HAL
archives-ouvertes.fr

P2P Networks: The interplay between legislation and information technology

Sulan Wong, Eitan Altman, Mouhamad Ibrahim

▶ **To cite this version:**

Sulan Wong, Eitan Altman, Mouhamad Ibrahim. P2P Networks: The interplay between legislation and information technology. [Research Report] RR-6889, INRIA. 2009. <inria-00371507v2>

HAL Id: inria-00371507
https://hal.inria.fr/inria-00371507v2

Submitted on 29 Jun 2009

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

P2P Networks: The interplay between legislation and information technology

Sulan Wong — Eitan Altman — Mouhamad Ibrahim

N° 6889 — version 2

initial version Mars 2009 — revised version June 2009

Thème COM

ISSN 0249-6399 ISRN INRIA/RR--6889--FR+ENG

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
SOPHIA ANTIPOLIS - MÉDITERRANÉE

P2P Networks: The interplay between legislation and information technology

Sulan Wong* , Eitan Altman†, Mouhamad Ibrahim‡

Thème COM — Systèmes communicants
Équipe-Projet Maestro

Rapport de recherche n° 6889 — version 2§ — initial version Mars 2009 —
revised version June 2009 — 30 pages

Abstract: P2P has become a major part of Internet traffic. Along with a growing economic e-commerce activity in which consumers purchase music, video, software and books over the Internet, P2P file sharing networks have enabled a free widespread public access to copyrighted material. A long lasting conflict accompanied by an impressive "arms race" has been developing between "producers" (i.e. copyright owner companies) and "users" (part of the web surfers community) [46]. In their effort to decrease internet "piracy", companies have lobbied for legislation that would ban this practice and that would increase their control and monitoring on the content transferred over the Internet. They have taken legal action against companies and individuals involved in P2P developments, sued individual web surfers, have formed alliances with some service providers to prevent access to P2P networks, and sued others that were not cooperative. Our paper describes and analyzes different facets of this conflict, and the way legal actions and network technology interact. We summarize the role of other actors involved and describe other business models for the producers that can co-exist with today's P2P networks. We then introduce mathematical models that study the efficiency of measures to restrict "piracy".

Key-words: Peer-to-peer networks, legislation, intellectual property, piracy, mathematical models.

* Faculty of Law, Campus of Elviña , University of Coruña , Coruña, Spain 15071. Email: swong@udc.es
† Maestro team, INRIA Sophia-Antipolis, France. Email: eitan.altman@sophia.inria.fr
‡ Maestro team, INRIA Sophia-Antipolis, France. Email: mibrahim@sophia.inria.fr
§ This second version contains some updates in Section 4.6 and corrections in Section 5

Centre de recherche INRIA Sophia Antipolis – Méditerranée
2004, route des Lucioles, BP 93, 06902 Sophia Antipolis Cedex
Téléphone : +33 4 92 38 77 77 — Télécopie : +33 4 92 38 77 65

Réseaux pair à pair : L'interaction entre la législation et la technologie de l'information

Résumé : Le partage de fichiers en pair à pair (P2P) constitue aujourd'hui une partie importante du trafic sur l'Internet. En parallèle à une croissance des activités de commerce en ligne où les internautes peuvent acheter musiques, vidéos, logiciels et livres, les réseaux pair à pair ont permis un accès libre et gratuit à des oeuvres protégées par le droit d'auteur. Un conflit juridique de longue durée, accompagné par une impressionnante "course à l'armement", a opposé les titulaires de droits à une large partie des internautes, utilisateurs de ces réseaux [46]. Dans leurs efforts de lutter contre le téléchargement illégal, les titulaires de droits ont fait pression pour que la législation interdise cette pratique et permette d'accroître leur contrôle et leur surveillance sur le contenu transféré sur Internet. Par ailleurs, ils ont engagé des actions en justice contre des entreprises et des individus impliqués dans le développement des réseaux pair à pair. Ils ont ainsi poursuivi des internautes, formé des alliances avec certains fournisseurs d'accès Internet pour empêcher l'accès aux réseaux pair à pair. De plus, Ils ont poursuivi d'autres fournisseurs qui n'ont pas été coopératifs. Notre étude décrit et analyse les différentes facettes de ce conflit, et la façon selon laquelle les actions judiciaires et la technologie peuvent interagir. Nous résumons le rôle d'autres acteurs impliqués dans ce conflit puis nous décrivons plusieurs modèles économiques qui permettraient la co-existence entre les producteurs et les réseaux pair à pair d'aujourd'hui. Ensuite, nous présentons des modèles mathématiques qui permettent d'étudier l'efficacité des mesures visant à limiter le piratage.

Mots-clés : Réseaux pair à pair, législation, propriété intellectuelle, piratage, modèles mathématiques.

1 Introduction

Within the networking community there has been a large amount of research devoted to P2P networks, to incentives for sharing information, to improve P2P protocol efficiency and to security related issues which include ways to keep peer anonymity. There are certainly huge economic interests which stimulate the research effort devoted to these networks, which are already responsible for creating between 30% to 60% of the Internet traffic. Yet there is little awareness among the network community of the legal aspects related to file sharing in P2P networks and of the dramatic impact that this could have on future developments in P2P network architecture. Understanding the evolution in legislation concerning P2P users, servers and developers is central to making research in this area relevant.

In contrast to the term "piracy" that clearly associates downloading with criminal activity, both legal as well as the social perception of file sharing are far from taking a clear side in this conflict: legislation dramatically differs from one place to another and the ethics of file sharing differs from one sector to another. On the legal side, there are countries where non-authorized downloading of copyrighted material is illegal and where individuals involved are prosecuted and fined. In other countries, downloading copyrighted material for non-profit personal purposes is not illegal and is even considered to generate benefit for copyright owners [65]. The following quote from [49] illustrates the difference in the way "piracy" is viewed: "As noted by one RIAA[1] lawyer, consumers who would never consider walking out of a record store with a CD that they had not purchased had no compunctions about obtaining MP3 files for free over Napster."

Halting or decreasing the amount of unauthorized download requires more than banning this activity. It requires legal and technological tools to either prevent access to internet hosts of such content, or to monitor P2P traffic, to identify both the illegal nature of a file transfer as well as the personal data of the user that initiated the transfer. These further require alliance or cooperation with other actors: either with the service provider (who has access to personal data or who can install filters) or with the equipment manufacturer (whenever the latter can include in the equipment detection of whether access to some content is authorized).

By taking legal actions against piracy or even just by threatening to do so, such downloads decrease [10]. How effective would such measures be? One of our main goals in this work has been to develop mathematical models that predict that efficiency. More precisely, we examine the following questions:

- What is the influence of decreasing the demand for a file by a given amount, on its availability (i.e. on the probability to find it in a P2P network)?
- What is the influence of decreasing the demand for a file by a given amount, on the rate of downloads of this file?

Using simple mathematical models that are based on queueing theory, we show that by decreasing the demand for a file by a given percent, its *availability* will

[1] RIAA stands for Recording Industry Association of America which is a trade association that represents the recording industry in the United States.

only decrease slightly if it is a popular file, whereas it could decrease dramatically if it is not. On the other hand, the rate of *number of downloads* of a popular file is expected to decrease more.

In view of our findings, we compare the current policy of content companies, based on fighting against free access to copyright material, with alternative proposed policies. We briefly mention the advantages that content companies, service providers and internet users could have from a new generation of centralized mega-P2P networks that would be hosted by content or service providers and that would allow subscribers to have unlimited access to a large range of content.

The structure of the paper is as follows. The first part is devoted to a background and a legal analysis of P2P networks: taxonomy of the various actors involved and their interests (Section 2), the interaction between them (Section 3), the legislation and its development in various countries (Section 4). The second part (Section 5) provides the mathematical study that predicts the availability of content and of the expected rate of downloads as a function of some measures of the popularity of a file. We end with a concluding section.

2 The actors and their interests: Taxonomy of actors

2.1 International Organizations

International institutions such as the World Intellectual Property Organization (WIPO), the World Trade Organization (WTO) and the European Union (EU), where member states jointly discuss and agree on resolutions and directives to establish a common legal framework relating to policies aimed at protecting intellectual property.

2.2 The State

For purposes of this work, we consider the State from the classical separation of powers theory, i.e., as policymaker (executive branch), as lawmaker (legislative branch) and as justice administrator (judiciary branch).

2.3 Internet subscribers

We are interested in Internet subscribers that engage in the copyrighted material sharing/downloading activity. From this perspective we subdivide them into:

1. First copy providers: users who create a digital copy of a copyrighted material and make it available for sharing/downloading over the Internet. Their reputation is based on the quality of the shared copy. Proud of their work, and to build a group of followers, they add their nicknames to the name of the files they share. In BitTorrent networks, they are known as *original seeds*.

2. Peer to Peer users: users who share content protected by copyright through P2P networks.

(a) With authorization of the copyright holders.

(b) Without authorization of the copyright holders.

3. Download users: users who download content protected by copyright.

   (a) Using free downloading services.

      i. With authorization of the copyright holders: like the rock bands Nine Inch Nails and Radiohead, many artists now put their works on their web pages for free legal download.

      ii. Without authorization of the copyright holders: there are legal file hosting sites in which users store copyrighted material for illegal download.

