

An analytical framework for evaluating peer-to-peer business models

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Abstract

While existing research on peer-to-peer (P2P) file-sharing services has increased our understanding in many respects, it has not yet supplied a comprehensive theoretical framework that explains business failures of P2P file-sharing network service models. We develop such an analytical model and base it on seven specific market constraints – technical, economic, structural, legal, political, cognitive, and cultural – that are specifically relevant for P2P services. We show how our model can be used as a tool for strategic analysis of P2P business model performance using Napster as a particular case of study. We show also how P2P file-sharing networks have migrated through a series of system typologies by incorporating technological innovations in response to market constraints. Finally, we offer a new theoretical conceptualization that views P2P file-sharing networks as electronic markets.

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1. Introduction

Millions of consumers are routinely trading digital content files over peer-to-peer networks. Traded content includes images, audio files, software, music, tv shows, games, movies, and other documents. Peer-to-peer (P2P) file-sharing networks such as Napster, Kazaa, Grokster, BitTorrent and Grouper to name just a few from among dozens, have since 1999 drawn increasing interest from users, and also from innovative businesses exploring ways to use them commercially, as well as from governance and judicial institutions with the responsibility of regulating the new file-sharing activities. There is clearly strong demand for P2P services from consumers in 2006, but no business has so far succeeded in finding a sustainable

legitimate and profitable P2P business model that delivers what consumers want. While existing research on P2P file-sharing has increased our understanding in many respects, it has not developed a comprehensive theoretical framework that explains business failures of P2P file-sharing network service models. The present paper aims to address this gap.

It is clear that P2P systems, under various conditions, can both destroy and create value as huge amounts of content are distributed, including previously available as well as derivative and new original content. It is also clear that huge amounts of copyrighted material are traded without permission from its owners. Much less clear, however, is how to best distribute and share the value that is created by these new trading networks, and how to design incentives that would entice everyone in the value chain to productively participate in the operation of these networks. Traditional corporate content providers are threatened with loss of control over distribution and quite possibly profits. Some consumers feel legally insecure about sharing

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content, while others perceive existing P2P file-sharing services as too limited, technically immature, or difficult to use. Some original content creators worry whether they will be able to collect proper rewards for their creative output. Lack of trust and economic risk have seriously undermined the development of consumer-friendly P2P business initiatives, as the content industry largely opposes the use of P2P file-sharing technology. A better outcome for all market participants would be possible if P2P networks for sharing information goods comprehensively addressed the concerns of all stakeholders. Clearly, this is not yet the case with P2P file-sharing services. Hence, there is a need to devise methods that allow us to (a) analytically diagnose service failures and (b) develop better business models for P2P file-sharing. These are the two main research questions that we are addressing in this paper.

The IS literature presents P2P file-sharing primarily as an IT application system [1]. In the present paper, however, we take a different, novel approach and view them more broadly as electronic markets. We argue that P2P systems implement all roles and functions of electronic markets. Through an extended analysis of the P2P research literature in the information systems area we develop an analytical framework based on seven constraints – technical, economic, cognitive, structural, legal, political, and cultural – and perform a comprehensive diagnosis of P2P business models. Using the well-known original Napster case, we first demonstrate how our model can be applied *ex post* to determine the feasibility of specific P2P service and business models. Next, we apply the model to analyze the evolution of P2P services in general. We also discuss the possibility of extending our new analytical framework beyond P2P environments to other electronic market configurations.

This paper makes several contributions. First, it offers a new theoretical lens for studying the performance P2P services by conceptualizing them as electronic markets. Second, it develops a new analytical framework for *ex post* performance analysis of P2P business models. And third, it lays the groundwork for developing a business management tool that can be employed to support strategic decision-making.

The remainder of the paper is organized as follows. The following section will give an overview of the functions and technical implementation of P2P file-sharing networks. Section 3 uses literature analysis to derive specific conceptual constraints that lay the foundation for our analytical model framework for evaluating P2P business models. Section 4 applies the analytical model to the case of Napster, and Section 5 applies the evolution of P2P service models in general. Section 6 will explain why viewing P2P networks as electronic markets rather than just IT applications puts us in a better position to gain insights for performance analysis of P2P business models. Section 7 will outline an implementation of our constraint framework as a business management tool and provide some additional discussion and conclusions.

2. P2P file-sharing networks: a brief review of the underlying technology

In technical terms, a *P2P file-sharing system* is a network whose nodes communicate directly for the purpose of exchanging content files, with no centralized governing node as a necessary intermediary [2]. Each participant in the network can behave either as a client, receiving files, or as a server, sending files, or both. P2P file-sharing systems are virtual networks operating over the Internet TCP/IP infrastructure, thus allowing users to exchange digital content directly between themselves. Participants in the network are users who are running a specific P2P application on their local computers. The best-known systems to date are music file-sharing networks such as the original Napster or Kazaa, but there are dozens more operating (e.g., BitTorrent, Limewire, Soulseek, Poison, e-Donkey, and others), and more in development. These systems are being used to exchange not only music, but also virtually anything else that can be digitized.

The extent to which different file-sharing networks employ direct P2P communication capabilities varies. In the original Napster (which is an example of Generation I in Table 1), for example, content discovery was conducted through a single central server index, while the actual file transfer itself was carried out between individual user nodes. One consequence of this design was the emergence of long queues (managed by the P2P network software), as users attempting to obtain a particular file waited in first-come first-serve queues for their turn to receive a download. The hybrid structure of Napster was abandoned by the second generation of P2P networks, which implemented distributed file indexing through the use of, most notably, the Gnutella engine, which powered Kazaa and other P2P file-sharing networks. Distributed file indexing obviated the need for a powerful central server farm, but also limited the reach of the system, because user queries only traversed parts of the network. The third generation of P2P innovation reduced the problem of long queues and subsequent waits for content due to single-server downloads by allowing simultaneous downloading from multiple sources (e.g., the BitTorrent engine), a technical innovation that made the sharing of very large content files practicable. Consequently, it was at this stage that significant amounts of video content, which make very large files even when compressed, began to appear on P2P networks. A fourth generation saw the first development of P2P file-sharing systems that can be organized as small-scale virtual private networks, to which access is limited and controlled by membership and passwords. Applications on this level include file-sharers who are unwilling to share content openly with large Internet communities, but also businesses that exchange internal documents for various purposes. Currently, a fifth generation is emerging that is aimed at P2P users who want to migrate to less visible and more difficult to track niches of the Internet for file-sharing activities, such as Usenet and IRC chat. Table 1 summarizes

Table 1
The evolution of P2P file-sharing system

Typology	Technology innovations	Examples	Users
I Client/server architecture	Complete list of content files available on the network kept on a central server; highly efficient search and content discovery Single-server queues – users search for a file on a single machine, then wait their turn for a complete download; efficiency of delivery is a function of demand and the number of copies in the system	Napster	Consumers
II Distributed system architecture	Distributed index the list of currently available files is distributed across nodes of the network, no indispensable central server in the system; many systems employ the Gnutella engine or similar technology; file search may not reach all network resources Single-server queues – users search for a file on a single machine, then wait their turn for a complete download	Kazaa Morpheus Grokster	Consumers
III Parallel system architecture	Many-to-many file service links – users can download a single file from many servers in parallel and simultaneously upload files to many users at once; efficient distribution of very large files Anonymous access – proxy connections, server log procedures, aggregation of file requests; but systems do not offer perfect, unbreakable anonymity	BitTorrent Freenet eMule	Consumers, Businesses
IV Virtual private network architecture	Restricted access via password logins and selective membership, controlled by licensee of a software product such as Qnext	QNext Groove Grouper	Consumers Businesses
V Co-opting system architecture	Use of existing Internet protocols that were developed for other purposes to exchange files Use of complementary applications such as IP Blockers User migration to the Darknet	Usenet Internet Relay Chat Instant Messaging	Consumers

this evolution of technological innovation and indicates how technology change has produced file-sharing systems with successively more sophisticated typologies.

