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Abstract

A fast-growing body of literature in information systems research as well as in other disciplines has examined peer-to-peer (P2P) filesharing from various perspectives, but has failed so far to offer a comprehensive analytic framework that would allow us to explain why the market has not yet produced any significant commercially successful P2P service models for digital content distribution. We argue that this is a result of a profound misconception of P2P systems. In this paper, we view them as electronic markets for trading digital content rather than as mere business applications, which has been the prevalent view in the IS literature. This different conceptualization allows us to apply general market design principles to analysis and development of P2P services. We propose that seven specific market constraints–technical, economic, structural, legal, political, psycho-cognitive and socio-cultural–together determine the success of P2P market designs.

Keywords: peer-to-peer, filesharing, information goods, electronic markets

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, pornography, movies, and other documents. Peer-to-Peer (P2P) filesharing systems such as Napster, Kazaa and BitTorrent, (and Grouper) to name just a few from among dozens, have since 1999 drawn increasing interest: first from users, then from businesses hoping to use them and industries facing new challenges from them, as well as from the academic community of researchers hoping to understand them and courts with the responsibility of regulating them. These revolutionary and disruptive systems leverage an enormous amount of power, distributed among their users but coordinated by the system. They exhibit fascinating characteristics of structure and performance among multi-user systems, and they continue to evolve at a swift pace.

P2P systems create markets where uploaders (sellers) and downloaders (buyers) exchange information goods, that is, digital content files. Moreover, filesharing systems constitute purely electronic markets, in that both the market environment and the goods traded are exclusively digital. While the technology keeps changing and legal issues are being debated, more content becomes available and more users adopt P2P filesharing.

It is clear that value is created as huge amounts of content are distributed, including previously available content, but also new and original content. It is less clear, however, how to best

distribute and share value, and how to design incentives that would entice everyone in the existing value chain to productively participate in these new electronic markets. Market structure has been identified as a factor with critical implications for all the stakeholders in the digital music industry (Bockstedt, Kauffman & Riggins, 2005). Traditional corporate content providers are threatened with loss of control over distribution and possibly profits. Some consumers feel legally insecure sharing content, while others perceive existing P2P 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 persecutes P2P technology. Williamsonian under-investment is occurring (Williamson, 1975). As a result, everyone is worse off in the current market situation.

A better outcome for all market participants would be possible if P2P markets for information goods worked better. If a market works well, everyone will participate, and do so in ways that improve the overall outcome. Clearly, this is not yet the case in P2P markets. Hence, we must be analytically able to diagnose certain market failures that would explain those shortcomings. And hopefully, we will then be able to also design better markets for P2P filesharing.

The design of physical and electronic markets is an issue that has received considerable attention in economics research. Work in the area of experimental economics suggests that there is a small number of fundamental principles that 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. Reviewing the literature related to market design to date, we notice that specific constraints are emerging – technical, economic, structural, legal, and political (see for example Porter, Rassenti, & Smith, 2004). It seems that the success or failure of a market depends on how well they are addressed in the implementation of a market design. These same constraints also apply to P2P filesharing markets. When we apply them to P2P exchange systems we would like to specifically emphasize the user-technology interaction and user interfaces, which should be considered psychological/cognitive constraints (Lang & Vragov, 2005a). Because P2P content-sharing markets deal largely in cultural objects (artistic expressions, entertainment) and are populated by various kinds of virtual communities (Hughes & Lang, 2003), we finally introduce another constraint, the socio-cultural, which represents cultural norms and values and the social processes that take place in digital information environments, and how they affect market operation.