   (b) Using paid downloading services.

      i. With authorization of the copyright holders: they work as digital stores of copyrighted contents, e.g., iTunes music store.

      ii. Without authorization of the copyright holders: the same services that offer free downloads, allow paying customers to access content with improved download speed.

2.4 Providers of Links

There are websites specialized in the hosting of links to files shared in P2P networks.They usually profit from advertisement.

2.5 Authors

The author[2] is the person who creates a literary, scientific or artistic work.

In the context of our work, the authors can be in favor of allowing freely sharing/downloading their creation or they can be against it.

2.6 Performers

We find in the International Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organizations (1961) that performers are "actors, singers, musicians, dancers, and other persons who act, sing, deliver, declaim, play in, or otherwise perform literary or artistic works" [69, Article 3.a]. In the Performances and Phonograms Treaty (1996), this definition is widened, in order to include "expressions of folklore" [70, Article 2.a].

As with authors, performers can have either a pro sharing or against sharing stance.

[2]From [68], we can infer that the author is the person who creates a "production in the literary, scientific and artistic domain, whatever may be the mode or form of its expression, such as books, pamphlets and other writings; lectures, addresses, sermons and other works of the same nature; dramatic or dramatico-musical works; choreographic works and entertainments in dumb show; musical compositions with or without words; cinematographic works to which are assimilated works expressed by a process analogous to cinematography; works of drawing, painting, architecture, sculpture, engraving and lithography; photographic works to which are assimilated works expressed by a process analogous to photography; works of applied art; illustrations, maps, plans, sketches and three-dimensional works relative to geography, topography, architecture or science".

2.7 Contents Production Industry (CPI)

Most of the contents available on P2P networks is cultural contents. The companies that produce this contents are entitled to related rights independent of that of the authors. We can find four main content producer types, either in favor or against file sharing:

- Phonogram producers (music).
- Cinematographic producers (movies).
- Publishers (printed materials).
- Broadcasting producers (radio and television).

Other types of contents shared in P2P networks are software. We shall not focus on this type of contents in this paper as it has very distinct features that are quite different than the cultural contents. These include specific intellectual property laws (such as patents), other types of conflicts between the related actors (e.g. the open source movement) and different types of economic models.

2.8 Internet Service Providers (ISPs)

ISPs are companies that deal Internet connections. The P2P traffic has become a major part of the Internet, with around half the amount of traffic transferred. There is thus a strategic importance for ISPs in offering access to P2P applications, to comply with their customers preferences. But, pressure has been mounting to make them the key actors in the new CPI strategy.

2.9 Content Service Providers (CSPs)

CSPs provide, throughout an Internet service, copyrighted contents, either licensed[3] or unlicensed[4] by copyright holders.

2.10 Media

Mass media have a big effect, or media influence, on how their audiences think and behave. As members of the CPI, they tend to have an anti-sharing position.

2.11 Royalty collecting societies (RCSs)

Authors, performers and producers usually form associations to collect royalties from and to police infringements to their copyrights. These organizations also serve as powerful lobbies that seek protection from each branch of the State.

2.12 Multimedia equipment manufacturers (MEMs)

MEMs are companies that manufacture equipment capable of playing and copying copyrighted contents.

[3] Like iTunes, AmazonMP3 or 7digital.
[4] Like FastTrack, eDonkey or Gnutella.

3 Interactions between actors

3.1 Interaction between CPI and P2P users

3.1.1 Confrontation strategies

- Lawsuit threats and legal actions: In the United States the RIAA had filed, settled, or threatened legal actions against at least 30,000 individual since 2003 [20].

- Three Strikes Law or Graduated Response: The proposed law promoting the dissemination and the protection of the creation over the Internet [31], that is currently being discussed in France[5], has been developed on a mechanism of warnings and sanctions [45], which involves the creation of an independent administrative authority [31, Article 2, §3]. This mechanism of warnings or "graduated response" follows three steps prior to the establishment of sanctions. An email is first sent to the infringer [31, Article 2 L.331-24], as an "advice", reminding the subscriber of his monitoring duty [31, Art. 6 L.336-3]. If the behavior does not change, a second warning is sent via registered mail [31, Art. 2 L.331-24 §2], for purposes of legal evidence. If the warnings are ignored, sanctions, ranging from suspension of the Internet service [31, Art 2 L.331-25], to an order for content control measures, will be applied.

- Service termination due to suspecting downloading patterns [50]: a variant of the three strikes law without invading the privacy of the subscriber. By analyzing downloading patterns, ISPs can identify file sharers with high certainty. To implement this strategy, cooperation with ISPs is needed through an agreement or legislation.

- Spreading fake songs, to litter and fool P2P networks: Using this strategy, Madonna has been able to share her thoughts about the subject of P2P file sharing with her fans [9].

- Prosecution of P2P users: CPI and RCSs are lobbying criminalization of P2P file sharing, to make the State the sole responsible entity. Litigation is an expensive business [55, 66], and the CPI and RCSs would like to unload that burden on the State.

3.1.2 Cooperative interactions

- Alternative cooperative interactions are not impossible. Litman writes in [42]: " Let's let everybody engage in peer-to-peer file trading, but pay for it. We have a number of practical models for doing that, especially in the music business. Composers, for example, get paid for every time the music they wrote is performed in a club, or broadcast on TV, or delivered by Direct TV to someone's satellite dish ...".

- Music Tax: ISPs would like to see some kind of blanket licence to cover all their users' downloads of copyrighted contents. Users will pay a monthly

[5]Spain, Ireland, Italy and New Zealand, in addition to France, are discussing similar initiatives. In USA, the RIAA has recently declared that they will no longer sue, and instead will seek alliance with ISPs to implement the three strikes law.

tax to compensate copyright holders for their sale losses. This approach has been proposed recently in UK[6] [67].

- A recent Dutch study [65] concludes that the benefits obtained by the savings users get when they download copyrighted material are bigger that what the CPI loses, producing positive net economic effects. A similar conclusion has already been obtained in [8] 10 years ago: " We find, for example, that under certain circumstances sharing will markedly increase profit even if sharing is inefficient in the sense that it is more expensive for consumers to distribute the goods via sharing than it would be for the producer to simply produce additional units."

  For other cooperative models, see: [65, 5, 7].

3.1.3 Other strategies: Educative Campaigns

On November 2008, the Ministry of Culture of Spain has launched a four month campaign "to raise awareness" in the population of P2P users, called "Si eres legal, eres legal"[7]. In 2007 [71], as part of the series for kids aged 8 to 12, called "Learn from the past, create the future", the book "The arts and copyright" was distributed. In 2008, the University of Alcalá [64] presented the project "Educar para crear" in association with CEDRO, NBC-Universal, Telefónica, Microsoft, MPA, Anele, BSA and Toshiba to teach kids and teenagers the problems intellectual property is facing due to file sharing. A pilot test was launched in four schools of Asturias in Spain, where videos were taken depicting kids as pirates who stole intellectual property from their legitimate owners.

Strengthening enforcement of intellectual property rights through education campaigns, is made possible by the State that actively supports the position of CPI. It indicates that internet piracy and the fight against it are becoming a central issue in our society and that perhaps an ideological change is required among Internet users if this phenomenon is to disappear. Indeed, as Smiers [55] says, there seems to exist a form of silent resistance to follow the guidelines that the CPI establishes, and perhaps what is happening is that "people do not obey laws that they do not believe in" [42, p. 217].

3.2 CPI v. Authors and Performers

In [32], the authors investigate whether and to what extent there is a conflict of interest between artists and their publishers, as to whether and to what degree illegal distributions of their copyrighted recordings should be prevented.

It is natural to expect cooperation between the CPI and authors and performers, due to their complementary roles. CPI need the latter to offer products. They can in turn offer all technical knowhow for the production and all the marketing support.

Potential conflicts may occur when:

- Authors and performers consider their share in the income as being too small.

[6] The Minister of Communications has proposed a tax, of around £20 per year, to broadband connections, as compensation for copyrighted material download.

[7] In English "if you are legal, you are legal". Available at: `http://www.siereslegalereslegal.com/portada.php`

- They are faced with other restrictions imposed on them concerning reuse of their material,
- They wish their work to be widely accessible, whereas the CPI prices (that would maximize their own profits) could induce a much smaller demand.

3.3 CPI v. ISPs

There have been both alliance as well as legal clashes between the CPI and ISPs. The CPI has been able to discover illegal downloads, without the intervention of ISPs; they have been able to get the IP addresses of such downloaders. At this point the CPI needs the cooperation of ISPs in order to get the personal data that corresponds to the IP addresses. Much more cooperation is needed in order to achieve efficient filtering and monitoring of downloads of unauthorized copyrighted material (see measures described in Subsection 3.1).

A possible strategy of the CPI to get ISPs on their side is to propose to pay ISPs by RCSs for each disconnection due to copyright infringement.

3.4 CPI v. MEMs

The consumers of equipment are users as well as service providers, and not so much the content enterprises. The relation between CPI and MEMs are therefore expected to be determined by what the MEMs represent for the CPI.

There is a potential conflict in that new technology developed by equipment companies can make it easier for users to share contents illegally and thus to reduce the benefits of CPI. There is also a potential benefit for cooperation as it can allow CPI to develop new business models based on specialized technologies which are less vulnerable to pirating.

The CPI thus has cooperative (peaceful) and non-cooperative (aggressive) actions it can use in its relation to the MEMs.

