayek developed his analysis on cosmos and taxis, namely on the very connection between spontaneous orders and human planning.

4 Economic Trends

Let us start our economic section on P2P systems as we did with its legal issues, that is by focusing, first of all, on copyright topics: in fact, the impact of recent technology on society and economy can be introduced with current debate on DRM (Digital Rights Management [42]) vs. DRM-free systems. In particular, some time ago, Steve Jobs [32], in his public speech "Thoughts on Music," criticized DRM systems that Apple has been imposing in order to protect its music against piracy. This approach brings however to a paradox: while DRM-protected digital music is prevented from being played by devices of different producers, DRM-free content, which uses open formats (e.g., MP3 for music and MPEG4 for movies), can conversely be downloaded, distributed, copied and played on different devices. This diversity involves an implicit disincentive to legally buy copy-protected digital content, because only DRM-free files are mostly interoperable: after all, 97% of the music filling iPods is unprotected and of unclear origins.

Jobs' conclusions – echoing theses already expressed elsewhere [20] – are thus surprising, inasmuch as they suggest both to abolish DRM systems and to sell music

encoded in open formats. Yet, even if the dream of a "DRM-free" world would finally occur, there is no obvious reason to believe that copyright infringement, one of the main reasons that has been alleged for the introduction of DRM systems, would decrease as such. Rather, it is likely that future legal market-models will have to consider serious, scalable, efficient, secure, and reliable alternatives to DRM-based centralized on-line stores.

The P2P paradigm seems to provide a technologically mature framework for this domain, possibly making digital content-sharing applications a valid solution even for small vendors and emerging artists. In fact, small-medium actors in the market-place could hardly afford production and maintenance costs that can be very high when distribution is provided by means of a resilient Content Delivery Network (CDN) architecture (as used, for example, by iTunes, Yahoo!, or Microsoft Media Shop).

Furthermore, the combination of DRM technologies with centralized systems might arise several problems. It suffices to stress the complicated procedures that users of Yahoo! Music Store will have to go through just to get either a reimbursement or a DRM-free copy of the songs they have purchased, due to the announced (at the time of this writing) closing down of the service and specifically of the related DRM servers [65]. While it is hard to say whether this represents either the failure of DRM technology as implemented in the market or simply of Yahoo! Music Industry, it urges to rethink both the media market and the role of P2P systems.

Despite their huge potentials, we already explained why P2P systems have become infamous as file sharing applications that make particularly easy for users to access copy-protected files for free. Indeed, it is very difficult to trace peers' activity, and identification of abuses cannot be easily performed, given the absence of a central authority. Moreover, a business model is hard to find. It is questionable who should be involved as a provider in the transaction: should it be only the owner of a given object or also other actors? In the same way, P2P distribution frameworks lead to technical advantages, but their economical benefits are far from clear. Consider the case of the purchaser who becomes distributor of that good later on: why should he/she provide properly the content if the owner wants to be reimbursed?

Another general perspective opens up by considering that P2P networks offer the ideal scenario to exploiting the Long Tail business [3, 4]. The reason is that they promote a perfect infrastructure to sell a large number of unique items in relatively small quantities. Up till now, it is well known that centralized architectures are efficient and dependable, when servers are replicated and content is fairly cached. Therefore, even if CDNs are still expensive and hard to maintain, they are preferred by (dominant) content providers for enabling a resilient market that can be easily controlled and managed. On the contrary, P2P systems are scalable in principle and they can largely help providers reduce administrative costs, the problem being to determine whether this technology is mature enough for a dependable, fair and profitable market place infrastructure.

Besides, the economic and technological convenience of P2P systems seems to depend on selfish or altruistic users' behaviors (as illustrated by the notorious free-riding phenomenon [1]). Of course, the introduction of some mechanisms that

provide incentives (e.g., the BitTorrent's tic-tac-toe strategy [15]) can stimulate cooperative behavior between users in order to fight the negative outcomes of free-riding, like degradation of the system performance, unpredictable availability of resources, or, under the most unfavorable circumstances, the complete collapse of the system. But, again, it is far from clear how a P2P based-economic model could be certain to prevent all of these flaws.