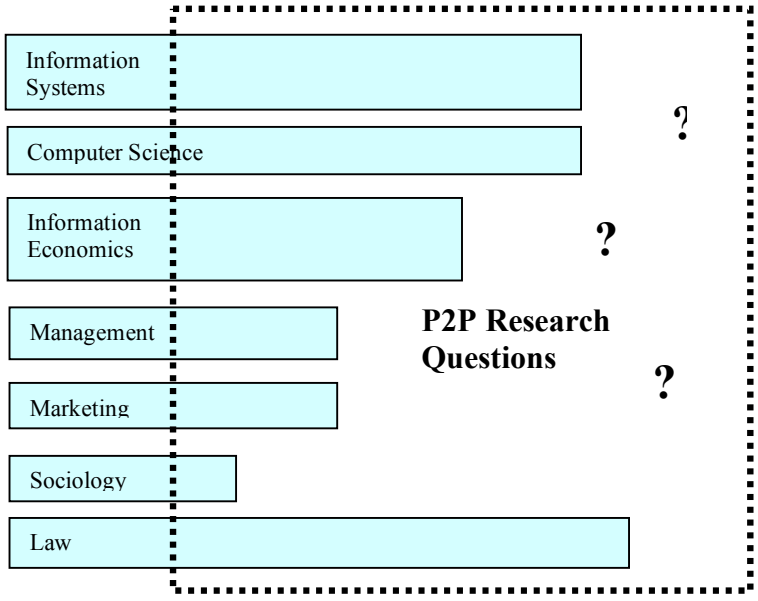
We argue that the principles of good electronic market design require the consideration of all seven market constraints. Failing to sufficiently address any of them renders a market vulnerable to underperformance or failure. Looking at the research literature on P2P, we find many conceptual and theoretical analyses as well as empirical studies that concern one or several of the constraints, but none, to our knowledge, has attempted to heed all seven market constraints in combination. We can identify market constraints in all current P2P systems of practice that were ignored or neglected, and thus explain why P2P filesharing has run into problems in the market. The organization of this paper is as follows. In the immediately following section, 'Evolution of Peer-to-Peer Filesharing Technology', we will give an overview of the short history of P2P markets to date. The next section, 'Electronic Markets Design Framework', presents and discusses this paper's primary focus, which is a unified research framework bringing together all

seven of the constraints upon electronic markets. The integration into a coherent framework is a unique contribution which appears nowhere else in existing literature. This section will analyze the impacts of each of these constraints upon the electronic markets implemented in P2P filesharing systems. The final section, 'Discussion and Future Directions', will integrate the various constraints and suggest potentially fruitful avenues for further research.

2. Evolution of Peer-to-Peer Filesharing Technology

A *Peer-to-Peer* system is one in which the nodes of the network communicate as equals, with no centralized governing node as an intermediary. Each participant in the network can behave either as a client, receiving files, or as a server, sending information, or both, and can establish these relationships with other nodes in the system. Peer-to-Peer architecture is basic to the structure of the Internet, as implemented in the TCP/IP protocols (Leiner et al, 1997). The P2P systems discussed herein should be considered overlay networks upon that basic Internet infrastructure. Our concern from the point of view of markets is P2P filesharing systems, systems in which the users freely exchange content directly between themselves. The most well-known of such systems to date are music filesharing networks such as the original Napster or Kazaa, but there are dozens more already operating (BitTorrent, eDonkey, Poison, e.g.), and more in development. These systems are now being used to exchange not only music, but also movies, television shows, books, software, pornography, and virtually anything else that can be digitized.

Figure 1: Multi-disciplinary literature on P2P systems



Research on P2P systems has not crystallized around one particular discipline. On the contrary, as the body of published literature grows, we find it staking out positions in a variety of research disciplines with questions relevant to the design, performance, uses, and impacts of P2P filesharing networks, among them Computer Science, Economics, Management, Law, Marketing, Information Systems, and Sociology. (Figure 1) Each of these perspectives brings valuable methodologies and analysis tools to P2P markets, and each finds important questions remaining to be answered about their operation. While each of these areas addresses topics

relevant to P2P systems, we believe that the Information Systems area, as an inherently interdisciplinary research field, is uniquely suited to providing a view which can coherently encompass these different research streams.