A confrontation policy P2P is not the first technology that introduces controversy between equipment and leisure industry. On 1984, US Supreme Court rejected the movie industry's attempt to bar Sony from manufacturing video recorders, siding in favor of the development of technologies that are capable of substantial non-infringement uses [41, 57].

In 1999, the DVD Copy Control Association (DVD CCA) took action to try to prevent the distribution of software which, if used, would enable individuals to play digital video disks (DVDs) without technological restrictions such as practical limitation codes imposed by their owners - movie proprietors [53]. The Court of Appeal for the Sixth Appellate District of the State of California has ruled that defendant Andrew Bunner and numerous other defendants are not required to refrain from the Internet publication of such software.

A cooperative policy Compromise based approaches can also be imagined as we can learn from history of other conflicts between CPI and MEM. In the early 1990s, the music industry and the Digital Audio Tape industry agreed to promote compromise legislation establishing a reimbursement scheme based on a safe harbor for devices using a "Serial Copyright Management System" memorialized in the Audio Home Recording Act of 1991 [49].

An example of cooperation between CPI and MEMs is illustrated in Apple iTunes store. Since its inception, the onmiprescent iPod has been linked to DRM that limited songs bought at Apple's iTunes, to be played only on one computer and one iPod. In 2007, Apple teamed with EMI to sell higher quality, DRM-free songs [2]. In January 2009, Apple communicated [3] that the remaining major music labels (Sony, Universal and Warner), as well as many independent labels, will join EMI in their DRM-free catalog. This approach could be a viable business model that could successfully compete with P2P non-authorized downloads.

4 Legal state of non-authorized sharing of copyrighted material

Every time the CPI faces a technological development that allows the dissemination of cultural contents, licensed or not by copyright owners, massive legal armies are levied: the danger of sales drops makes for a perfect argument [34]. Well-financed lobbies are used to push for legislative responses that protect from any act of piracy of the intellectual property of cultural works. Both yesterday and today, new technologies have been presented as a threat to copyright: cassette recorders, VCR's, CD and DVD recorders. Now is the turn of the P2P networks.

4.1 Developing P2P networks

The first generation of P2P networks based on a central server with free access to unauthorized copyright material have now disappeared. They are considered illegal everywhere, see Appendix.

4.2 Download and upload of non-authorized content

We will examine the legality of the file-sharing of copyrighted contents through P2P networks, based on the limits to the reproduction right of copyright holders. Both, Berne Convention [68, Art. 9.2] and European Directive 2001/29/EC [26, Art. 5, 2b], have given to member States, power to limit the exercise of this right. However, this power is conditioned on both texts. Maybe, the European Directive is more explicit in regard to the issue of exceptions and limitations to the reproduction right. These limits can be established by the EU member States if the reproduction is made by an individual for private use, without direct or indirect commercial purposes and provided that there is fair compensation to the owner of the copyright.

Countries such as France [30, Art. L. 122-5-2], Spain [38, Art. 31.2], Sweden [39, Art. 12], Netherlands [40, Art. 16b.1] and Norway [36, §12] provide, as an exception to the reproduction right, the copy for private use. On the other hand, USA [63, 17 §107], UK [59, Arts. 29,30,31] and Canada [12, Art. 29] do not, but they regulate their exceptions under the doctrine of fair use and fair dealing.

In this regard, it is necessary to clarify that copyright infringement, may constitute a civil or criminal violation. (A civil violation is brought to justice

by the plaintive where as a criminal violation is persecuted by the state. Imprisonment is only possible in criminal cases.) For a copyright infringement to be considered a criminal offense, it shall conform to the elements that define the crime[8]. For example, under Spanish law, an act of reproduction of copyright protected works is considered a crime if it is made for profit and to the detriment of third parties [37, Art. 270.1]. Even more explicitly, Circular 1/2006 of Spain's Attorney General states that anyone who puts protected works in a web site through a server without permission of the owner of the rights of exploitation, could be held liable for unauthorized communication, but if monetary compensation is not proven, the intent of profit is not found, and the infringer can't be prosecuted [6, III. 2. c)], but a civil case is possible[9]. Also, those who download copyrighted content without paying, from someone making an unauthorized communication, are just doing a private copy of the work: this cannot be considered criminal behavior [6, III. 2. c)][10].

4.2.1 Criminal Cases

Chan Nai-Ming

In 2005, Hong Kong courts handed down the first criminal conviction related to P2P networks in the world. Chan Nai-Ming [52, 28] was convicted for having served as the original seed for three movies copied from VCD's legally purchased. The conviction was upheld by the Court of Final Appeal in 2007 [17].

Aurèlien D.

In France, in May 2006, the Criminal Chamber of the Court of Cassation [16] overturned a prior decision [15] and forwarded the case of Aurèlien D. to the Aix-en-Provence Court of Appeals [14]. The defendant was found guilty of copyrighted material counterfeit, because, according to the Court of Appeals, by placing copies in a P2P network he would no longer be covered by the statutory exceptions: for the private use of the copier and not intended for collective use [30, Art. L. 122-5(2)].

4.2.2 Civil Cases

BMG Music *et al.* v. Cecilia Gonzalez

In 2005, the United States Court of Appeals for the Seventh Circuit [62] upheld the decision of the United States District Court for the Northern District of Illinois that declared Cecilia Gonzalez liable for copyright infringement. It was the first time a Court of Appeals sanctioned the direct liability for copyright

[8] This is known in Latin as *Nullum crimen, nulla poena sine praevia lege poenali.*

[9] In Spain, the four biggest companies of the entertainment industry (Warner, Universal, EMI and Sony-BMG) and Promusicae, have recently attempted a civil action against the developer of Blubster, Piolet and Manolito, because his tools have been designed for "illegal" file sharing, between individuals and with "clear intent of profit". Plaintiffs have demanded as compensation 13 million euros and the closing of the web sites [51]

[10] This circular was criticized by the International Intellectual Property Alliance (IIPA), the most powerful U.S. lobby on issues related to copyright [35]. For them, the circular "decriminalized" P2P file-sharing, not a good sign for a country with one of the biggest levels of per capita P2P file-sharing in Europe. For this reason, the IIPA recommended keeping Spain on its watch list of countries that do not protect copyright

infringement by users who downloaded copyrighted content via P2P platforms. The doctrine of fair use was rejected in both instances: a copy downloaded, played, and retained on one's hard drive for future use is a direct substitute for a purchased copy and without the benefit of the license fee paid to the broadcaster [62, §3]. Moreover, the Court rules that downloads from P2P networks such as KaZaA, are an illegal competition for authors, who see their profits undermined by them. In addition, the Court stated that authors should decide on the best way to make their work available.

As reported in section 3.1.1, this is not the only lawsuit the RIAA has filed against users of P2P networks, but it has been the only case to reach that far into the US justice system.

4.3 On the legal status of linking

Techno Design v. Brein

In 2004, the District Court of Haarlem (Netherlands) [58] said that Techno Design, through its website zoekmp3.nl, didn't engage in illegal activities by making available to its users links to copyrighted files. For the Court, zoekmp3.nl worked as a search engine for hyperlinks/deeplinks, leading users to the files containing copyrighted material, but not hosting them, even if by clicking on a link, a file could be directly played from the hosting site or it could be downloaded onto the user's computer. The Court found that by warning its users about the inadmissibility of copyright infringements, Techno Design was relieved of liability for any possible illegal behavior of its users.

In 2006, The Court of Appeal of Amsterdam [66] reversed the decision of the District Court, citing that Techno Design was aware that its search engine, in a systematic and structural way, provided access to copyrighted contents. In addition, Techno Design got most of its economic benefits through the activity zoekmp3.nl. Finally, the warnings that Techno Design gave to its users, according to the Court of Appeals, was insufficient to discourage violations of copyright. zoekmp3.nl users used the service because they were looking for a way to directly reach the files containing copyrighted material.

4.3.1 Tono *et al.* v. Frank Allan Bruvik d/b/a Napster.no

In 2005, there was a decision in Norway (in the case of Tono *et al.* v. Frank Allan Bruvik d/b/a Napster.no) which determined the liability of a provider of hyperlinks to copyrighted material. This helps uploaders make copyrighted content available without permission from their owners. Linking in itself is not, in the eyes of the Supreme Court of Norway, a direct infringement under this country's Copyright Act. But uploading without permission was, and the Supreme Court confirmed the decision of the court of first instance: Frank Allan Bruvik was liable for having acted at least negligently [56, §8] by linking to copyrighted material uploaded by infringers. For the highest court, without the links provided by Napster.no (direct links to files or deep-links) "the users would normally not be able to find a music file which was uploaded on a computer connected to the Internet. The appeal court has not paid regard to the fact that it is first when a link is made to a file, that the users normally can get access to the file. Links are of vital importance for the use of the Internet" [56,

§22]. This was one of the first cases in which a link provider was held liable for accessory copyright infringement.

4.3.2 The Pirate Bay

In his decree of August 1, 2008, the Preliminary Investigations Court of Bergamo [4] issued a preventive seizure order on the Swedish website The Pirate Bay. The owners of this provider of links were charged with aiding and abetting, for profit, the illegal exchange of copyrighted material. The Court of Bergamo, therefore, argued that the site was the instrument for the infringement of the copyright law, as it allowed for illegal file-sharing. Because the operation of the website may "deteriorate or extend in time the consequences" of that crime, the Court decided to place it under preventive seizure, and enjoins all ISP's established in Italy, from granting their users access to www.thepiratebay.org, its aliases and its static IP address.