In any case, when discussing on the economic role of P2P systems in the real world, we need to keep in mind that the entire product's value-chain has really been upset. This is the main reason why "P2P economics" is a very active field nowadays, with many attempts to define the human interaction which occurs in the digital environment, according to the theory of informational goods, the Internet distribution chain with its variable and marginal costs of production and distribution, along with network externalities [55], cognitive capitalism, and the very value of the "network information economy" [10]. Some scholars [7] have even claimed that their work on P2P systems shows that a new paradigm is emerging, thanks to the superiority of the "free software/open sources" model as key of a new P2P economics.

Within this context, let us grasp here some peculiarities of the P2P business model by focusing on roles and interactions identified in [30], and referring to the Oslo's tutorial on "Peer-to-Peer Market Places" [53]. Although different application/service styles can be taken into account for a generic discussion, for the sake of simplicity (and also for the relevance of the topic) we will focus mainly on digital content-sharing and distribution.

First of all, we need to compare the digital domain with the traditional value-chain of a media object (e.g., a movie, or a music album) that is characterized by five distinct services or phases: authoring, production, distribution, delivery, and consumption. Authoring is related to the creation of the artifact, and may include a pre-production phase, for example with the preparation of a demo tape to be presented to a content producer. Production starts with a contract between the content author and a business organization, like a record company, adding a relevant value to the object. In this phase, the artifact is usually refined by a team of professionals, and finally copied on a given physical support, like an audio CD. The record company starts the distribution of produced objects, according to a given marketing strategy. Physical objects are shipped all around the country (and, sometimes, the world), increasing the cost of the artifact by means of transportation service-suppliers that would be using airplanes, trains, and so on. All the objects are delivered to the distributed network of malls and shopping centers that provide the final link to the customers, fixing the ultimate price for each single object. Finally, the client consumes the product, ideally closing the chain by paying a fee that covers all of the costs augmented after every step of the cycle.

Digital technology literally disrupts this value-chain. In fact, distribution and delivery collapse in one single service that is provided by a fully integrated information system implemented by means of complex server architecture, such as a CDN. This is the case of popular on-line stores, like iTune or Amazon that connect customers and content owners more rapidly through the Internet. In order to understand roles and interactions between market's actors, we report in Fig. 1 the model presented in [30].

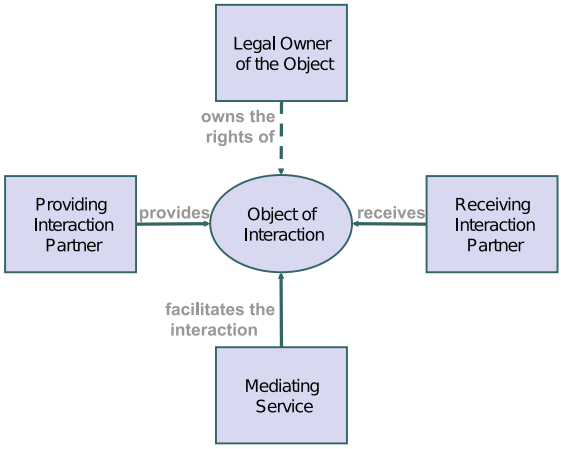

Fig. 1 Roles and interactions

The main problem with P2P markets is that peers in the network can interchange all these roles. Quite trivially, a receiver can become a provider of a previously retrieved digital content in further interactions, due to the servent (both client and server) nature of a node. Nevertheless, in principle every user can access the P2P system to insert a digital object, and as a consequence the owner of the object can have the role of a provider, with or without third parties mediating between the authors and the market. Finally, a mediating service, such as a search engine, can be executed on a central server (e.g., Napster's search directory), or a decentralized one by using flooding strategies or other scalable and more sophisticated models (e.g., Gnutella [23], Kademlia [43], and so on). Hence, P2P disrupts the remaining traditional aspects that still survive in centralized digital market: distribution and delivery are provided by whomever manages the on line store, by subscribing a contract with the technology provider (e.g., Akamai for CDN infrastructures). If P2P is used instead, both services rely on contribution of the users, who may advocate their rights as authors, consumers, providers, and distributors.