Table 1 – Generations of P2P Filesharing Systems

Gen.	Technologies	Examples	Users	Outcomes
I	Central-index – complete list of files available on the network kept on a central server; highly efficient file 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	Forced to close in 2001 by legal action: A&M Records v. Napster, U.S. 9th Circuit Court of Appeals
II	Distributed index – list of available files is distributed across nodes of the network, so no single server is indispensable to the system; many systems employ the Gnutella engine or similar technology; file search may not view all network resources Single-server queues - users search for a file on a single machine, then wait their turn for a complete download	Kazaa Limewire Morpheus Grokster	Consumers	Network creators and users under legal attack Most networks still in operation but less popular than newer systems
III	Many-to-many file service links – users can download a single file from many servers at once, can 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; most systems do not offer perfect, unbreakable anonymity	BitTorrent Freenet eMule	Consumers Businesses	Some systems under legal attack Low but growing adoption for large-file distribution such as software updates Anonymous use hard to track
IV	Private P2P networks – restricted access via password logins, controlled by licensee of a software product such as QNext	QNext Groove Grouper	Consumers Businesses	Niche market for private systems; Usage not publicly visible
V	Use of existing Internet protocols to exchange files User migration to the Darknet	Usenet Internet Relay Chat Instant Messaging	Consumers	Large volumes of activity; Difficult to track

A P2P market is implemented on the Internet, for the purposes of exchanging purely digital information goods. Unlike markets for physical goods such as commodities, real estate or

consumer items, P2P markets can logically only exist within a framework of Information Technology which enables connections to be created and exchanges to take place, and provides for storage and display of the digital media content. In response to pressure from users, competitors, and legal institutions, P2P markets have already passed through at least five stages of development, as follows (Table 1).

The shortcomings of all of the above, especially from the perspective of making P2P applications useful for addressing business needs, flow not only from the legal constraints placed upon them, but also from the high degree of flexibility built into the networks, a characteristic which accounts for a significant portion of their power in the first place. Concerns of the business community include reliability under various load conditions, the problems of freeriding, security, and the verification of file content (Schoder & Fischbach, 2003; Whinston, Susarla & Parameswaran, 2001).

3. Electronic Markets Design Framework

As the movement of businesses toward online markets matures, it becomes useful to consider P2P filesharing systems as a significant distribution mechanism (Lang and Vragov, 2005b): a means of facilitating exchanges of information goods. The most prominent filesharing tools have functioned primarily as Consumer-to-Consumer (C2C) barter markets, in which both bandwidth and content are, under various technical and structural schemes, the goods of interest. Under various P2P protocols in development or operating on the Internet, users may participate in any or all of the following transactions:

Table 1 - Peer-to-Peer Market Transactions

Obtain / Offer	Content files	Improved Download Bandwidth	Improved Queue Position
Nothing	✓ (leech)		
Content Files	✓ (seed)	✓	✓
Higher Upload Bandwidth	✓ (superpeer)	✓	✓
Network Index Information	✓ (supernode)	✓	✓

While P2P application developers have set up their networks to make content as widely available as possible, they have also been concerned with addressing the potential problems of free riding: downloading content from the network while providing none in return. The chart above reflects in part developers' efforts to reduce freeriding by providing incentives for users to contribute to the network, in terms of both content and performance.

In table 2 we summarize the critical constraints on markets which, collectively, determine the ability of a market to develop to its full potential. Together, these seven factors comprise a framework which provides a crucial theoretical link between the features of P2P systems as they are actually designed and implemented, and the perspectives of research which has been carried out on such systems. This framework can be applied to the analysis 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.