On appeal, the Court of Bergamo said that the decree adopted by the Court of Preliminary Investigation was a sui generis personal order, as it affected the ISPs, which had no responsibility in the crime, so that their users would not have access to the web site. As this measure was not established in the Italian criminal procedure, the preventive seizure of The Pirate Bay was lifted.

4.3.3 Sharemula

Recently, the Provincial Court of Madrid (Spain) held the decision of the Examining Court Nr. 4 [48], which ordered the dismissal of proceedings in the criminal case initiated against sharemula.com, a provider of P2P links to copyrighted content. As a service provider that provides links, the activity of sharemula.com is regulated by the Information Society Services and Electronic Commerce Act (July 11, 2002). The responsibility for the content linked to, is subject to actual knowledge of its wrongfulness; without knowledge, there is no liability. Moreover, the Court held that linking does not provide a public communication under the Spanish Criminal Code. This decision, in line with the Circular of the Attorney General (section 4.2), summarizes the Spanish doctrine that has been applied in other cases and that the IIPA has openly criticized [35, p. 9].

4.4 The responsibility of multimedia equipment manufacturers

In 1999, the RIAA filed an action before the United States Court of Appeals for the Ninth Circuit, to prevent Diamond Multimedia Systems from manufacturing and distributing its Rio, the first portable music player in MP3 format. The RIAA argued that the Rio did not meet the requirements of the Audio Home Recording Act (AHRA) for digital audio recording devices, as it lacked the serial copy management system and royalties for manufacturing and distribution had not been paid. The Court found, first, that the Rio was not a digital audio recording device in terms of the ARHA, the files it copied were not stored in a digital recording device; computers "are not digital audio recording devices because their 'primary purpose' is not to make digital audio copied recordings" [60, §29]. Second, the Court understood that the communication established between the Rio and a computer could not be classified as a "transmission"

within the meaning of the Copyright Act, which, again, ruled out the Rio as a digital audio recording device [60, §21–23]. The lawsuit was dismissed and, even though it seems a huge pro-technology ruling, decisions favoring the CPI on P2P cases, were based in the Rio case.

4.5 The legal status of the ISP

Digital Millennium Copyright Act (DMCA)

In 1998, the Digital Millennium Copyright Act (DMCA), composed of five titles covering various topics on copyright, was approved in the United States of America. Title I is designed to adapt U.S. law on copyright to WIPO treaties[11], giving legislative response to CPI's concerns about the risk that technologies developed to circumvent copyright protection systems [63, 17 §1201], i.e., Digital Rights Management (DRM).

In Title II, a series of limitations on liability relating to material online for the providers while performing their business activity, were described [63, 17 §512]:

1. Transitory communications when an ISP acts as a conduit for a copyrighted file requested by an user.
2. System caching of a copyrighted file requested by an user, with the purpose of saving bandwidth when another request for the same file arrives.
3. Storage of information on systems or networks at direction of users.
4. Linking or referring infringing material by Internet information location tools.

The measures contained in Titles I and II of the DMCA, and studied in this section are found in [26, Chapter III] and [25, Art. 12], respectively.

4.6 Legal aspects of measures used by CPI

- The proposed French law [31] creates a series of questions relating to fundamental rights and freedoms [27, Articles 7, 8 and 11], and the possibility of their interference by an administrative authority[12] or a private entity[13]. In this regard, the Commission's position on Amendment 138 [23] adopted by the European Parliament in plenary vote on 09/24/2008, states that "no restriction may be imposed on the fundamental rights and freedoms of end-users, without a prior ruling by the judicial authorities, notably in accordance with Article 11 of the Charter of Fundamental Rights of the European Union on freedom of expression and information, save when public security is threatened where the ruling may be subsequent" [22]. Likewise, the European Parliament has argued that the Commission and

[11] Copyright Treaty (1996), Art. 11, and Performances and Phonograms Treaty (1996) Art. 18.
[12] Like HADOPI.
[13] Like ISP.

Member States should avoid "adopting measures conflicting with civil liberties and human rights and with the principles of proportionality, effectiveness and dissuasiveness, such as the interruption of Internet access" [24, §23].

However, some European countries, besides France, are making efforts to achieve regulations based on the philosophy of graduated response. In the United Kingdom, the main ISP tried to negotiate a private arrangement with the content industry, to cut the service of repeat offenders, after several warnings. Spain and Italy, through their respective ministers of culture, have praised the French model.

The trend seems to be global, as we can find news from Japan, South Korea, Australia or the USA, about the wisdom of the graduated response model.

The Constitutional Council [13], after the approval of the Act in Parliament, has rejected the sanctions mechanism established in it, appealing to the principles and values enshrined in the Declaration of the Rights of Man and of the Citizen. The privacy of communications is the guarantee of freedom of speech, and this in turn means the freedom of Internet access.

Accordingly, an administrative authority can not decide on the restriction of constitutionally protected rights and guarantees. However, the warning mechanism, which involves filtering and monitoring of the Internet connections is kept [29].

A new project, complimentary to the HADOPI Act, has been introduced in the Senate [1]. Officials of the HADOPI will act as a police force of the Internet, reporting intellectual property infringements to the courts. Criminal justice will prosecute infringers for *contrafaçon* (counterfeit), which is punished with imprisonment and fine penalties, and if the infringer is also the subscriber, suspension of service can be applied as an accessory penalty.

ISPs can be fined €3750 for each case of intellectual property infringement not reported to the HADOPI.

But the first country that will apply a graduated response law is not France, but New Zealand. The Copyright Amendment Act [44], scheduled for February 2009, includes the new 92A section, which states that ISP's "must have policy for terminating accounts of repeat infringers".

- In Belgium, the Trial Court of the District of Brussels, on 29 June 2007 in the case Sabam v S.A. Tiscali (Scarlet), decided that Scarlet was liable for P2P copyright infractions by its customers and should find a way to control those infractions. If Scarlet was not able to do so by October 2008, it will pay 2500 € per day. On October 28, 2008 Scarlet convinced the Court that it was impossible to stop the infractions, at least using the solution proposed by Sabam, a software called Audible Magic. The Court said it was for the Brussels Court of Appeals to decide on technical and legal issues put forward by Scarlet: "can it be made legally compulsory for Internet Access Providers - such as Scarlet - to filter content; unfair

competition; consumer rights; and whether encrypting does not make any filtering technologies impossible" [18].

5 Mathematical model for users' behavior

Consider a peer P that searches for some file F. We focus on a steady state phase in which it is assumed that the probability q that a peer has the file F when it connects, remains constant in time.

We consider two types of peers. The first, which we call "cooperative", connect and remain some generally distributed time in the system, during which they may download files and let others download from them.

Free riders are those peers that remain just the time they need to download a file. We assume that if the file is not available they immediately disconnect and try to connect at a later time. We assume that these remain in the network a negligible amount of time so that their contribution to the amount of shared file available for the community is negligible.

Behavior of cooperative Peers
Assume that cooperative peers connect at a rate λ and that a cooperative peer remains connected during some generally distributed time Θ with mean σ. Let r be the probability that a cooperative user is interested in the file F, assuming it does not have it yet. We assume that connection time is independent on whether the peer has F or not, nor on whether it is interested or not to have it. A dependence exists for users that wait till F is available and then download it and disconnect; but this type of behavior is, by our definition, not a cooperative one, and thus does not concern cooperative peers.

Measures against Internet piracy
We shall consider two types of measures. The first, consists on discovering and taking measures against uploads and thus targets cooperative users: if peer P responds to a request for uploading a file, then the source of the request receives the IP address of P. This is how RIAA proceeded to obtain data concerning users of file sharing networks [21]. A second approach consists on directly discovering and taking measures against illegal downloads using e.g. deep packet inspection.

Definition 5.1. *(i) The availability of a file F is defined as the probability that a peer that does not have the file finds it upon arrival.*
(ii) The popularity of a file F is the probability that a peer has the file F just before connecting, i.e. the probability q. Note that the probability that a connected peer has the file F may be larger than q.
(iii) The probability of future opportunities is defined as the probability that a peer who does not find the file F upon arrival, receives it during its connection duration.
(iv) The DownLoad Rate (DLR) of F is defined as the rate at which peers acquire the file F.
(v) The Interested Arrival Rate (IAR) given by $\beta := \lambda r(1-q)$ is the rate of arrival of peers that are interested in F and do not have it when connecting.
(vi) Upload arrival rate (UAR), α, is the arrival rate of cooperative peers having F.

The IAR can be viewed as the rate of arrival of demand where as UAR is the rate of arrival of offer for F. We shall see how diminishing any one of these impacts the availability of F, as well as the download rate of cooperative users.

Behavior of Free Riders

A free rider probes the network at times $\{S_i\}$ till it finds F. The CPI's actions will aim to decrease the probing rate. Our goal is to study the impact of this on the total time that a free rider will have to spend in probing the system till it finds F.

When analyzing free riders behavior, we shall assume in subsection 5.2 that there is little interest in F among those that do not have it, i.e. r is taken to be zero. We believe that this is an interesting regime since we shall see that measures against downloads are more efficient then.