From both an economic and a technological point of view, mediators are still necessary. Of course, production is a complicated process, and an artwork may sometimes be professionally arranged or refined. But if a revenue model is to be planned, other trusted third parties should be considered in the overall process, such as a bank, a credit card company, a payment broker when financial transactions may occur, or, finally, a certification authority when authenticated communications are needed.

In particular, users need a platform that has to be implemented and updated. Above all, they need a community where it is possible to exchange information, receive feedbacks, suggestions, comments, and so on. Such a community can also provide other mediating services, like a search engine or a financial broker (e.g., PayPal). Whereas we noted in Section 3 how often P2P systems spontaneously evolve in small world ways, it must be added that such a community may also plan a

peculiar revenue model that can include membership or submission fees for sharing content, as well as mechanisms for enabling receivers to pay providers and/or mediators. However, all of these solutions may legally be problematic, because the legal owner is not (always) identical with the provider, let aside the hypotheses on who is responsible for the community to pay license fees, or to undersign an agreement with owners.

In conclusion, new mediators can release an open platform, represent the community, purchase licenses, digitalize content and insert items in the network (or enabling the users to insert items by their own). But the following points must be kept in mind, if the Grokster 's lesson has been learned:

First, the revenue for owners must be clear.
Second, the profit should be shared with providers and/or mediators, if the community owner wants to save both in terms of distribution and of delivery costs.
Finally, a dependable and scalable technical solution shall be adopted.

5 Political Aspects

The political dimensions of P2P systems play an obvious role in the further development of this technology, both at economical and legal levels. However, it is crucial, above all, to clarify what is meant by "political" in this context as well as the interpretation that should be given to the very term of "P2P systems."

Regarding the first point, we interpret the concept of "politics" rather broadly, in order to cope with all the ways in which people make decisions to get certain goals. This is certainly a wider definition than the one referred to the activities of civil governments, and in a certain sense it tends to include what is currently understood under the conceptual framework of "governance" [5].

Concerning the second point, we should distinguish between "P2P systems" as "technological systems" (according to the meaning which is usually given in engineering circles) and "P2P systems" as a metaphor for supposedly new emerging forms of human organization and participation [7, 10]. Although this latter interpretation is intellectually fascinating, it deserves a more thorough discussion than the one that can be offered here. Therefore, the focus will be on P2P as "technological systems" in order to highlight their relevance for political activities (in the broader sense specified above).

Indeed, the political role of "P2P systems" becomes a significant one as soon as we couple the technical definition of P2P networks as massively distributed platforms for information storage and retrieval, with a rather uncontroversial statement in politics. Namely, control of information and, hence, the possibility to obtain such information and to act upon it, are crucial issues for people making decisions to achieve definite ends.

This very possibility of sharing growing amounts of information via P2P networks empowers individuals with the information they need in order to "do politics"; such empowerment has a profoundly different nature as it regards mono-directional media such as TV, radio or traditional printed press, which are

representatives of the "industrial information economy" [10]. In these one-to-many systems, in fact, it is much easier for a limited number of people to act as informational gatekeepers, effectively deciding what information should be distributed.

It is not possible to analyze in detail how control over information influences the sphere of political action. It is nonetheless rather intuitive that a large set of political decisions and of decisions with political implications is taken on the basis of certain information being available – or, much more importantly, being unavailable – to stakeholders concerned with the results of those decisions. Let aside particular well-defined circumstances, usually when a major threat to the wellbeing of the members of a political community is looming (as in time of war), modern democracies rest on the assumption that the availability of information to all citizens is a basic precondition for meaningful participation to decision-making processes and, therefore, to political life in the widest implication of the word.