Table 2 - Electronic Market Design Framework

Market Constraint	Description	Examples
Technical	Questions of hardware, software, networks, compression, content creation (file types) and control (Digital Rights Management technologies), and the quantitative performance of systems	Adar & Huberman, 2000 Liu & Kwok, 2002 Stoica et al, 2003 Saroiu, Gumadi & Gribble, 2003 Krishnan & Uhlmann, 2004
Economic	Pricing, incentives and disincentives, utility, supply/demand relationships	Klein, Lerner & Murphy, 2002 Chen, Y., & Png, I. 2003 Bhattacharjee et al, 2003 Lang & Vragov, 2005 Gopal et al, 2005 Liebowitz, 2003, 2004
Structural	Market participants and the degree of control they are able to exert; channel power, channel conflict, monopolies, oligopolies	Fox & Wrenn, 2001 Lechner, & Hummel, 2002 Clemons, Gu & Lang, 2002 Premkumar, G. 2003 Telang et al, 2004
Legal	Copyright law, fair use, sharing versus stealing, piracy, lawsuits, Digital Rights Management (DRM)	Tanaka, 2001 Samuelson, 2003 Heverly, 2003 Moore & McMullan, 2004 Gopal et al, 2005
Political	Power relationships both within and between groups and institutions, lobbying	Samuelson, 2004 Lessig, 2004
Cognitive	Interaction of users and P2P systems; how users understand the function of P2P apps and networks, how users understand the market mechanism	Good & Krekelberg, 2003 Lang & Vragov, 2005a
Socio-Cultural	Broad impacts on communities, social networks and societies driven by the availability and use of P2P networks; cultural norms and value	Robinson & Halle, 2002 Giesler & Pohlmann, 2003 Strahilevitz, 2003 Hughes & Lang, 2003

Technical

Technical factors (Rassenti & Smith, 1998) of P2P markets are of primary interest to researchers publishing in the Computer Science area. An example of a technical factor is the development of multimedia compression algorithms of sufficient power to make distribution via P2P networks over existing consumer Internet connections feasible. The recent increase in the availability of video multimedia objects on P2P networks (Schiesel, 2004) is due in part to the success of the MPEG-4 specification and its implementation in codecs commonly seen in P2P files such as Xvid or DivX. A second technical innovation, just as critical for P2P video data, is the BitTorrent method of distribution, whereby files are acquired, and served to, many nodes at once, instead of via a dedicated link to just one other node in the network (Izal et al, 2004). Media

content packages as large as 12 gigabytes are traded in this way, although downloads this large involve a significant time investment, even with the efficiency of BitTorrent, and not infrequently fail to complete delivery. Since the continuous presence of specific nodes in the network is not guaranteed by P2P protocols, the risk of a failed transaction rises as the required download time increases.

The technical problems of P2P markets addressed in the literature are diverse. A seminal paper in this category is Adar & Huberman's (2000) "Free Riding on Gnutella", a study which found that P2P markets are surprisingly robust even in the presence of high levels of the user behavior known as free riding, a finding which has been borne out in practice since that time (Saroiu, Gummadi & Gribble, 2003). Liu & Kwok (2002) find the incompatible protocols of the various P2P engines to be a limiting factor in their effectiveness, and set out to design a means of enabling different P2P systems to exchange content effectively. Stoica et al (2003) address one of the problems created by the legal shutdown of the Napster index, which is file discovery. Distributed systems lacking a central server face a problem in making files in the system available to all users. They propose using a distributed system of hash codes (Chord), a type of solution that has been adopted for many P2P systems, particularly those intended to provide secure and reliable file content. Krishnan & Uhlmann (2004) examine the technical problems of attempting to address a user concern, the desire for private transactions, and suggest a method which bundles requests and submits them on behalf of a group, instead of an individual user.

Economic

By Economic factors, we mean the various economic forces at work in P2P markets, and their relationships, analyzed in conceptual, empirical or mathematical models. These may include pricing, incentive structures, profit sharing, scarcity vs abundance, service differentiation, competition, and information asymmetries. For example, Klein, Lerner & Murphy (2002) analyzed the music industry in the presence of the original Napster system, and concluded that the result would be to lower the value of copyrights. The music industry is a natural place to examine these questions, since practically every conceivable method of pricing, bundling, distribution and incentivizing is being tried in the real-world environment, and can be observed from inception, the very moment of birth of new markets.