The reader not interested in the mathematical analysis may go directly to Subsection 5.4 that describes the qualitative results that we learn from the mathematical model.

5.1 Mathematical analysis

Let $\widetilde{N}(t)$ be the number of connected peers that have the file F at time t or that are interested in having it at that time.

Theorem 5.1. *The number of connected peers at any given time t has a stationary Poisson distribution with parameter $\rho = \lambda\sigma$, and the number of connected peers hat have the file F upon arrival is Poisson distributed with parameter ρq. The distribution of $\widetilde{N}(t)$ is Poisson with parameter $(\alpha+\beta)\sigma$ where $\alpha = \lambda q$ and $\beta = \lambda r(1-q)$.*

Proof. The statement follows by observing that the process that counts the number of connected peers at t has the dynamics of an $M/G/\infty$ queue with an arrival rate λ and a service time distributed like Θ. The second part follows from similar arguments. ◇

Let $G(u)$ be the probability that $\Theta \leq u$. We shall need the following.

Lemma 5.1. *Consider an $M/G/\infty$ queue with arrival rate $\widehat{\lambda}$ and with service probability distribution $G(u)$. Let $B^*(s,\widehat{\lambda})$ be the LST of the residual busy period at time 0 in stationary regime (we take it to be 0 if the server is idle at that time). We have*

$$B^*(s,\widehat{\lambda}) = \frac{\widehat{\lambda}}{\beta\mu(\beta)}p(\infty)$$

where

$$\mu(s) = \lambda\int_0^\infty \exp(-st)p(t)dt$$

$$p(t) = \exp\left\{-\widehat{\lambda}\int_0^t (1-G(u))du\right\}dx$$

Proof. It directly follows from equation (1) in [11] that $B^*(s,\hat{\lambda})$ is given by

$$\lim_{y\to\infty}\frac{\widehat{\lambda}}{\mu(s)}\int_0^\infty \exp\left\{-sx-\widehat{\lambda}\int_0^{y+x}(1-G(u))du\right\}dx$$

(note that the expression in [11] is for the forward recurrence time, whose distribution is the same as the past recurrence time.) ◇

Theorem 5.2. *Consider a cooperative peer interested in F and that does not have it before connecting. The availability probability is given by $1-\zeta$ where*

$$\zeta = B^*(\beta\sigma, \alpha)\exp(-\alpha\sigma) \tag{1}$$

The stationary probability of future opportunities (i.e. that the peer receives F during his connection, given that he did not receive it upon arrival) is $1-\Theta^*(\lambda q)$. where $\Theta^*(s)$ is the Laplace Stieltjes Transform (LST) of Θ at point s.
The download rate is given by

$$DLR = \beta(1-\zeta+\zeta(1-\Theta^*(\lambda q)).$$

Proof. Consider the arrival process of only those peers that just before connecting, do not have F but are interested in getting it. This is a Poisson process with intensity β. The process that describes the number of connected sessions among these corresponds thus to the number of customers in an M/G/∞ queue with arrival rate β and i.i.d. service time distributed like Θ. Focus on $t=0$ and consider the past busy period of those that were interested in F. At time $t=0$ there is no connected peer with F if and only if the following two events occur:

- no peer that arrived with F before this past busy period is still in the system when the busy period begins. The probability of this event is $\exp(-\alpha\sigma)$.
- No arrivals of peers with F occurred during that past busy period. The probability of this event is $B^*(\beta\sigma, \alpha)$.

This implies the Theorem. ◇

Remark 5.1. *An alternative derivation of ζ is as follows. The process that counts the number of connected peers that have F or that are interested in F at t has the dynamics of an $M/G/\infty$ queue with an arrival rate $\alpha+\beta$ and a service time distributed like Θ. Let C be the event that a peer with F is present in the system at time 0. C occurs iff there has been at least one arrival of F during the past busy period at time 0. Let N_p be the number of arrivals in the current busy period before time 0, and let $G_p(z) = E[z^{N_p}]$ be its probability generating function. Then*

$$P(C|N_p) = 1 - \left(\frac{\beta}{\alpha+\beta}\right)^{N_p}$$

and hence

$$1-\zeta = P(C) = 1 - G_p\left(\frac{\beta}{\alpha+\beta}\right).$$

Example: exponentially distributed Θ. Consider an M/M/∞ queue with arrival rate $\hat{\lambda}$ and service rate of 1 unit. Define

$$Q_n(s,u) = \int_0^1 e^{-ux}(1-x)^{s-1}x^n dx,\ n \geq 0$$

Then [47, 33] the Laplace Stieltjes Transform of the residual busy period at stationary regime is

$$B^*(s,\hat{\lambda}) = \frac{Q_1(s,\hat{\lambda})}{Q_0(s,\hat{\lambda})}.$$

We conclude the following:

Theorem 5.3. *Consider the $M/M/\infty$ queue with arrival rate $\hat{\lambda}$ and service rate of 1 unit. Then the availability is given by*

$$1-\zeta = 1 - \frac{Q_1(\beta,\alpha)}{Q_0(\beta,\alpha)}\exp(-\alpha).$$

The probability of future opportunities (PFO) is given by

$$PFO = \frac{\alpha}{\alpha+1}$$

The download rate is given by

$$DLR = \beta\left(1 - \frac{Q_1(\beta,\alpha)}{Q_0(\beta,\alpha)}\frac{\exp(-\alpha)}{1+\alpha}\right)$$

5.2 Analysis of Free Riders' Delay

As before, the probability to find F upon connection is $\overline{q}$. We set $S_0 = 0$ and set $\tau_i := S_i - S_{i-1}$. Let ξ_i be the number of the cooperative peers who have the file at time S_i. Without loss of generality we can ignore cooperative peers that do not have the file. Indeed, as we shall take $r = 0$, they will not contribute to the availability of the file. Thus the arrival rate of cooperative peers is $\lambda = \alpha$. We then have $\rho = \alpha\sigma$. Let $\mathcal{S}_c$ be a random variable distributed as the past sojourn time of a cooperative node.

Theorem 5.4. *Assume that there is very little interest in F among those that do not have it, i.e. r is taken to be zero. Then*
(i) The expected time that it takes for a free rider peer to obtain the file F is given by

$$E[S] = \sum_{i=1}^{\infty} S_i P(\xi_i > 0, \xi_1 = ... = \xi_{i-1} = 0)$$

$$= \sum_{i=1}^{\infty} S_i (1 - \exp(-\rho P(\tau_i < \mathcal{S}_c)) \prod_{j=1}^{i-1} \exp(-\rho P(\tau_j < \mathcal{S}_c))$$

(ii) The expected number of samples (probes) of the peer is given by

$$E[N] = \sum_{i=1}^{\infty} i (1 - \exp(-\rho P(\tau_i < \mathcal{S}_c)) \prod_{j=1}^{i-1} \exp(-\rho P(\tau_j < \mathcal{S}_c))$$

Proof. The time S at which a free rider obtains F is S_{n+1} if and only if $\xi_i = 0$ for $1 \le i \le n$ and $\xi_{n+1} > 0$. It is strictly greater than S_n if and only if $\xi_i = 0$ for $1 \le i \le n$. We note that $\xi_k = 0$ is a renewal event so that

$$P(S > S_n) = P(\xi_0 = \xi_2 = ... = \xi_n = 0) = P(\xi_0 = 0) \prod_{i=1}^{n} P(\xi_i = 0 | \xi_{i-1} = 0)$$

as well as

$$P(S = S_{n+1}) = P(\xi_1 = \xi_2 = ... = \xi_n = 0, \xi_{n+1} > 0)$$

$$= P(\xi_1 = \xi_2 = ... = \xi_n = 0) P(\xi_{n+1} > 0 | \xi_n = 0).$$

It thus suffices to compute the distribution of ξ_{i+1} conditioned on $\xi_i = 0$. We compute this using the following coupling argument.

Recall that the cooperative peers arrive according to a Poisson process. Let T_n be the arrival time of the nth cooperative peer. Let $\nu(i)$ be the index of the last arrival of a cooperative peer before time S_i. More precisely, $\nu(i) = k$ if and only if $T_k \leq S_i < T_{k+1}$.

Consider a second fictitious P2P system that has arrivals of cooperative peers at times $\widetilde{T}_n, n \geq 0$ where $\widetilde{T}_n := T_n - S_i$, $n > \nu(i)$. Thus in the new system there are no arrivals of cooperative peers till time 0. The sojourn times $\widetilde{\Theta}_n$ of cooperative peers are assumed to be the same as Θ_n for all $n > \nu(i)$. Clearly, whenever the original network is empty at time S_n, then the number of peers with F at time S_{n+1} is the same as the number of peers with F at time τ_1 in the new network. We compute therefore the distribution of the latter.