So, P2P systems should be understood according to their capability to facilitate flow of information, particularly when such information is withheld by entities – including, but not necessarily limited to, the State or related entities – which intend to profit (economically or otherwise) from such control.

Obviously, it is not particularly useful to treat "P2P systems" as a single monolith when assessing their relevance – positive or negative – for political action. As we stressed in previous sections, it makes a real difference whether P2P systems are strongly centralized (e.g., Napster) or decentralized (e.g., Gnutella, Pastry [51], Kademlia [43]). In the same way, it is important to distinguish P2P systems which allow anonymous communications (e.g., Freenet [38] or Publius [61]); plausible deniability (e.g., Publius [61]); confidential communications, and so on.

For example, the presence of single points of failure in a centralized P2P system explains why it is likely that these networks suffer from disruption to their relevant information-sharing functions more easily than decentralized systems. This might happen when such a network is used by its participants to share information that is regarded by others as politically sensitive and/or damaging. The capability to clearly identify and target a limited number of nodes, either via legal means (e.g., court injunctions) or through other, less legal, ways (e.g., denial of service attacks), is obviously a strong advantage for the entity that considers such an information as damaging. Vice versa, a decentralized P2P system helps counter this threat, but it might render more difficult to clearly identify an authoritative source in sharing information, which is an important element in political activities. Besides, it may raise difficulties in coordinating such political relationships, notwithstanding the fact that information technologies themselves might provide tools, such as filtering, tagging and recommendation systems, for more effective coordination [10, 56].

Similar considerations can be applied to P2P systems that allow anonymous communication, that is making extremely difficult for an entity to stop spreading of sensitive information via identification and action upon the participants of the network. Anonymous P2P systems make the sharing of information, and possible political action based upon such a sharing, available (or less risky) even in those political regimes that have developed extensive monitoring infrastructures [17]. Nevertheless, full anonymity might also encourage irresponsible acts (in the strict sense of the word, i.e., acts whose responsible cannot be identified) or be used for criminal

purposes. This hypothesis raises a lot of difficult questions, most of them related to the possible use of technologies allowing anonymous communications to criminal organizations. The usage of pseudonymous systems, such as OpenID (see on-line documentation at http://openid.net) might be a feasible partial solution to this complex challenge.

In the context of their usefulness for political action, the same debate would apply when examining P2P systems that provide both plausible deniability and high degree of confidentiality, usually by encrypting communication between peers. These characteristics are, strictly speaking, very different from the capability of a system to provide anonymity. In particular, the possibility to offer plausible deniability is very important in those political environments where the mere usage of tools allowing confidential communication might create serious issues to their participants. By the way, this is becoming familiar even in democratic regimes under the fallacious assumption that those who have "nothing to hide" will not want confidentiality in their communications [58] . In any case, it is hard to draw a precise line between the necessity of providing a venue for political information-sharing activities in countries where the surveillance of citizens is routine, and the possibility that such systems protect or even encourage criminal activities [18].

Another point that must be clearly stressed is that sharing information in a more efficient and/or effective way does not necessarily mean any action based upon that information would be taken. P2P systems can, as mentioned above, help lowering the transaction costs of group coordination, by easing the sharing of the specific information which is necessary, whether directly or indirectly, for such coordination [10, 56]. However, there are many other factors that play a role in facilitating or inhibiting political activities: let us mention here three of them.

First, the very distributed nature of P2P systems can represent a formidable obstacle to the information sharing which turns into real action. Indeed, geographical distances between persons who might share a common goal, are not, up to today, reflected in the topology of P2P systems (although, there are proposals of P2P systems that organize their topology on the basis of geographical proximity [34, 66]).

Secondly, the sheer amount of information to be transferred in P2P systems can turn into an obstacle to practical action, insofar as human peers may suffer from information overloading [57].