3. Developing the seven market constraints framework for P2P business model performance analysis

Motivated by work in economic systems design research done in the economics field, which found that designers of economic systems rely on design principles that can be derived from a small number of constraints [3,4], we postulate that it is possible to derive similar constraints for designing and developing P2P business models.

3.1. Framework development

For that purpose, we surveyed the IS literature and identified research papers on the P2P file-sharing topic. The 54 papers in our convenience sample (as shown in Table 2) address the topic from multiple perspectives and are grounded in different reference disciplines. They use a variety of research methods ranging from conceptual pieces and empirical studies to work based on analytical modeling techniques. The co-authors read and discussed the abstracts of the papers from which they determined the salient P2P problem issues that were addressed. Ambiguity about issues were resolved through inspection of the entire paper in question. Disagreements in judgment were resolved through discussion. Finally, the salient issues addressed in the papers were coded as low-level categories,

as shown in the second column of Table 2. Related low-level categories were then grouped together and abstracted into high-level categories that yielded our seven specific market constraints. While many papers addressed several low-level category issues, only a few addressed more than two high-level constraints in any substance.

Our exploratory literature analysis used a qualitative, interpretive approach. Therefore, no scoring methods or weighting schemes were applied to establish significance of the categories. Hence, the fact that most papers are associated with the technical and economic constraints does not mean that these two constraints are more important than others. All seven constraints are essential and non-reducible. The skewed frequencies can be explained by the prevalent orientation and interests of researchers in the information systems area who traditionally focus on research issues directly related to the IT artifact or economic analyses (in the sub-area of information economics). However, it has become clear that P2P research is really an interdisciplinary endeavor and needs to address issues that may fall outside the traditional core of IS research. This may mean that IS researchers need to collaborate more with colleagues from other disciplines when working on the larger issues of P2P network environments.

We argue that P2P business model performance analysis requires the consideration of all seven constraints. Failing to sufficiently address any single one of them renders a business model vulnerable to underperformance or failure. While deficiencies on some constraints may be tolerable short-term, it is imperative to meet all of the seven

Table 2
The seven market constraints framework

Constraint	Low-level categories research issues	Reference discipline	Support sources
Technical	Questions of hardware, software, networks, content representation and storage, searching and indexing, compression algorithms, content transfer methods, content creation systems, file formats, content control methods, digital rights management; questions regarding the quantitative performance of systems	Computer science	Adar and Huberman [5] Clarke et al. [6] Liu and Kwok [7] Ripeanu et al. [8] Rollins and Almeroth [9] Serjantov [10] Yang and Garcia-Molina [11] Balakrishnan et al. [12] Kubiatowicz [13] Ooi et al. [14] Stoica et al. [15] Sarioi et al. [16] Krishnan and Uhlmann [17]
Economic	Pricing, profitability, revenue generation, participation incentives and disincentives, risk, service differentiation, public goods issues, information asymmetries, utility, supply/demand relationships	Micro economics	Golle and Leyton-Brown [18] Kleinet al. [19] Chen and Png [20] Bhattacharjee et al. [21] Buragohain et al. [22] Grothoff [23] Liebowitz [24] Asvanund et al. [25] Cunningham et al. [26] Gopal et al. [27] Lang and Vragov [28] Liebowitz [29] Peitz and Waelbroeck [30] Schmidt [31] Zentner [32]
Cognitive	Interaction of users and P2P systems; user interface, self-efficacy, how users understand the function of P2P apps and networks, how users understand the market mechanism	Psychology, HCI, behavioral research	Good and Krekelberg [33] Lang and Vragov [34]
Structural	Industry structure, public policy, market participants and the degree of control they are able to exert; channel power, channel conflict, monopolies, oligopolies	Industrial organization, strategic management	Fox and Wrenn [35] Alexander [36] Lechner and Hummel [37] Clemons et al. [38] Premkumar [39] Lohmann [40] Telang et al. [41]
Legal	Copyright law, fair use, sharing versus stealing, piracy, lawsuits, law enforcement	Law and legal studies	Tanaka [42] Samuelson [43] Heverly [44] Barker [45] Moore and McMullan [46] Furtado [47] Samuelson [48]
Political	Power relationships both within and between groups and institutions, regulation, lobbying	Political science, public affairs	Agre [49] Samuelson [50] Lessig [51] Einhorn and Rosenblatt [52]
Cultural	Broad impacts on communities, social networks and societies driven by the availability and use of P2P networks; cultural norms and social value	Sociology, media theory, anthropology, cultural studies	Brown et al. [53] Robinson and Halle [54] Giesler and Pohlmann [55] Strahilevitz [56] Hughes and Lang [57] Gopal et al. [58]

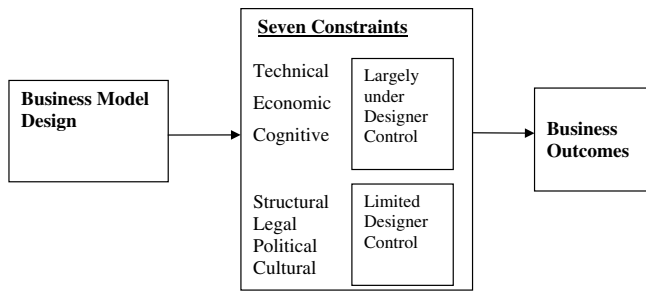


Fig. 1. P2P file-sharing business design model.

constraints to create a viable and sustainable business for the long run. The degree of success of viable P2P business models will of course also depend on market competition (see Fig. 1).

In Table 2, we summarize the critical constraints on P2P business models which, collectively, determine their ability to develop its full potential. Together, these seven factors comprise an analytical framework, which we call the *Seven Constraints Framework for P2P Business Model Performance Analysis*, that can serve as the basis for an effective method to analyze P2P business models in practice. This framework can be applied to the evaluation of any specific P2P service model, predicting that if one or more of the constraints is not adequately addressed, it will not be commercially viable.

Since our literature analysis that generated our seven constraints framework was restricted to P2P research we cannot claim that it is applicable to other forms of electronic markets or e-commerce businesses. However, we will discuss later in the paper the possibility of extending our framework to more general analysis.

3.2. Framework constraints

Here we provide a brief description of the seven specific constraints that emerged from our literature analysis. For the sake of clarity, we present the constraints in a linear, independent fashion, but it is important to understand that there are interdependencies among them that are significant. Also, notice that the first three constraints are mostly controlled by the business model designer, whereas the latter four are largely determined by the external business environment.

3.2.1. The technical constraint

Technical factors of P2P file-sharing systems include aspects of both hardware and software. An example of a technical factor in P2P systems is the development of multimedia compression algorithms of sufficient power to make exchanges of goods via P2P networks over existing consumer Internet connections feasible. Content representation, storage, and transfer methods are also considered technical aspects. Other examples relate to search capabilities and other user application functions, and complementary services such as bandwidth management, communication, security, or anonymizing capabilities. Computer science is

the chief reference discipline for IS researchers that primarily focus on the design and implementation of the IT artifacts underlying P2P systems.