The new network is an $M_t/\mathrm{G}/\infty$ queue where the arrival process is a non homogeneous Poisson process $\lambda(t)$ with intensity $\lambda(t) = 0$ for $t < 0$ and intensity $\lambda(t) = \lambda$ after that. The distribution of the number of customers at any time t in an $M_t/G/\infty$ queue was derived in [19]. Specifying equation 3 in [19] to our setting we conclude that it is a Poisson distribution with parameter $\rho P(\tau_i < \mathcal{S}_c)$. This yields (i) and (ii) after some direct algebra. ◇

As an example, assume that the sojourn time of cooperative peers is exponentially distributed with parameter μ. Then $\mathcal{S}_c$ is known also to have exponential distribution with parameter μ, so we obtain:

Corollary 5.1. *Assume that the sojourn time of cooperative peers is exponentially distributed with parameter μ. Then*

$$E[S] = \sum_{i=1}^{\infty} S_i(1 - \exp(-\mu\tau_i)) \exp(-\mu S_{i-1})$$

$$= \sum_{i=1}^{\infty} S_i[\exp(-\mu S_{i-1}) - \exp(-\mu S_i)]$$

If moreover $\tau_i = \tau$ are constant then we get

$$E[S] = \frac{\tau}{1 - \exp(-\rho \exp(-\mu\tau))}$$

and

$$E[N] = \frac{1}{1 - \exp(-\rho \exp(-\mu\tau))}$$

5.3 Numerical results

For the case of cooperative peers, we investigated the availability and the download rate as a function of α and β. The goal is to understand the impact of an effort by the CPI to decrease the interest in a file as a function of its upload arrival rate and the demand for it. The time unit is chosen such that $\sigma = 1$.

Figure 1 depicts the availability probability (y-axis) as a function of β (x-axis) for five values of α: 4, 2, 1, 0.5 and 0.05. β varies in the range $[0.05, \ldots, 8.5]$ with an incremental increase of 0.5. The curves are decreasingly ordered in α: $\alpha = 4$ corresponds to the curve that dominates all the others (straight line) and

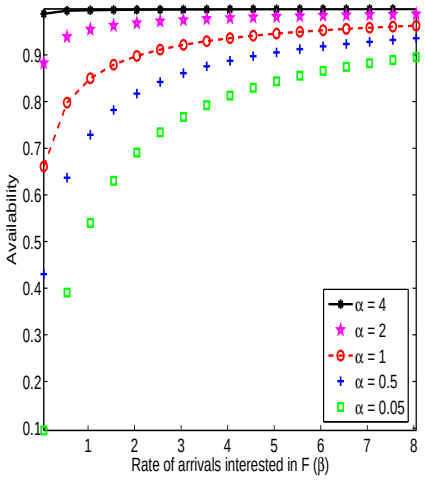

Figure 1: The availability probability (y-axis) as a function of β (x-axis) for 5 values of α: 4, 2, 1, 0.5 and 0.05. The curves are decreasingly ordered in α. $\sigma = 1$.

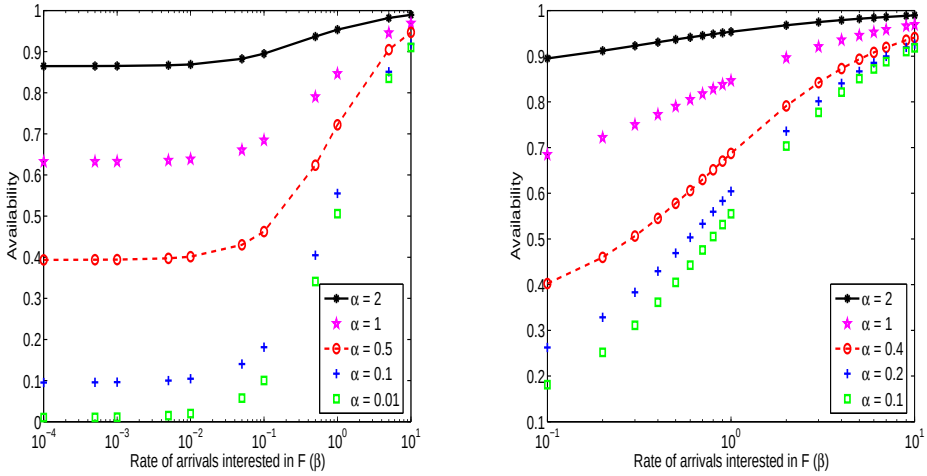

Figure 2: The availability probability (y-axis) as a function of β (x-axis with a logarithmic scale), for 5 values of α. (**Left**): β varies in $[10^{-4}, 10^{1}]$ and $\alpha \in \{0.01, 0.1, 0.5, 1, 2\}$. (**Right**): β varies in $[10^{-1}, 10^{1}]$ and $\alpha \in \{0.1, 0.2, 0.4, 1, 2\}$. The curves are decreasingly ordered in α. $\sigma = 1$.

the lowest curve corresponds to $\alpha = 0.05$. Figure 2 plots the availability as a function of α and β on a logarithmic horizontal scale.

Similarly, Figures 3 plots the download rate as a function of α and β.

For the case of free riders, we looked to the impact of sampling frequency on the mean waiting time. Figure 4 plots the mean waiting time of a free rider to download a file (y-axis) as a function of the sampling interval τ (x-axis). In the left figure, $\lambda = \alpha = 1$ is fixed and μ takes three different values: 1, 0.5 and 0.05. In the right figure, $\mu = 1$ is fixed and α takes three values 1, 0.5 and 0.05.

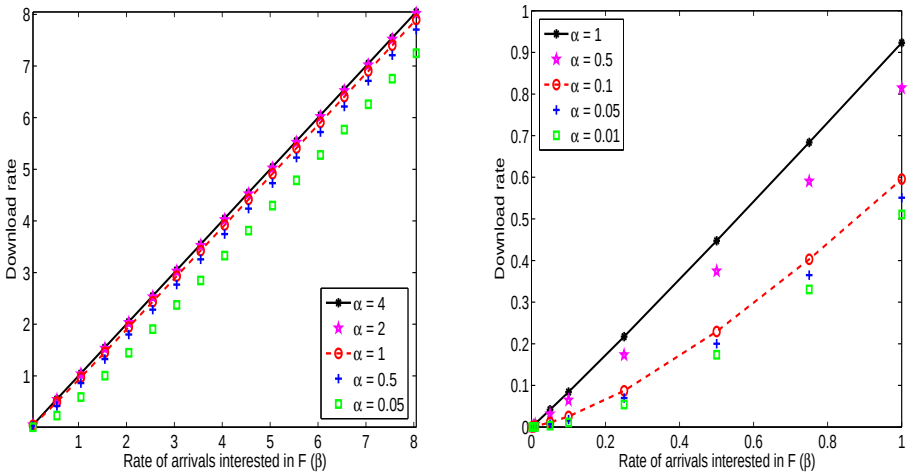

Figure 3: The download rate (y-axis) as a function of β (x-axis) for 5 values of α. (**Left**): β varies in $[0.05, 8.5]$ with an increment of 0.5 and $\alpha \in \{0.05, 0.5, 1, 2, 4\}$. (**Right**): β varies in $[10^{-3}, 1]$ and $\alpha \in \{0.01, 0.05, 0.1, 0.5, 1\}$. The curves are decreasingly ordered in α. $\sigma = 1$.

5.4 On the efficiency of CPI measures: Conclusions drawn from the figures.

5.4.1 Impact on availability for cooperative peers

- For α large (value greater than 1), no matter how much effort is put to discourage the download interest of peers, the file will remain highly available (probability more than 0.8). Thus a huge effort that reduces β from 8.5 to 0.05 will result in minor decrease on file availability. Hence, if $\lambda q \sigma$ is around 1 or more, then the benefit of trying to discourage the download is negligible.

- This conclusion remains true also if the effort is made to decrease α when β is large where a decrease in α will not have much impact on the availability probability.

- However, when both α and β are small, a decrease in β will decrease dramatically the availability of the file in the network. For instance, we observe that by reducing β from $\beta = 1$ to half its value at $\alpha = 0.05$, the availability will decrease from 0.53 to 0.4, i.e. by around 30%.

- Here is another way to view this behavior. Define the slope of the availability curve for a fixed α as the **Availability Decrease Rate (ADR)**. It indicates the decrease of the availability per unit of decrease in β. We observe that the curves in Figure 1 are all concave. This implies that the ADR increases when either β or α increase. Hence for each α it is maximized at $\beta = 0$.

- So far we observed how does a unit decrease in the IAR affects the availability. This concerned subtracting a unit. Next we consider how does

a multiplicative rate reduction affects the availability. The multiplicative reduction is equivalent to subtracting from the IAR a unit on a logarithmic scale. We observe this effect in Figure 2 whose horizontal axis is logarithmic. The curves are no longer concave anymore, but instead they have a sigmoid form. Now the largest reduction of the availability due to shrinking the IAR by a multiplicative constant does no longer occur anymore on the boundary but at an interior point. For instance, when $\alpha \leq 1$, dividing the rate of arrivals β by 10 has the largest impact in reducing the availability (see Figure 2-Right).

We thus conclude that if the effort of the CPI is proportional to the amount by which it can decrease the interest in a file, or more precisely, the arrival rate β, then the largest decrease in the availability for a given effort is obtained for content that has β and α as small as possible. If the effort of the CPI is proportional to the multiplicative factor by which the interest arrival rate β is reduced, then the value of β for which the decrease in the availability per a given effort is largest is in general an interior point - it is obtained at those (α, β) for which the slope in Figure 2 is the largest.