Finally, there is another possible problem that, to be fair, is not necessarily peculiar to P2P systems, but generally to decision-making processes in large or weakly connected social groups (which characterize some, but not all of, P2P systems.) In a nutshell, the suspicion is that participants will tend to coalesce around positions which are not necessarily the best ones, but rather the most widely accepted and/or least controversial ones [35].

The actual relevance of these issues is still widely debated, one central point of discussion being that P2P networks should not be compared to an utopian picture of both information sharing and political action, but rather to the current framework of highly centralized mass-media environment [10, 56]. In this way it is clear what remains to be assessed in terms of the political practices allowed by existing and emerging P2P systems along with their social impact.

Indeed, it is not necessary to insist, once again, on the political significance of any particular architecture, i.e., the bidirectional connection by which policy-making processes constrain or stimulate certain kinds of P2P architectures over others (as we saw in Sections 3 and 4), while digital architecture influences different kind of political actions (as we mention in this section).

Rather, it is crucial to analyse whether and how far information sharing, which is allowed by forthcoming P2P systems, actually turns into real action. Therefore, in order to enrich that bidirectional connection with which we are dealing throughout this chapter, a fruitful perspective is given by some technical details on the threefold levels of P2P services that are the subject of the next section.

6 Turning Forthcoming P2P Systems into Reality

The aim of this section is to let the P2P paradigm suit (some of) the legal, social, economic, and political issues underlined in previous parts of the chapter. We partially refer to the P2P Service Model defined in the Service Oriented Peer-to-Peer Service (SOPPS) [22], which comes from the Market Management of Peer-to-Peer Services (MMAPPS) European research project. In such scenario, the Service Model outlines the different types of services a peer can offer to other peers as well as the interfaces through which they can be accessed.

In particular, we present the service model introduced in [52] which shows a structure that can logically be divided in three different levels, that we present in a bottom-up order: (1) the *Overlay Level*, (2) the *Accounting Level*, and (3) the *Market Level*. These modules give different services to other modules, and even if we can think of them, at this present degree of abstraction, as a pile of protocols, applications can use functions and operations offered at different levels. Each module is defined in terms of the functions they export to the other parts of the framework (see Fig. 2):

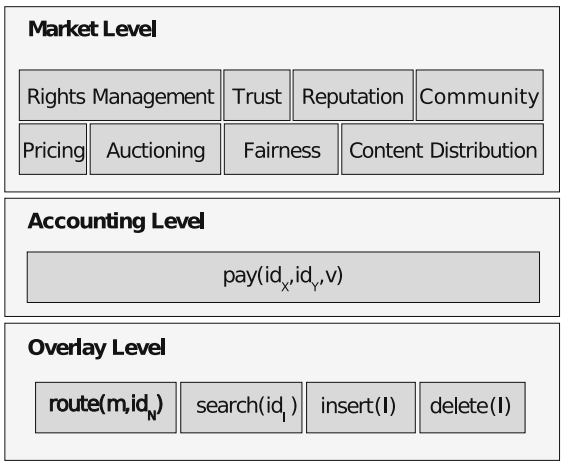

Fig. 2 Logical layers of a P2P service model

6.1 Overlay Level

The overlay network can be *unstructured* (e.g., Gnutella, Kazaa, and so on) or *structured* (e.g., Pastry [51], Chord [59] and Kademlia [43]). Scalable overlays are considered more scalable than the others. Very roughly, structured overlays are defined in terms of a *topology* (i.e., a forest, a ring, and so on), a *routing mechanism*, and an *identifier space*, which is used to uniquely locate nodes and resources in the network. The key idea of a *Distributed Hash Table* (DHT) system is that each node N is responsible for a set of resources whose identifiers are "closer" to N's identifier than to the others; in fact, a *distance metric* is defined for each different system. Usually, a distributed storage service is defined over this basic layer. It is possible to insert a new resource in the network that will be assigned to the node of responsibility. Hence, given a generic node N and a resource R, respectively identified by id_N and id_R, the overlay layer should be able to export the following functions:

route(m, id_N): it routes message m to node N;
search(id_R): it looks for R, and returns a pointer to the node (or the set of nodes) that is responsible (or that caches) the searched resource.
insert(R) and *delete(R)*: these functions are used to store and to remove a given resource to a node. Some systems implement basic authentication mechanisms: for example, only a node with given credentials can access or modify a resource from the network (e.g., the Likir system defined on a Kademlia-like structure [2]).