3.2.2. The economic constraint

By economic factors, we mean the various economic variables and relationships that play a role in P2P business model designs. These include, for example, pricing, profits, revenue generation, incentive structures, profit sharing, service differentiation, risk, competition, public goods issues, and information asymmetries. Papers in this category are mostly from the information economics research community and draw heavily on microeconomics as their reference discipline.

3.2.3. The cognitive constraint

Psychological factors [59,60] shape people's behavior. Here, they are those that govern how users understand and employ the features available in P2P systems, both concretely in terms of the actual user interfaces of specific applications, and more broadly in terms of understanding the future implications and risks involved in the usage of these networks. Cognitive comprehension of a P2P system by a user would thus involve not only the design of the software, but also questions such as understanding downloading/uploading rules, reactions to uncertainty, and the role of feelings and emotions [54]. Psychology, human-computer interaction and behavioral research are the main reference disciplines for studies on this constraint.

3.2.4. The structural constraint

Structural factors [3] are those defining the industry structure in which P2P systems operate in terms of number of participants, roles and functions, and the relative degrees of control which they are able to exert upon it, with well-known idealized forms such as monopoly, oligopoly, or perfect competition. These address strategically important topics such as strategic alliances, channel power, channel conflict, power shifts, entrenched businesses versus new entrants, and intermediation versus disintermediation. In the case of P2P file-sharing, it refers to the particular structures of the music and entertainment industries that are relevant in our context. The industrial organization and the strategic management literature provide the main references for research on this constraint.

3.2.5. The legal constraint

Legal factors may emerge as critical when the stakeholders in a particular P2P network have interests which are not adequately addressed by its activities, often as a result of unanticipated changes in technology and user behavior. Since P2P systems have been used to acquire content that is under copyright protection, they have been of great concern to both copyright holders and consumer interest groups from a legal point of view. Questions of legislation, regulation, enforcement, court rulings, different interpretations of the law and its purposes, and awareness and

understanding among P2P users of applicable law and legal risks are all relevant here. Law and legal studies are the main reference disciplines on this issue.

3.2.6. *The political constraint*

Political factors [4] are those which influence access to and control of P2P networks via coalitions of interest groups and the exercise of power. This would include not only the power exerted by the executive branch of government through enforcement of laws, but also the relative power exerted within and between particular communities and institutions with an interest in particular networks (e.g., [51]). Interested stakeholders are industry and consumer groups, lobbying organizations, government bodies (legislative), regulatory bodies (Federal Trade Commission and Federal Communications Commission), and perhaps unions as well. Political science and public affairs are the most important reference disciplines for work in this area.

3.2.7. *The cultural constraint*

Cultural constraints are those which stem from the values, beliefs and attitudes, and norms of communities that are active in P2P environments. They influence tastes and preferences as well as usage behavior. These may include group dynamics in virtual communities, mass phenomena, cultural values, social norms, gender effects, ethical biases, generational differences, and the formation and evolution of subcultures. Sociology, media theory and communication studies are the main reference disciplines in this category.

3.3. *Interactions among constraints*

As mentioned earlier, there are significant interdependencies between constraints. Allocating resources to improve performance along one dimension in the business model may come at a cost on another. For example, there are many trade-offs between decisions to remedy economic shortcomings and consequences in terms of user culture. Charging for content may be difficult in an environment that is shaped by a culture of free sharing. That is, improving profitability by restricting the copying of content (economic constraint) could cause resentment in user communities that have adopted a flourishing sharing culture (cultural constraint). Tradeoffs also occur between the technical and the economic constraints. For example, digital rights management has been proposed as a technical solution to impose business rules on consumers, but may have a negative economic impact if this technology is shunned by consumers and drives them away to alternative services. Addressing problems on the legal constraint can also have severe implications for the economic constraint. For example, removing copyrighted content legitimizes a service model, but at the same time may also limit the value proposal a file-sharing service offers its customers. Other

examples of interactions between constraints could be construed.

When developing P2P business models it is essential to heed all seven constraints simultaneously. Any change in one dimension can cause changes in others. Previous research has typically focused on improving performance on only one constraint without sufficiently taking into account possible ramifications in the other dimensions. Applying our analytic framework forces decision-makers to consider all relevant business dimensions simultaneously.

The constraints in the framework can be divided into two distinct groups. Generally, designers of P2P systems have much control over the economic, technical, and cognitive constraints. Therefore, these constraints can be addressed directly by the firm. The designer, on the other hand, cannot easily change the structural, political, legal, and cultural constraints. Nevertheless, firms need to adapt to these external constraints and find ways to successfully operate within them. External constraints may change long-term as the industry matures and the business environment changes.

Using these seven fundamental constraints as the dimensions for developing P2P business models, we next demonstrate by example how our framework can be used to explain outcomes in a specific P2P business case. We deliberately chose Napster as a case that is both well studied and has a well-known outcome. The main purpose of the following section is to show how our framework can be applied to systematically derive an assessment of a given business model. Knowing the outcome of the historic case allows us to benchmark the results of our analysis against the actual outcome. While this does not present formal validation of the method it adds credibility for using it. We do not claim to offer any specific new insights on Napster itself that would go beyond what has already been reported [e.g., [61]].

4. **The Napster case: analysis of a P2P business model**

Napster was founded in 1999 and became the first widely adopted P2P network for trading music files. It grew swiftly, came up against each of the market design constraints, and addressed them with varying degrees of success. Its purpose was to create an online platform through which participants could easily find and exchange digital audio files. To this end, Napster's software created two linked applications: the central index, running on Napster's own servers, which would list all of the content resources available in the network, and the Napster user interface, running on users' local computers. Downloaders in this scheme were Napster members searching for content, while uploaders were members providing content stored on their own hard drives to share with others. Commercial copyright owners rarely participated in uploading their content in Napster. Users provided content almost entirely themselves, mostly without permission from the content owners, and delivery of goods was car-

ried out through the system by direct P2P links between the parties to an exchange. Napster operated for less than two years, until February 12, 2001, when it was closed down by order of the 9th Circuit Court of Appeals, in the decision on *A&M Records v. Napster*, because of its contribution to massive copyright infringement. The interested reader can find details of the history of Napster, including numerous data on the factual background of the trading activities and user behavior in Ref. [61]. We will now examine each of the seven constraints in turn as they applied specifically to the original Napster P2P file-sharing service.

4.1. *The technical constraint*

The technical viability of Napster was premised on several IT innovations which Napster did not create itself. The first was the digitization of music content. A second factor was the adoption of broadband connectivity by consumers, a prerequisite for easy exchange of digital music content. A third factor was the general adoption of the MPEG-1 Layer 3 (MP3) audio compression encoding scheme as the de facto standard for digital music.

With these technological innovations in place, the contribution of Napster was software for content and management as well as information coordination. Napster was a hybrid P2P file-sharing system. It employed a centralized index hosted on Napster's site to support content discovery while the actual digital exchange of content took place by direct member-to-member links maintained by the Napster client software running on members' local computers. As demonstrated by its extraordinarily swift rate of adoption by millions of members, Napster was considered by its participants to have provided a successful technical solution to trading music online.

4.2. *The economic constraint*

While Napster succeeded in developing a technologically well-working service model, it failed to adequately address the economic constraint. Two issues in particular, pricing and participation incentives, prevented their business model from ever becoming economically viable. First, the uploaders' offering of content for free (zero pricing), as well as Napster's willingness to tolerate free trading, made it impossible to directly compensate the content owners for having their products shared among users. Prices are an efficient mechanism to allocate scarce resources. But unfettered copying and zero prices in the case of Napster led to a degenerated market where content became abundant and demand was soaring at the cost of destroying any participation incentives copyright owners may have had otherwise. Attempts to establish an exchange mechanism based on gift economies [62] faltered because unpaid-for copies of content products were used as the currency for the reciprocal trade.