5.4.2 Impact on download rate of cooperative peers

As for the download rate, we observe that it grows with β at a rate that is close to constant and almost independent of the value of α (Figure 3-Left). In fact, the linear behavior occurs when the availability is large (close to 1). There, the download rate is close to β. By reducing the IAR β to some β' in this range, the download rate obviously decreases by the same amount. We say that measures for reducing the download rate are effective if by reducing the IAR from β to $\Delta\beta$, the download rate decreases by a multiplicative factor larger than Δ. We see that this occurs again at low α and β. For instance, we observe in the right part of Figure 3 for $\alpha = 0.05$, that when β decreases from 1 to 0.5 by a factor of 2, the DLR decreases by a factor close to 3.

5.4.3 Impact on delays of free riders

As can be expected, we observe that for a given mean sojourn time of cooperative users, the mean waiting time of a free rider increases with larger sampling intervals. Inversely, for a given sampling interval, the mean waiting time decreases when the mean sojourn time increases.

This is illustrated in Figure 4. For a given λ, and as the value of μ becomes large (i.e. cooperative peers stay connected for short time), a small increase in the probing rate τ results in a large increase in the expected time that the free rider has to spend probing till it finds F. The same conclusion is seen to hold when μ is fixed and α becomes small.

We conclude that if CPI can take actions that decrease the probing rates of free riders, then it can affect expected waiting time of free riders dramatically when $\rho = \alpha/\mu$ is already small, otherwise this measure does not have much impact.

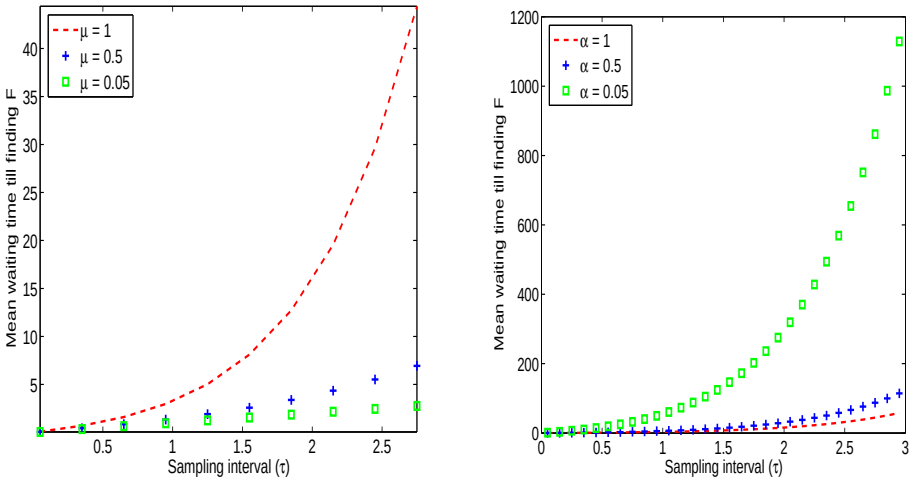

Figure 4: The mean waiting time for a free rider (y-axis) as a function of sampling interval τ (x-axis). (**Left**): $\lambda = 1$ constant and $\mu \in \{0.05, 0.5, 1\}$. (**Right**): $\mu = 1$ is constant and $\lambda \in \{0.05, 0.5, 1\}$.

6 Conclusions

The legislative status of P2P is experiencing many rapid changes, which may have impact both on its future business models as well as on its architecture.

Through a simple mathematical model we have shown that the efforts of reducing interest in downloading may not result in decreasing of the availability of files for downloading. This is in line with the conclusions drawn in [10] from experimental results reported there. Similar conclusions were drawn for the waiting time of free riders. We have identified however cases in which actions for reducing the rate of requests for a file have a large impact on the file's availability and on the download rate.

We conclude with some insight from the past on the question of whether one can expect open legal access through P2P networks to copyright material in the future. In 1984, US Supreme Court rejected the movie industry's attempt to bar Sony from manufacturing video recorders, siding in favor of the development of technologies that are capable of substantial non-infringing uses [41, 57]. As already mentioned, in the early 1990s, the music industry and the Digital Audio Tape industry agreed to promote compromise legislation establishing a reimbursement scheme based on a safe harbor for devices using a "Serial Copyright Management System" memorialized in the Audio Home previous term Recording next term Act of 1991, 17 U.S.C. 1001-1010 (2000) ("AHRA") [49]. We may expect similar moves in the future towards a new P2P concept in which some flat rate is paid to copyright holders representatives for unlimited access to P2P networks that may contain copyrighted music and films.

References

[1] Alliot-Marie, M. Projet de Loi relatif à la protection pénale de la propiété littéraire et artistique sur internet (PROCÉDURE ACCÉLÉRÉE

ENGAGÉE). `http://www.senat.fr/leg/pjl08-498.html`, Juin 2009.

[2] Apple Press Release. Apple Unveils Higher Quality DRM-Free Music on the iTunes Store, Abril 2007.

[3] Apple Press Release. Changes Coming to the iTunes Store, January 2009.

[4] Arena, A. Italy: Italian Courts Ban Pirate Bay, but then Lift the Block (IRIS 2008-10:13/21). IRIS Merlin, 2008.

[5] Arora, G., Hanneghan, M., and Merabti, M. P2P commercial digital content exchange. *Electronic Commerce Research and Applications 4*, 3 (May 2005), 250–263.

[6] Attorney General of Spain. Circular 1/2006 on crimes against intellectual and industrial property after the Reform of the Organic Law 15/2003, 2006.

[7] Bakker, P. File-sharing – fight, ignore or compete paid download services vs. P2P-networks. *Telematics and Informatics 22*, 1-2 (February-May 2005), 41–55.

[8] Bakos, Y., Brynjolfsson, E., and Lichtman, D. Shared information goods. *Journal of Law and Economics 42*, 1 (1999), 117–55.

[9] BBC News. Madonna swears at music pirates, 2003.

[10] Bhattacharjee, S., Gopal, R. D., Achara, K. L., and Marsden, J. R. Impact of legal threats on online music sharing activity: an analysis of music industry legal actions. *Journal of Law and Economics 49*, 1 (April 2006), 91–114.

[11] Browne, S., and Disele, J. M. Transient behavior of coverage processes with applications to the infinite-server queue. *Journal of Applied Probability 30*, 3 (1993), 589–602.

[12] Canada. The copyright act, 1985, Revised.

[13] Conseil Constitutionnel. Décision Nro. 2009-580 DC du 10 juin (Loi favorisant la diffusion et la protection de la création sur internet), 2009.

[14] Cour D'Appel d'Aix en Provence 5ème chambre des appels correctionnels Arrêt du 5 septembre 2007. 2007/501, September 2007.

[15] Cour D'Appel de Montpellier, 3ème Chambre Correctionnelle. Dossier 04/01534, Mar 2005.

[16] Cour De Cassation, Chambre Criminelle Arrêt du 30 Mai 2006. Numéro 05-83.335, 2006.

[17] Court of Final Appeal of the Hong Kong Special Administrative Region. Final Appeal No. 3 OF 2007 (criminal) (On Appeal from HCMA No. 1221 of 2005), 2007.

[18] Crowell & Moring. Crowell & Moring Client Scarlet Obtains a First Positive Decision in Sabam vs. SA Scarlet Extended. Press Release & Announcements, October 2008.

[19] Eick, S. G., Massey, W. A., and Whitt, W. The physics of the $M_t/G/\infty$ queue. *Operations Research 41*, 4 (July-August 1993), 731–742.

[20] Electronic Frontier Foundation. RIAA v. The People: Five years later, 2008.

[21] Electronic Frontier Foundation. RIAA v The People: Five years later, 2008.

[22] European Commission. Commission position on Amendment 138 adopted by the European Parliament in plenary vote on 24 September, MEMO/08/681, 2008.

[23] European Parliament. Legislative resolution of 24 September 2008 on the proposal for a directive of the European Parliament and of the Council amending Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services, Directive 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and Directive 2002/20/EC on the authorisation of electronic communications networks and services, Texts adopted P6_TA(2008)0452, 2008.

[24] European Parliament. Resolution of 10 April 2008 on cultural industries in Europe, Texts adopted P6_TA(2008)0123, 2008.

[25] European Parliament and Council of the European Union. Directive 2000/31/EC on certain legal aspects of information society services, in particular electronic commerce, in the Internal Market (Directive on electronic commerce). Official Journal of the European Communities L178, Volume 43, 17 July, 2000.

[26] European Parliament and Council of the European Union. Directive 2001/29/EC on the harmonisation of certain aspects of copyright and related rights in the information society. Official Journal of the European Communities L167/10, Volume 44, 22 June, 2001.

[27] European Union. Charter of Fundamental Rights of The European Union (2000/C 364/01). Official Journal of the European Communities C364/1, Volume 43,18 December, 2000.

[28] Filby, M. Big Crook in Little China: The Ramifications of the Hong Kong BitTorrent Case on the Criminal Test of Prejudicial Effect. *International Review of Law, Computers & Technology 21* (November 2007), 257–283.

[29] Française, R. LOI no 2009-669 du 12 juin 2009 favorisant la diffusion et la protection de la création sur internet. Journal Officiel Nro. 0135 Texte Nro. 2, Juin 2009.

[30] French Republic. Intellectual Property Code (in french Code de la propriété intellectuelle) .

[31] French Republic. Draft of the Act for the Difussion and Protection of the Creation over the Internet (original in french Projet de loi favorisant la difusion et la protection de la création sur internet), 2008.