The reader should observe that searches could be managed in a *centralized* (and largely efficient) manner. Napster is an example; however, as reminded in Sections 2 and 4, it might be considered illegal to centralize the provisioning of a directory service, even when the objects are stored on the computers of the community logged on. No one can implement a technology that prevents every kind of misuses. But, of course, a service provider (or a community owner) should avoid legal prosecution, through denying the accountability for other users' actions. On the contrary, decentralized searches in unstructured systems are not efficient (e.g., the flooding search strategy in Gnutella) or transfer the potential legal liability of this type on few super-peers (e.g., Kazaa-like policies). Additionally, a centralized system has a single point of failure presenting technical as well as political drawbacks, as we have shown in Section 5. This brings us to the first learned lesson that must be considered during the implementation of the given P2P service model:

Lesson Learned No. 1 *Structured overlays are to be preferred to unstructured P2P systems in order to let the community owners and/or the developers decline their responsibilities on users' actions. Moreover, such a system is free of single points of failure.*

Another important issue is given by anonymity and confidentiality, that should be granted as (optional) services to P2P users, as discussed in Section 5. It is critical that the solution is given at a lower level of the technological platform, because when using an overlay network, it is possible in principle to trace back to the content

source (i.e., the user or the node that inserted a given object) and/or to the content provider (i.e., the user or the node that is storing/caching a given object). Secondly, the node identifier should not be coupled with the real identity of the user, in order to grant a given level of anonymity with the adoption of user generated pseudonyms. Other forms of identity management must be preferred instead (e.g., OpenId.)

Lesson Learned No. 2 *The Overlay level should integrate an authentication protocol and an identity verification policy that could accept pseudonyms instead of real generalities of users.*

The reader should observe that if peers communicate each other using authenticated channels, then they can easily cipher content before transmitting as well as storing and sharing it (for example using a Diffie-Hellman key exchange protocol). As a consequence, objects stored in the overlay system can be protected against not authorized access, without any responsibility of the content provider (when the latter is different from the source and/or the owner of the object).

6.2 Accounting Level

In order to satisfy economic constraints discussed in Section 4, security concerns at this level should be considered very seriously.We have to manage both macro-payment and micro-payment transactions; frauds are common; services and resources consumption must be accounted as well. The most part of actual markets adopts a central authority that manages economic transactions (e.g., PayPal) when services are provided or items are sold. At the resource level, many credit-based incentive mechanisms have been proposed over the last years. However, the accounting level must provide functions for *crediting* or *debiting* users (considering a *currency* with or without legal value). For the sake of simplicity, we define only the following function:

pay(id_X, id_Y, v): it invokes all the measures in order to securely provide a payment of value v from user X to user Y.

The *pay* method can be implemented by way of a central authority (very common, and maybe preferable, for managing macro-payments) or of a distributed system. In the latter class of proposals, many strategies can be further classified as *Local Accounting*, *Token-Based Accounting*, and *Remote Accounting*. For a more thorough discussion on different accounting strategies, see [30]

Let us stress that this accounting level is not necessarily related to the revenue policy that the community owner has decided to adopt, and that should be considered at the Market Level of the given model. In fact, several economic studies have sharpened how the flat-fee economic model can generate greater profits per good on respect to the pay-per-use model depicted in monetary systems (see for example [19]). Nevertheless, it has been clearly discussed how free-riding can be easily

reduced if incentives for contributing are managed. Hence, crediting and debiting users introduce the need of a dependable business support, which must be scalable in terms of the many transactions that may occur in a P2P system.