There were four major stakeholders in Napster: the primary goods providers, which were artists and firms creating most of the original content; secondary goods providers, which were users who uploaded content copies to the network; consumers who downloaded content from the network; and Napster Inc., the firm that organized the network and facilitated the file-sharing activities.

Napster did not charge for content provision and took neither transaction fees nor service subscription fees. The company never succeeded in developing significant income from its value proposition of providing a service platform for exchange of content [63]. While several alternatives were probed by Napster's leadership, most notably selling advertisement space, none was fully implemented before Napster was forced to close, having operated at a loss during the entire time of its existence. Although Napster created significant consumer value, it did so primarily through wealth transfer away from content owners.

By not charging for the sharing of content, Napster thus provided inadequate incentives for owners of copyrighted content to participate in its business. Under the assumption that a download is a lost retail sale, copyright owners refused to provide goods, even though some artists assert that there is an incentive to participate in file-sharing networks, claiming that increased product exposure due to P2P file-sharing activity leads to increases in concert ticket sales and retail disk sales. However, the extent of the negative impact of file-sharing on retail sales appears inconclusive [27,64,65].

4.3. *The structural constraint*

The now defunct Napster is considered the first full-service file-sharing system operating in the music industry. It created a new consumer environment for providing music content. It may have had some first-mover advantage by leveraging possible network effects to grow a huge user base very fast. Pioneering online music file-sharing in 1999 during the dot-com boom era, while the business climate was still conducive to experiments with new Internet business models, enabled Napster to develop its service for some time. However, after the dot-com bubble burst in 2000, the company quickly found itself under increasing pressure from the traditional industry structure of the music business, which had the competitive advantage of operating within mature and solid structural market arrangements in the form of well-established businesses, effective lobbying arms, strong relationships with retailers, media, and (at least initially) consumers, as well as with institutions that had passed laws and regulation designed to support the traditional business of selling music recordings. Despite its considerable technological and service innovations, Napster was not able to sufficiently address the structural market constraint. It neither gained enough institutional support nor achieved sufficient market power to develop a structurally sound online file-sharing business environment or attract effective partnerships with industry incumbents.

4.4. *The legal constraint*

The original Napster initially operated in uncharted territory under no serious legal challenge. However, the explosive use of Napster by its fast growing member base to exchange copyrighted goods soon prompted legal action, even though Napster itself didn't provide the goods. The record company A&M Records sued Napster for "vicarious and contributory copyright infringement". Napster's defense centered on the decision of 1984 obtained in *Sony v. Betamax*, in which the courts held that innovations in technology could find "safe harbor" against injunctions attempting to prevent their use, as long as there were also significant non-infringing uses of the technology. Non-infringing uses did occur in Napster and in subsequent P2P networks, as some traded content was actually permitted or in the public domain. But the precedent established in *Sony v. Betamax* proved insufficient to legally protect Napster. The courts held the company accountable for contributing to copyright infringement, in part by providing a central index of files that users could use to easily locate and download protected content. Napster was closed by a court injunction issued in February 2001, and never re-opened in its original form.

The legal constraint was particularly difficult for Napster's management to address effectively. While there is still a notable lack of consensus in the legal community on precisely how to strike the balance between protection of intellectual property owners and consumer interests, it became clear that Napster had gone too far with allowing users to copy content on a massive scale. Late attempts by the company to contain unauthorized copying proved legally insufficient.

4.5. *The political constraint*

Napster's operations took place in a political environment which at first took little notice of it, then dismissed it, and then finally moved to suppress it. Power in the music industry, particularly in popular music, was concentrated in the hands of a small number of traditional record companies (referred to as the "big five" at the time). Typically, music labels identified bands with talent and potential, invested in developing their roster of artists, and then produced and marketed their music through their traditional channels. Napster upset this system by enabling its members' network power collectively to circumvent the traditional music markets' distribution channels. Napster's role in creating large networked online communities threatened to shift too much power away from the traditional music industry to consumers.

Once they became aware of the significance of Napster's activities, recording industry firms, acting together under the Recording Industry of America Association (RIAA), its lobbying arm, exercised considerable power to put Napster out of business. The concentration of industry power in the hands of players with the ability to lobby legislators

and argue legal cases was pitted against the diffused power of the Napster user community, Internet activists, and Napster's shareholders. In the end, Napster was not close to prepared in terms of political power to defend its service and business model.

4.6. *The cognitive constraint*

Napster's interface was widely praised at the time as innovative and easy to use. As demonstrated by the widespread adoption of Napster, participants had little trouble in understanding and using the features of the system, despite some notable exceptions. For example, it appears that some users were unaware of the bandwidth consumption of their own Internet connections when swapping content on Napster, and thus also unaware of what bandwidth contributions they might have been making to the network [33]. Some users may have been unaware of precisely what portions of their hard drives were visible to the network. Napster's easy to use and yet very powerful user interface connecting millions of music lovers struck a chord with consumers who discovered file-sharing as a new way of finding and listening to music.

4.7. *The cultural constraint*

Napster did more than just address the cultural constraint. It actually created a wholly new culture that changed the way people consume and socially experience music. Terms like "Napster culture" or "Napsterization" have meanwhile entered the canon of common English language. Napster users were widely referred to as the "Napster Community." Napster met some of the typical needs of virtual communities by including chat and forum posting capabilities in its interface [61]. However, subsequent developments, as other P2P systems became available, showed that the social ties of the Napster community were ultimately pretty weak, as users readily switched to newer networks.

Perhaps somewhat surprising was the degree to which legal norms concerning intellectual property rights failed to translate into corresponding social norms, once the practical barriers to violations were removed by IT. Educational information about the legal consequences of file-sharing copyrighted intellectual property did not have a significant effect on music piracy behavior in the online music community [58]. The continued use of P2P systems today to swap copyrighted content suggests that within a population segment comprising millions of file-sharers worldwide, a fairly stable social norm that views file exchanges over P2P networks as acceptable may have developed [46].

4.8. *Discussion of the results of the analysis*

Looking at the seven constraints that we proposed earlier, we find that Napster was able to address some of them quite effectively, while others remained critically problematic. Our analysis reveals the considerable bias

that was present in the design of Napster's network. It leaned heavily towards the demands of the user community. Considerable attention was paid to the needs of the users. Thus, the technical, cognitive and cultural constraints were addressed in much detail. However, less attention than necessary was paid to the economic, structural, legal and political realities of the industry in which Napster chose to operate. While Napster was successful in terms of service innovation and consumer popularity, it failed to muster support from the music industry and its governing institutions that could have allowed its creators to redesign their business model and make it economically viable and legally sound.

Some interactions among the various constraints also contributed significantly to the outcome in the Napster case. For example, the technical solution of creating a central server index provided excellent performance, but increased legal vulnerability in terms of abetting copyright violations, and ultimately made it easy for the courts to shut down the service. Similarly, the lack of a viable economic model may have reduced Napster's ability to mount a legal defense, and its relative lack of political power also played a role in the failure of the company to win its legal case. Generally, improving performance on one dimension may have negative impacts on other dimensions. Hence, from a business strategy point of view, it is vital that the business model satisfy all seven market constraints simultaneously. This will typically require trade-offs among interdependent constraints. Napster's service model started out with overreaching on some dimensions and falling well short on others. The company could never recover from the resulting disparities and was unable to engineer a business model that represented a feasible balance between technical possibilities and market realities. Table 3 summarizes the outcomes for Napster on each constraint, and shows a strong bias towards the technical and user side of the music industry, and a neglect of the considerations of other stakeholders.