[32] Gayer, A., and Shy, O. Publishers, artists, and copyright enforcement. *Information Economics and Policy 18*, 4 (November 2006), 374–384.

[33] Guillemin, F., and Simonian, A. Transient characteristics of an M/M/∞. *Advances in Applied Probability 27*, 3 (September 1995), 862–888.

[34] International Federation of the Phonographic Industry (IFPI). Digital Music Report 2009, 2009.

[35] International Intellectual Property Alliance. Spain: IIPA 2009 Special 301 Report on Copyright Protection and Enforcement, 2009.

[36] Kingdom of Norway. Act No. 2 of 12 May 1961 relating to Copyright in Literary, Scientific and Artistic Works, etc, with subsequent Amendments, latest of 16 April 1999, Act No. 19, 1961.

[37] Kingdom of Spain. Official Bulletin of the State, No. 283. November 26, 2003.

[38] Kingdom of Spain. Law 23/2006 of July 7, amending the text of the Intellectual Property Law, approved by Royal Legislative Decree 1/1996 of April 12. Official Bulletin of the State, No 162, July 8, 2006.

[39] Kingdom of Sweden. Act on copyright in literary and artistic works, 1960.

[40] Kingdom of the Netherlands. Copyright Act 1912 of Netherlands, 1912.

[41] Lee, E. The ethics of innovation: P2P software developers and designing substantial noninfringing uses under the Sony doctrine. *Journal of Business Ethics 62*, 2 (2005), 147–162.

[42] Litman, J. Ethical disobedience. *Ethics and Information Technology 5* (2003), 217–223.

[43] Makowski, A. M. On a random sum formula for the busy period of the M/G/∞ queue with applications. Tech. Rep. CSHCN TR 2001-4, Army Research Lab., Adelphi, MD, 2001.

[44] New Zealand. Copyright (New Technologies) Amendment Act 2008, October 2008.

[45] Olivennes, Denis. The development and protection of cultural works on the new networks (original in french Le Developpement et la Protection des Oeuvres Culturelles sur les Nouveaux Reseaux), 2007.

[46] Piatek, M., Kohno, T., and Krishnamurthy, A. Challenges and directions for monitoring P2P file sharing networks – or – why my printer received a DMCA takedown notice. In *3rd USENIX Workshop on Hot Topics in Security (HotSec '08)* (July 2008).

[47] Preater, J. M/M/∞ transience revisited. *Journal of Applied Probability 34*, 4 (1997), 1061–1067.

[48] Provincial Court of Madrid, Second Section. Ruling Nr. 582/08, 2008.

[49] Radcliffe, M. F. Grokster: The new law of third party liability for copyright infringement under United States law. *Computer Law and Security Report 22*, 2 (2006), 137–149.

[50] Ribas, J. The control of downloads (original in spanish El control de las descargas). El País.com, December 2008.

[51] Rodríguez, S. Promusicae suits Blubster and ManolitoP2P creator for 13 million euros (original in spanish Promusicae demanda al creador de Blubster y ManolitoP2P por 13 millones de euros). El Mundo.es Navegante, 2008.

[52] Rui, Z. P2P Copyright Debate. China.org.cn, 2005.

[53] Saxby, S. CLSR briefing news and comment on recent developments from around the world. *Computer Law and Security Report 19*, 3 (May 2003), 250–265.

[54] Schaumann, N. Direct infringement on peer-to-peer networks. *Journal of Internet Law* (April 2005).

[55] Smiers, J., and van Schijndel, M. *Imagine... No Copyright.* Libertad y Cambio. Gedisa, Barcelona, 2008.

[56] Spang-Hanssen, H. S. Translation of ("Norwegian Napster") Case: Tono et. al v. Frank Allan Bruvik d/b/a Napster, Hr-2005-00133-A, Rt-2005-41 (Supreme Court of Norway, 27 January 2005 - Docket No. 2004/822. *SSRN eLibrary* (2005).

[57] Supreme Court of the United States of America. Sony Corporation of America, et al., vs. Universal City Studios, Inc., et al. No. 464 U.S. 417, 1984.

[58] The Court in Haarlem, Three-Judge Section. Techno Design 'Internet Programming' BV v. Stichting Bescherming Rechten Entertainment Industrie Nederland, Brein (85489/HA ZA 02-992), May 2004.

[59] United Kingdom. Copyright, designs and patents act 1988, 1988.

[60] United States Court of Appeals for the Ninth Circuit. Recording Industry Association of America v. Diamond Multimedia SYS No. 180 F.3d 1072, 1999.

[61] United States Court of Appeals for the Ninth Circuit. A&M Records, Inc., et al., v. Napster, Inc. No. 00-16401, 2000.

[62] United States Court of Appeals for the Seventh Circuit. BMG Music, et al., vs Cecilia González (No.05-1314), 2005.

[63] United States of America. United States Code.

[64] University of Alcalá (Spain). Educate to create (original in spanish Educar para crear), 2008.

[65] van Beijnum, I. Dutch government study: net effect of P2P use is positive. ars technica, January 2009. `http://arstechnica.com/`.

[66] van der Wal, B. Netherlands: Court Puts an End to Exploitation of MP3 Search Engine (IRIS 2006-7:16/28). IRIS Merlin, 2006.

[67] Webster, P., and Sabbagh, D. £20 broadband charge to fight online music and film piracy. Times Online, January 2009.

[68] World Intellectual Property Organization (WIPO). Berne Convention for the Protection of Literary and Artistic Works, 1886, Revised.

[69] World Intellectual Property Organization (WIPO). International Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organizations, 1961.

[70] World Intellectual Property Organization (WIPO). Performances and Phonograms Treaty (WPPT), 1996.

[71] World Intellectual Property Organization (WIPO). Learn from the past, create the future: The arts and copyright, 2007.

Appendix: The case of Napster

In 2000, the United States Court of Appeals for the Ninth Circuit reviewed the decision of the United States Court for the Northern District of California, which ordered Napster to stop the activities that, through its software, allowed sharing copyrighted content without the express permission of the owners of such rights[14]. Napster was held liable by the Court of District, of having designed, operated and made available to Internet users a system that allowed the infringement of copyright. The Ninth Circuit was the ground for a new battle between the CPI and technology innovators. The Court of Appeals found that Napster users were not fair users, and that their upload and download activities infringed, at least, on two exclusive rights: "the rights of reproduction, 106(1); and distribution, 106(3)" [61, §11]. Moreover, AHRA's liability exemption could not be applied to Napster users, because, as stated in the Diamond ruling, a computer's hard disk containing music files was not a "digital musical recording".

Napster liability for contributory infringement was confirmed by three arguments: first, direct infringement by Napster users was declared; second, Napster did a material contribution to the direct infringement committed by its users, by providing the service to exchange copyrighted files[15]; and third, "Napster by its

[14] The Court of Appeals ruled that A&M Records et al. should notify Napster "of copyrighted works and files containing such works available on the Napster system before Napster has the duty to disable access to the offending content" [61, §84].

[15] "We agree that Napster provides 'the site and facilities' for direct infringement" [61, §58]

conduct, knowingly encourages and assists the infringement of plaintiffs' copyrights" [61, §49]. Napster, was also declared a vicarious copyright infringer by having financial benefits of these violations [61, §61] and by failing to control[16] the illegal use given to its network.

This decision was the turning point in the position of the American Courts about the liability of P2P networks developers. Around 75 million people [54, p. 2] in America were held liable for direct copyright infringement, a necessary ruling to let the CPI fight the easiest foe with the easiest argument: technology industries and their contributory and vicarious infringement.

[16]"Conversely, Napster may be vicariously liable when it fails to affirmatively use its ability to patrol its system and preclude access to potentially infringing files listed in its search index. Napster has both the ability to use its search function to identify infringing musical recordings and the right to bar participation of users who engage in the transmission of infringing files" [61, §85].

Centre de recherche INRIA Sophia Antipolis – Méditerranée
2004, route des Lucioles - BP 93 - 06902 Sophia Antipolis Cedex (France)

Centre de recherche INRIA Bordeaux – Sud Ouest : Domaine Universitaire - 351, cours de la Libération - 33405 Talence Cedex
Centre de recherche INRIA Grenoble – Rhône-Alpes : 655, avenue de l'Europe - 38334 Montbonnot Saint-Ismier
Centre de recherche INRIA Lille – Nord Europe : Parc Scientifique de la Haute Borne - 40, avenue Halley - 59650 Villeneuve d'Ascq
Centre de recherche INRIA Nancy – Grand Est : LORIA, Technopôle de Nancy-Brabois - Campus scientifique
615, rue du Jardin Botanique - BP 101 - 54602 Villers-lès-Nancy Cedex
Centre de recherche INRIA Paris – Rocquencourt : Domaine de Voluceau - Rocquencourt - BP 105 - 78153 Le Chesnay Cedex
Centre de recherche INRIA Rennes – Bretagne Atlantique : IRISA, Campus universitaire de Beaulieu - 35042 Rennes Cedex
Centre de recherche INRIA Saclay – Île-de-France : Parc Orsay Université - ZAC des Vignes : 4, rue Jacques Monod - 91893 Orsay Cedex

Éditeur
INRIA - Domaine de Voluceau - Rocquencourt, BP 105 - 78153 Le Chesnay Cedex (France)
http://www.inria.fr
ISSN 0249-6399