Lesson Learned No. 3 *Crediting and debiting users can reduce the free-riding phenomenon, but they introduce the needing of an economic support. The execution of (many) pay*(id_X, id_Y, v) *calls must be dependable, not repudiable, and scalable in terms of the number of transactions in a large community of users.*

Let us observe that commonly used Local Accounting strategies are trivially abstracted by the *pay* method: Indeed, both an eMule-like crediting system and a TicTacToe strategy (used in BitTorrent) can be seen in terms of a peer *paying* a fee to another peer, even if it results in a differentiated service (e.g., high priority in waiting queue of debtors) instead of real money transfers. Otherwise, other more reliable micro-payment systems must be used if the virtual coins correspond to real currency (see, for example, the Rivest's lottery scheme [50] and PPay proposed by Yang and Garcia-Molina [64]).

6.3 Market Level

This level includes most of the services as perceived by the final user. We list here a set of properties and functions that a framework could implement, in order to solve many of the issues we stressed in the previous sections of this chapter.

Pricing: We may define a pricing function that maps a service onto a tariff function or a scalar value that basically represents the price of the service consumption. It can be *fixed* or *competitive*; in the second case, each provider of the same service can offer it at different prices. For example, in a storage application, some peers can offer slices of its own disk space at a lower price than a competitor. PeerMint [27] gives an interesting approach to pricing mechanism in a P2P market.

Auctioning: When the good under sale is in limited number, the merchant can take different bids into consideration. In virtual markets that deal only with electronic sources (different replica can easily be produced), auctioning is less important. See PeerMart [28] as the state-of-the-art approach for enabling auctioning in a P2P system.

Intellectual Property Management: Even if there is no definitive solution to the DRM vs. DRM-free debate, we cannot underestimate the importance of intellectual property management, as discussed in Section 2. Although a flat-fee strategy is adopted, the community manager can be asked to account the content owner accordingly to the popularity of his/her own artifact.

Fairness: When the owner is credited under a given revenue model, then also the provider, who contributes to the system with her own bandwidth, cpu cycles, and disk space, should be (at least partially) credited as well. We think that this

property has been deeply underestimated and a proper implementation of fair mechanisms can strongly incentive users to behave legally and bring success to a market place. The reader interested in such a topic, can refer to FairPeers [52].

Content Distribution: No electronic item must be delivered by traditional *shipping* methods (e.g., air mail). On the contrary, electronic content can alternatively be distributed depending on the kind of service. In fact, *delay-tolerant* (DT) connections (e.g., TCP based) can be used for file sharing applications, but *time-sensitive* (TS) mechanisms are needed when audio/video (e.g., a soccer match) is streamed to a set of paying users. If the task of content distribution is fairly shared by the participants, systems performance can optimize bandwidth available at the host side.

Trust and Reputation: When a transaction is completed (or even maliciously aborted), involved participants can be asked to submit a (positive or negative) feedback. Reputation management can be critical if pseudonyms are used instead of real identities: community owners may benefit from the users' active participation to isolate fraudulent users and to reduce misuses of the given platform.

Community Services: This higher level of abstraction can include some other services and functions (as a recommendation engine, social networking facilities, and so on), which can harness small world properties that characterize P2P community (see Section 3). A deeper discussion on such issues is out of the scope of this chapter. However, the reader can refer to *DeHinter*, a recommendation system for Gnutella network [54], that provides an example of a practical exploitation of spontaneous topological properties.

Therefore, a developer of a future P2P system must take care of each item in the given list, as it is stressed in the following learned lessons.