Napster's approach to addressing the cognitive and cultural constraints was so successful that Roxio Inc. acquired its brand name out of bankruptcy to market a new legitimate online music service, Napster 2.0. It aimed to appeal to people who loved using the original Napster, although it offered a service model that only shared name and logo with the original service. While the original Napster was unable to successfully address the political constraint that accelerated its demise, it nevertheless

may have contributed to a possible long-term shift empowering consumers in the digital entertainment space [66]. But, of course, it was the legal constraint that proved to be the ultimate stumbling block Napster could not overcome. Overall, the story of Napster provides a cautionary tale about the risks of entrepreneurship in an area troubled by high legal uncertainties.

5. Applying the seven constraints framework to the evolution of P2P systems

The previous section on the specific Napster case has demonstrated how our framework supports the evaluation of a specific P2P business model. In this section, we show how our framework applies to an analysis at the aggregate level in the longer term. Similar to Dai and Kauffman [67], who examined how the typology of business models in electronic B2B markets has morphed in response to technology change, we now look at the evolution of P2P systems over time and analyze how the seven constraints have impacted the general development of the business models in this industry. We track the migration of P2P service models over time in a changing business environment.

It is interesting to note that technological development did not end with the demise of Napster. On the contrary, it has progressed via successor file-sharing systems that continue to serve former Napster users as well as new generations of file-sharers. In fact, the P2P file-sharing systems of the post-Napster era have become far more efficient [cf. Table 1]. The current availability of multimedia content on P2P networks [68] is due in part to the success of the MPEG-4 video encoding specification and its implementation in codecs commonly seen in P2P files such as Xvid or DivX. Another technical innovation, just as critical for P2P video data, is the BitTorrent file-sharing protocol that decomposes content and parallelizes distribution across multiple nodes in the network [69].

Fig. 2 depicts the five generations of P2P system that correspond to the five system typologies that were introduced earlier, in Table 1, and illustrates our evolutionary analysis of P2P systems. For the sake of simplicity, we show the interplay of constraints and redesign of business models for only two of the seven constraints. Similar figures could be presented for any other combination of constraints. Here, our analysis focuses specifically on the way the networks have responded to the legal constraint with technological innovations. Fig. 2 shows how new P2P service models have emerged that address legal challenges by pushing the technical constraint. More specifically, we see that during the first three generations various technological improvements in P2P applications tried to evade the legal constraint instead of fully addressing it. Technical sophistication provided better shelter from legal action, but without resolving the legal issues. This resulted in many legal obstacles on the way, and eventual inability to provide reliable service. The first real attempt at addressing the legal constraint was made in Generation IV. This is

Table 3
The seven constraints in the case of Napster

Constraint	Key factors	Outcome
Technical	Content discovery, Content file exchange	Success
Economic	Content pricing, Participation incentives	Failure
Structural	Institutional Support, Music Industry Structure	Weak
Legal	Copyright law and regulation	Failure
Political	Market power, Lobbying	Insufficient
Cognitive	User interface, Trade logic	Success
Cultural	Norms and values, Online music culture	Success

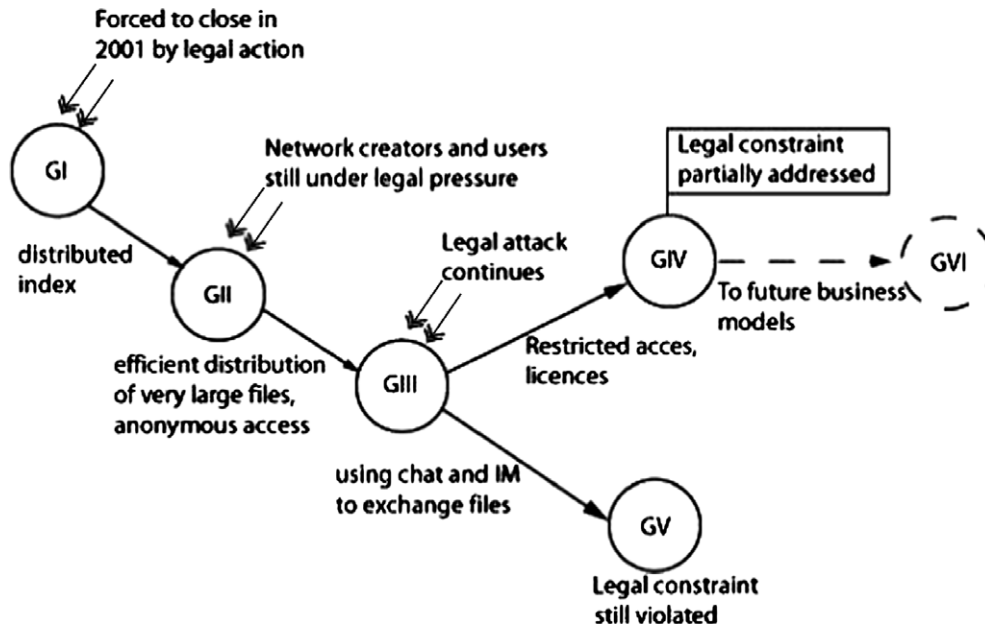


Fig. 2. Evolution of P2P models along technical and legal constraints.

the generation of private P2P networks whose access is restricted via password logins, thereby preventing massive copyright infringement and aiming at supporting small-scale, legitimate sharing activities. Our framework predicts that future developments of business models can continue further only from this generation onward. Constraints cannot be avoided successfully in the long term; they need to be addressed eventually.

A similar dynamic diagram could be created to trace the way in which some of the economic constraints were addressed. Initially P2P networks did not provide incentives to users to upload content. This resulted in substantial free-riding behavior. During the following generations some networks started introducing user scores that accumulated as the user shared more content. These users later received preferential treatment in downloading content from the network. Using our framework we can predict that eventually, under a successful business model, users who share more content and provide more bandwidth will incorporate participation incentives (e.g., compensation or rewards).

Fig. 2 also illustrates some interactions between the constraints. We can see that actions that reduce the importance of the technical constraint might increase the importance of the legal constraint. For example, in the transition from Generations II to III, an innovation that improved on the technical constraint (the more efficient parallel download/upload of large files) increased the networks' vulnerability to legal attacks, as the increased sharing of movies resulted in additional legal action from the Motion Picture Association of American (MPAA), which represents the movie industry.

6. Electronic markets and file-sharing networks

So far we have limited our attention in this paper to the analysis of P2P environments. Because our constraints

framework is specifically grounded in a content analysis of P2P research in the IS literature we cannot make well founded claims on its generalization to other electronic settings. However, considering P2P file-sharing as a special case of an electronic market does suggest raising the possibility of extending our framework to other special cases, or electronic markets in general. In order to support this argument we will next systematically develop in some detail a novel conceptualization of P2P service offerings as specific cases of electronic markets.

From a technical point of view, P2P file-sharing systems are particular IT applications for content distribution that can be adopted by service providers to support their business. From an economics point of view, on the other hand, P2P file-sharing systems are arguably better understood as online markets. In order to make this argument clearer, let us briefly review the basic concepts of physical and electronic markets before we introduce our new conceptualization of P2P file-sharing systems as a particular form of electronic markets.