Lesson Learned No. 4 *In a P2P system every peer can be a merchant. The incremental exploitation of the P2P paradigm must include no trivial negotiation mechanisms, such as pricing and auctioning that are very strategic practices in the long tail business scenario (e.g., eBay.)*

Lesson Learned No. 5 *The U.S. Supreme Court decision in MGM v. Grokster case shows that in some parts of the world, developers can legally be prosecuted for inducing copyright infringement committed by their users. Intellectual property management must seriously be considered, and developers must provide a method for enabling legal sharing of copy-protected or otherwise governed information.*

Lesson Learned No. 6 *There are technological and political drawbacks in single points of failure. The needing of a distributed control over content and user's behavior makes mandatory the adoption of reputation and trust schemas.*

Lesson Learned No. 7 *The exploitation of the long tail scenario shows that the more the users are stimulated to contribute to the system, the more resources are available in the community. Fairness strategies can potentially expand the market as well as content distribution can benefit of user's enthusiastic participation.*

Lesson Learned No. 8 *Several scientific analyses have demonstrated the existence of small world networks at various levels of any P2P system (as well as other interesting patterns, such as power law distributions of nodes' degree). Spontaneous structures in network and community topologies can be exploited to enhance the performance of the given system (e.g. reducing the number of hops during searches) and to introduce new challenging social networking services (e.g., recommendation systems, lookup of neighbors of neighbors, and so on).*

7 Conclusions

Our analysis on the social impact of P2P systems has dealt with a work that obviously is still in progress. In Section 2, we mentioned the difficulties to precisely define the legal boundaries of a technology capable of substantial non infringing uses, along with the necessity to find out a fair (but difficult) balance between copyright and privacy issues. In Section 3, we referred to the spontaneous orders of P2P systems and their complex interaction, say, with the reality of taxis and legislation. In Section 4, we stressed how the potentialities of this technology do not have yet dissolved many doubts about its use as a dependable, fair and profitable marketplace infrastructure. In Section 5, it was the turn for political uncertainties which depend on geographical distances, overloading issues, or conformist risks, let aside the very possibility that such systems protect or even encourage criminal activities. Whereas, in Section 6, we depicted a plausible scenario for further developments of P2P systems, we were conscious that a key problem consists in turning forthcoming systems into reality (as the title of that section clearly warns).

Of course, all those open questions do not mean to forget merits and advantages of such a technology which has led many scholars to present it as a sort of new paradigm in social interaction. Rather, these issues prevent us from conceiving P2P systems as a form of panacea or utopia, insomuch as they invite to highlight the bidirectional connection stressed since the introduction and that has represented our personal thread of Ariadne throughout this chapter.

Indeed, we observed that legal networks, economical trends, and political debates are influencing P2P evolution, whereas, at the same time, those very systems have been transforming some key terms of our legal, economic, and political discourse. Hence, the picture we gave about a work that is still in progress should be also interpreted the other way around. In Section 2, we explained why initial apprehensions for copyright issues have left room to growing data protection concerns and, likely, new legal cases will arise in defense of freedom of research. In Section 3, we presented empirical work which proves P2P systems are part of a far more complex framework, i.e., Hayek's cosmos, irreducible as such to simple human programming as in the case of spontaneous affinity networks. In Section 4, it was the turn of classical political economics and how many of its central concepts have been upset, as it occurs with the value-chain of goods with their variable and marginal costs of production and distribution, networks externalities, or the very

idea of informational goods. Then, in Section 5, we insisted on the new horizons opened up by P2P networks in politics, once properly understood in terms of information and, more precisely, in terms of control, access, and distribution for people making decisions to achieve definite ends. So, when we illustrated further developments of the technology as with the P2P service model in Section 6, the aim was not only to properly take into account the complex social environment with its own set of rules, constraints and possibilities, within which any technology has to be conceived. Rather, the aim was also to emphasize the way in which social interaction has already changed because of the introduction and functioning of P2P systems.

Finally, our analysis is obviously open to scientific debate and attempts of falsification; yet, our effort has been to ground it upon a historical balance of that continuous cycle in which each of its terms, namely technology and the social environment, affects or gives feedback to the other. While such a perspective means to take into proper consideration the social constraints within which any further development of P2P systems should be assessed, it also allows to ponder the consistency of some legal crusades, political queries, or economical misconceptions, still popular in current debate. After all, this is another good reason why it is so important to stress "the social impact of P2P systems".

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