Markets are socio-economic arrangements that bring buyers and sellers together for the purpose of trading goods. The main functions of markets are summarized in left column of Table 4. Traditionally, markets require physical space for the organization of the marketplace. Electronic markets relax the physical space requirement by carrying out market activities and implement market functions through the application of information technology [70]. Early electronic market systems were limited to supporting the online exchange of information about available products while the actual order fulfillment occurred through traditional, physical channels [71]. With the digitization of information products it is now possible to set up electronic markets that not only bring buyers and sellers together to exchange information and make deals but also

deliver the sold products to the buyers. In other words, electronic markets for digital information goods whether for financial products or air tickets can be designed to support all market functions electronically.

In the case of P2P file-sharing, the digital goods traded are content files representing cultural artifacts (music, movies, games, etc.). Uploaders, participants offering content, represent sellers, while downloaders, who obtain content from the network, represent buyers. Unlike markets for physical goods, and independent of the type of content being traded, P2P markets can only run over networked IT platforms. They enable electronic connections to facilitate content delivery through file exchanges, and additionally provide for storage and display of the digital media content. The IT in P2P file-sharing markets is supplied in part by the market facilitator (i.e., the P2P service provider) but more importantly also by the participants themselves, who connect their own digital resources to the P2P network. Network members can provide not only content resources for exchange but also network bandwidth and processing resources to increase the efficiency of the service. Many P2P systems now make explicit use of this fact, offering differential service levels for users who trade resources.

P2P file-sharing networks are designed as decentralized markets where participants are geographically dispersed but connected via the file-sharing application software that runs over the Internet. While market coordination can be centralized or decentralized, it is the users who hold collectively the content inventory on their local computers. As the right column of Table 4 shows, P2P file-sharing services implement all traditional market functions. In other words, we can say that P2P file-sharing services set up markets for trading digital content products.

Now that we have established the notion that P2P businesses constitute electronic markets for exchanging content, we need to ask whether our market constraint framework can also be applied to other e-market arrange-

ments like Internet auctions, B2B electronic markets, user-generated content sites, social network applications, and so on. For that purpose, let us briefly show how our constraints framework would be applied to the case of the popular online video-sharing site YouTube.com, which is not a P2P business. It is an user-generated content site that enables users to post and share their own media creations – original pieces as well as copies and derivative works of existing and often copyrighted content, often shared without permission from the original content owners. This service allows users to share video content by letting them upload clips to a central server site and watch videos by having them streamed to their local computer.

Importantly, YouTube does not employ P2P technology to implement its content sharing model. In Table 5, we summarize the outcome of our constraints analysis, which reflects the state of the business at the time of this writing. As the company matures it will likely implement changes to its service model that will affect its performance along the constraints, which could prompt an update of the analysis that follows.

YouTube appeared as a purely cultural phenomenon in the very beginning. It is still not clear how YouTube can leverage its innovation to generate profits since one of the reasons for its popularity was the fact that it was non-commercial. However, unlike Napster, it does have a strong partner in Google, which acquired the service in October 2006 for \$1.65 billion. While it is unclear whether it will be possible to successfully sell advertisements on YouTube, the company is in a good position to explore this revenue option [72]. A major obstacle will be the influence of traditional advertising companies and TV channels that are currently doing the bulk of advertising in terms of dollar value. The partnership with Google has also been a great boon with respect to the structural and political challenges that YouTube has been facing. Since the days of Napster the main players in the content industry have begun to

Table 4
Market functions and their implementation in P2P file-sharing services

Market functions	Implementation of market functions in P2P file-sharing service models
Bring together buyers and sellers	They bring together downloaders (buyers) and uploaders (sellers) for the purpose of trading content
Make available information about the goods in the market	They make available information about the content products in the market by executing file searches in response to user queries for specific titles. Uploaders provide meta-data tags for the files to describe the content they make available for trading
Make available information about the pricing of goods in the market and determine prices and quantities of the traded goods	They determine price and quantity. The cash price for most content products in current file-sharing systems is usually zero, which resembles a degenerated pricing system but a pricing system nevertheless. Some newer systems use a system-internal currency that attaches quasi-prices to content products and lets users redeem earnings within the system
Negotiate the terms of a transaction	They facilitate negotiation and establishment of the terms of a transaction by providing interface controls for participants to set their own upload bandwidth, or by providing local storage for network content indexing information
Execute the transaction.	They execute the transaction by creating the direct P2P link between participants over which digital information goods are transmitted as files
Facilitate the transfer of traded goods	They transfer and deliver the traded goods by initiating, maintaining, and monitoring the actual file download process through completion of delivery

Table 5
The seven constraints in the case of YouTube in its current state (as of January 2007)

Constraint	Key factors	Outcome
Technical	Content discovery, Content file exchange	Success
Economic	Revenue model Participation incentives	Unresolved
Structural	Institutional Support, Movie/TV Industry Structure	Partial Success; Somewhat resolved
Legal	Copyright law and regulation	Partial Success; Somewhat resolved
Political	Market power, Lobbying	Success; Resolved at present
Cognitive	User interface, Trade logic	Success
Cultural	Norms and values, Online community culture	Success

work more with new online ventures and have agreed to some deals with YouTube concerning the sharing of copyrighted content over their site [73]. Management has made serious attempts to address the legal constraint through a mix of licensing arrangements, technical restrictions, and oversight. Some TV companies have allowed part of their shows to be shown and posted on YouTube while others have asked YouTube to delete copyrighted content. But legal issues remain thorny, and could thwart the fragile agreements that YouTube has been able to make with the copyright industry [74]. Our constraints analysis shows that YouTube has made strides to overcome the legal, structural, and political problems that plagued other content sharing businesses like Napster, for example. But unless it also generates sustainable revenue streams it cannot become a viable business in the long run, and interactions among the constraints may very well jeopardize the accomplishments that have been made if the economic constraint is not addressed soon.

7. Conclusions and future directions

This paper used exploratory literature analysis within the realm of P2P research to construct an analytical framework for evaluating P2P business models. We proposed seven specific market constraints that determine boundaries for feasible P2P business models. Based on this theoretical framework, we also developed a tool for strategic business analysis, and demonstrated how it can be employed to perform a viability analysis of P2P business models.

There are some obvious parallels between our constraints and research that has been done on the design of physical and electronic markets in economics (see [4] for example). Notably, work in the area of experimental economics and market design theory suggests that a small number of fundamental principles determine whether a particular market design can work well or not. Numerous studies have examined and compared different market designs on overall efficiency and effectiveness and all of them have come across upon constraints similar to the ones we propose in the present paper.

Our approach is, of course, not limited to studying the historic case of Napster. It can be readily applied to other file-sharing services that are currently operating. While it has become clear that unrestricted copying of content for

the mere purpose of sharing is legally inadmissible, it is less clear how sharing can be organized as a business so that it generates value for both content owners and consumers. We found that there is a clearly discernable evolution of system typologies from a technological point of view, but the P2P file-sharing market has not yet matured enough to establish a stable typology of business models. There are experiments with advertisement-based business models offering free content, subscription-based services, as well as other fee-based approaches, but none of them so far has been able to effectively incorporate all of our seven constraints and become successful in the marketplace.

User-generated content sites are currently among the fastest growing Internet services. Our analytic approach based on electronic market design principles should be useful to help design and develop new business models that are being proposed in these evolving areas. While we considered specifically business models based on P2P file-sharing in this paper, we suggest that our approach could be more generally adapted for businesses in the digital entertainment space.

In order to complement our theoretical analysis let us conclude by briefly outlining how our framework can be used as the basis for developing a business management tool to support strategic decision-making regarding designing and developing business models based on content sharing. One possibility we envision is the development of a decision support system software product with a dashboard-style user interface akin to balanced scorecard systems [75]. The goal of the system would be to give a clear and balanced view of the enterprise to the top management by offering strategic feedback showing the present status of the business model and its performance from the seven perspectives defined in our market constraints framework. Diagnostic feedback from the various business processes would guide improvements for developing the business model on a continuous basis. Operational performance measures for each of the seven market constraints would need to be specified so that organizational performance trends could be tracked over time and indicate decision needs as they occur.

Each constraint could be represented graphically with specific performance measures, with links to more detailed data sources, plotted in color-coded areas representing four performance levels and directions of change. Improvements and deteriorations would be traced over time and

used to spot significant interactions across constraints. Performance targets for each measure would be specified and an analysis would be performed periodically (e.g., every month or quarter). This business model design and redesign process would continue until it reached a state where the business model showed a stable and satisfactory performance. At this stage, the business model development phase would be complete. The venture might be integrated with the general business of the company, and business performance analysis could shift to a regular balanced scorecard system.

P2P technologies and file-sharing systems are still evolving swiftly. Although innovations in these systems can be narrowly explored and studied ad hoc, we believe that it is also important to have available a robust and flexible analytic framework that will help IS researchers conduct analyses on various developments in P2P and content sharing markets. The particular fronts on which file-sharing business struggles are being fought shift continually. But the fundamental forces that we have integrated here, on which the actual outcomes depend, however, do not. Thus our contribution here is to provide such a framework for analysis, founded in technology and basic principles of economics and other relevant areas, but oriented toward practical business outcomes for strategic guidance and understanding.

References

- [1] A. Whinston, M. Parameswaran, A. Susarla, P2P networking: an information sharing alternative, *IEEE Computer* (July) (2001) 1–8.
- [2] D. Schoder, K. Fischbach, Peer-to-peer prospects, *Communications of the ACM* 46 (2) (2003) 27–30.
- [3] S. Rassenti, V. Smith, *Deregulating electric power: market design issues and experiments* Designing Competitive Electricity Markets, International Series in Operations Research and Management Science, vol. 13, Kluwer Academic, Boston and London, 1998, pp. 105–120.
- [4] D. Porter, S. Rassenti, V. Smith, Economic systems design, Manuscript, ICES, George Mason University, 2004.
- [5] E. Adar, B. Huberman, Free riding on Gnutella, *First Monday* 5 (10) (2000).
- [6] I. Clarke, O. Sandberg, B. Wiley, T. Hong, Freenet: a distributed anonymous information storage and retrieval system in designing privacy enhancing technologies, in: *Proceedings of the International Workshop on Design Issues in Anonymity and Unobservability*, 2001.
- [7] S. Liu, S. Kwok, Interoperability of peer-to-peer file sharing protocols, *ACM SIGecom Exchanges* 3 (3) (2002) 25–33.
- [8] M. Ripeanu, I. Foster, A. Iamnitchi, Mapping the Gnutella network: properties of large-scale peer-to-peer systems and implications for system design, *IEEE Internet Computing Special Issue on Peer-to-Peer Networking* 6 (1) (2002) 50–57.
- [9] S. Rollins, K. Almeroth, Pixie: a jukebox architecture to support efficient peer content exchange, in: *Proceedings of the 10th ACM international conference on Multimedia*, 2002, pp. 179–188.
- [10] A. Serjantov, Anonymizing censorship resistant systems, in: *Proceedings of the First International Workshop on Peer-to-Peer Systems*, 2002.
- [11] B. Yang, H. Garcia-Molina, Efficient search in peer-to-peer networks, in: *Proceedings of the 22nd International Conference on Distributed Computing Systems*, 2002.
- [12] H. Balakrishnan, M. Kaashoek, D. Karger, R. Morris, I. Stoica, Looking up data in P2P systems, *Communications of the ACM* 46 (2) (2003) 43–48.
- [13] J. Kubiatawicz, Extracting guarantees from chaos, *Communications of the ACM* 46 (2) (2003) 33–38.
- [14] B. Ooi, C. Liau, K. Tan, Managing trust in peer-to-peer systems using reputation-based techniques, in: *Proceedings of International Conference on Web Age Information Management*, 2003.
- [15] I. Stoica, R. Morris, D. Liben-Nowell, D. Karger, M. Kaashoek, F. Dabek, H. Balakrishnan, Chord: a scalable peer-to-peer lookup protocol for internet applications, *IEEE/ACM Transactions on Networking* 11 (1) (2003) 17–32.
- [16] S. Saroiu, K. Gummadi, S. Gribble, Measuring and analyzing the characteristics of Napster and Gnutella hosts, *Multimedia Systems* 9 (2) (2003) 170–184.
- [17] S. Krishnan, J. Uhlmann, The design of an anonymous file-sharing system based on group anonymity, *Information and Software Technology* 46 (4) (2004) 273–278.
- [18] P. Golle, K. Leyton-Brown, Incentives for sharing in peer-to-peer networks, in: *Proceedings of the Third ACM Conference on Electronic Commerce*, 2001.
- [19] B. Klein, A. Lerner, K. Murphy, The economics of copyright ‘Fair Use’ in a networked world, *American Economic Review* 92 (2) (2002) 205–208.
- [20] Y. Chen, I. Png, Information goods pricing and copyright enforcement: welfare analysis, *Information Systems Research* 14 (1) (2003) 107–123.
- [21] S. Bhattacharjee, R. Gopal, K. Lertwachara, J. Marsden, Economic of online music, in: *Proceedings of the Fifth International Conference on Electronic Commerce*, 2003, pp. 300–309.
- [22] C. Buragohain, D. Agrawal, S. Suri, A game theoretic framework for incentives in P2P systems, in: *Proceedings of the Third International Conference on Peer-to-Peer Computing*, 2003.
- [23] C. Grothoff, An excess-based economic model for resource allocation in peer-to-peer networks, *Wirtschaftsinformatik* 3 (2003). Available from: <http://grothoff.org/christian/ebe.pdf>.
- [24] S. Liebowitz, Will MP3 downloads annihilate the record industry? The evidence so far, in: Gary Libecap (Ed.), *Advances in the Study of Entrepreneurship, Innovation, and Economic Growth*, JAI Press, 2003.
- [25] A. Asvanund, K. Clay, R. Krishnan, M. Smith, An empirical analysis of network externalities in peer-to-peer music-sharing networks, *Information Systems Research* 15 (2) (2004) 155–174.
- [26] B. Cunningham, P. Alexander, N. Adilov, Peer-to-peer file sharing communities, *Information Economics and Policy* 16 (2004) 197–213.
- [27] R. Gopal, S. Bhattacharjee, G. Sanders, Do Artists benefit from online music sharing? *Journal of Business* 79 (3) (2006) 1503–1534.
- [28] K.R. Lang, R. Vragov, A pricing mechanism for digital content distribution over peer-to-peer networks, in: *Proceedings of the 38th Hawaii International Conference on System Sciences*, 2005.
- [29] S. Liebowitz, Filesharing: creative destruction or just plain destruction? *Journal of Law and Economics* 49 (2006) 1–28.
- [30] M. Peitz, P. Waelbroeck, Why the music industry may gain from free downloading – the role of sampling, *International Journal of Industrial Organization* 24 (2006) 907–913.
- [31] A. Schmidt, Multi-level markets and incentives for information goods, *Information Economics and Policy* 18 (2006) 125–138.
- [32] A. Zentner, Measuring the effect of file sharing on music purchases, *Journal of Law and Economics* 49 (2006) 63–90.
- [33] N. Good, A. Krekelberg, Usability and Privacy: a Study of Kazaa P2P File-Sharing, in: *Proceedings of the Conference on Human Factors in Computing Systems*, 2003, pp. 137–144.
- [34] K. Lang, R. Vragov, Using experimental methods to evaluate the effectiveness of different pricing mechanisms for content distribution over peer-to-peer networks, 2005 (Working paper).
- [35] M. Fox, B. Wrenn, A broadcasting model for the music industry, *The International Journal on Media Management* 3 (2) (2001) 112–119.

- [36] P. Alexander, Peer-to-peer file sharing: the case of the music recording industry, *Review of Industrial Organization* 20 (2) (2002) 151–161.
- [37] U. Lechner, J. Hummel, Business models and system architectures of virtual communities: from a sociological phenomenon to peer-to-peer architectures, *International Journal of Electronic Commerce* 6 (3) (2002) 41–53.
- [38] E. Clemons, B. Gu, K. Lang, Newly vulnerable markets in an age of pure information products: an analysis of online music and online news, *Journal of Management Information Systems* 19 (3) (2002) 17–41.
- [39] G. Premkumar, Alternate distribution strategies for digital music, *Communications of the ACM* 46 (9) (2003) 89–95.
- [40] F. Lohmann, Voluntary collective licensing for music file sharing, *Communications of the ACM* 47 (10) (2004) 21–24.
- [41] R. Telang, A. Asvanund, R. Krishnan, M. Smith, Interest-based self-organizational of peer-to-peer networks: a club economics approach, Working paper, <http://ssrn.com/abstract=585345>, 2004.
- [42] H. Tanaka, Post-Napster: peer-to-peer file sharing systems: current and future issues on secondary liability under copyright laws in the United States and Japan, 22 *Loyola of Los Angeles Entertainment Law Review* 37 (2001) 37–84.
- [43] P. Samuelson, DRM (and, or, vs.) the law, *Communications of the ACM* 46 (4) (2003) 41–45.
- [44] R. Heverly, The information semicommons, *Berkeley Technology Law Journal* 18 (4) (2003) 1127–1189.
- [45] J. Barker, Grossly excessive penalties in the battle against illegal file-sharing: the troubling effects of aggregating minimum statutory damages for copyright infringement, *Texas Law Review* 83 (2) (2004) 525–559.
- [46] R. Moore, E. McMullan, Perceptions of peer-to-peer file sharing among university students, *Journal of Criminal Justice and Popular Culture* 11 (1) (2004) 1–19.
- [47] D. Furtado, Television: peer-to-peer's next challenger, *Duke Law and Technology Review* 0007 (2005). Available from: <http://www.law.duke.edu/journals/dltr/articles/2005dltr0007.html>.
- [48] P. Samuelson, Did MGM really win the *Grokster* case? *Communications of the ACM* 48 (10) (2005) 19–24.
- [49] P. Agre, P2P and the promise of internet equality, *Communications of the ACM* 46 (2) (2003) 39–42.
- [50] P. Samuelson, What's at Stake in *MGM v. Grokster*? *Communications of the ACM* 47 (2) (2004) 15–20.
- [51] L. Lessig, *Free culture*, Penguin Press, New York, 2004.
- [52] M. Einhorn, B. Rosenblatt, Peer-to-peer networking and digital rights management: how market tools can solve copyright problems, *Policy Analysis #534* (2005), Cato Institute. Available from: <http://www.cato.org/pubs/pas/pa534.pdf>.
- [53] B. Brown, A. Sellen, E. Geelhoed, Music sharing as a computer supported collaborative application, in: *Proceedings of the 2001 Seventh European Conference on Computer Supported Cooperative Work*, September, 2001.
- [54] L. Robinson, D. Halle, Digitization, the Internet, and the Arts: eBay, Napster, SAG and e-Books, *Qualitative Sociology* 25 (3) (2002) 359–383.
- [55] M. Giesler, M. Pohlmann, The social form of Napster: cultivating the paradox of consumer emancipation, *Advances in Consumer Research* 30 (1) (2003) 94–100.
- [56] L. Strahilevitz, Charismatic code, social norms, and the emergence of cooperation on the file-swapping networks, *Virginia Law Review* 89 (2003).
- [57] J. Hughes, K. Lang, If I had a song: the culture of digital community networks and its impact on the music industry, *The International Journal on Media Management* 5 (3) (2003) 180–189.
- [58] R. Gopal, G. Sanders, S. Bhattacharjee, M. Agrawal, S. Wagner, A behavioral model of digital music piracy, *Journal of Organizational Computing and Electronic Commerce* 14 (2) (2004) 89–105.
- [59] K. McCabe, M. Rigdon, V. Smith, Positive reciprocity and intentions in trust games, *Journal of Economic Behavior and Organization* 52 (2) (2003) 267–275.
- [60] A. Tversky, D. Kahneman, Judgment under uncertainty: heuristics and biases, *Behavioral Finance* 1 (2001) 24–31.
- [61] J. Menn, *All the Rave: The Rise and Fall of Shawn Fanning's Napster*, Crown Business, New York, 2003.
- [62] K. Veale, Internet gift economies: voluntary payment schemes as tangible reciprocity, *First Monday* 8 (12) (2003). <http://www.firstmonday.org>.
- [63] S. Cartwright, Napster: a business in search of a model, *Journal of Business Strategy* 21 (5) (2000) 28–32.
- [64] F. Oberholzer, K. Strumpf, The effect of file sharing on record sales: an empirical analysis, Working paper, Department of Economics, Harvard Business School, 2004.
- [65] S. Bhattacharjee, R. Gopal, K. Lertwachara, J. Marsden, Consumer search and retailer strategies in the presence of online music sharing, *Journal for Management Information Systems* 23 (1) (2006) 129–159.
- [66] R. Arakij, K.R. Lang, Digital consumer networks and producer-consumer collaboration: innovation in the digital entertainment industry, Working paper, Zicklin School of Business, City University of New York, 2006.
- [67] Q. Dai, R.J. Kauffman, Business models for internet-based B2B electronic markets, *International Journal of Electronic Commerce* 6 (4) (2002) 41–72.
- [68] S. Schiesel, File-Sharing's New Face, *New York Times*, February 12, 2004.
- [69] M. Izal, E. Biersack, P. Felber, G. Urvoy-Keller, A. Al Hamra, L. Garces-Erice, *Dissecting BitTorrent: Five Months in a Torrent's Lifetime*, 5th Passive and Active Measurement Workshop, 2004.
- [70] J. Bakos, Reducing buyer search costs: implications for electronic marketplaces, *Management Science* 43 (12) (1997) 1676–1692.
- [71] T. Strader, M. Shaw, Characteristics of electronic markets, *Decision Support Systems* 21 (1997) 185–198.
- [72] A.R. Sorkin, Dot-Com Deal Echoed in Deal to Buy YouTube, *The New York Times*, 2006, p. A. 1.
- [73] B. Garfield, The YouTube effect, *Wired Magazine* 14 (12) (2006) 222–227.
- [74] L.M. Holson, Hollywood Asks YouTube: Friend or Foe? *The New York Times*, 2007, p. C. 1.
- [75] R.S. Kaplan, D.P. Norton, The balanced scorecard – measures that drive performance, *Harvard Business Review* 70 (1) (1992) 71–79.