Understanding utility in P2P markets is a particularly complex problem, since there are so many interrelated factors at work. The legal aspects of P2P markets and the actions taken by the music industry in response have prompted some analysts to include a term for the risk associated with participation in some types of P2P systems. Bhattacharjee et al (2003a), for example, created a simulation which examines revenue-maximizing strategies in the presence of the threat of piracy, and found that the strategy with the highest returns may be one which does not attempt to totally eliminate piracy. Some authors have included a term which differentiates between the quality of a music CD and that of an MP3 file obtained in a P2P market (Chen & Png, 2003). Both of these analyses must be reconciled with survey data which suggest that risk and quality may play less of a role than perhaps originally expected (Bhattacharjee, Gopal & Sanders, 2003). P2P markets in their early stages of development may also present users with significant costs in time and effort to obtain desired files as compared to non-P2P channels such as Apple's iTunes, which can be modeled as friction in acquisition activities. On the other hand, the de-incentivizing effect of such friction may be partially offset by the use in some distribution channels of Digital Rights Management restrictions on content files, which imposes its own frictions on acquisition and use

of digital media content, and may negatively modulate the utility function of a heavily protected file.

Structural

Structural factors of a market (Rassenti & Smith, 1998) are those defining the number of participants, and the relative degrees of control which they are able to exert upon it, with well-known ideal forms such as monopoly, oligopoly, or perfect competition. These address strategically important topics such as channel power, channel conflict, power shifts, entrenched businesses vs new entrants, and intermediation vs disintermediation. It is in the nature of the most prominent examples of P2P systems that have been used, that, as C2C vehicles, they tend to blur the distinction between buyers and sellers. However, the degree to which this occurs is at least in part dependent on the application, or lack thereof, of Digital Rights Management technologies, a factor which itself raises not only technical questions, but also those of copyright and law generally.

Fox and Wrenn (2001) suggest that the market forces brought to bear by the availability of P2P filesharing tools could push the recording industry toward a services model built upon a broadcasting business model, in which revenues are derived from advertising sales and licensing fees, rather than from direct purchase of products. Lechner and Hummel (2002) evaluate the business models of the music industry as they arise from various system architectures, with particular attention to the power conferred upon communities of users by P2P systems, resulting in a diminution of the value added by the music industry. Clemons, Gu and Lang (2002) examine the music industry and conclude that it is vulnerable to disintermediation, as not only consumers but also the musicians themselves take advantage of disruptive technological innovations to carry out functions formerly reserved to the record companies. They suggest that in the presence of effective P2P distribution, record companies must fundamentally re-examine the value they attempt to provide consumers. Premkumar (2003) briefly examines the supply chain of the music industry, and finds that it is burdened with high fixed costs, which together with the increased power of the consumer due to alternate distribution channels makes it likely that the traditional business models of record companies will need to be supplemented with or perhaps even replaced entirely by newer ones.

Legal

Since P2P systems have been used to acquire music which is under copyright protection, they have been of great concern from a legal point of view. While the law on intellectual property is well-developed (if poorly understood), in 2005 its application to content available on P2P systems, and regulation of the systems themselves, is not. Questions of legislation, regulation, enforcement, court rulings, academic debate among law scholars vs codified law, 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. However, while the legal aspects of P2P systems are hotly argued and swiftly evolving, questions of legality may not even be among the major forces at work, given the enormous amount of power which such systems confer upon users—through 2005, legal efforts to shut down filesharing activity had not achieved their stated goals.

Legal constraints upon the operation of P2P filesharing networks are focused primarily on issues of copyright. The original Napster operated under no legal strictures from October 1999 to March of 2001; all P2P systems since then have been forced to address legal questions which arise from their use. The primary legal reference in all of the legal proceedings through 2005 has been 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 there were significant non-infringing uses (uses which do not violate copyrights) of the technology. This legal precedent could not protect Napster, which the courts held contributed to copyright infringement, in part by providing a central index of files which users could use to easily locate and downloaded protected content (Greene, 2001). Garnett (2001) argues that, in the presence of P2P technologies, copyright law can no longer fulfill its function of striking a just balance between the rights of copyright holders and those of the public, and suggests that this function must now be implemented by sophisticated Digital Rights Management solutions. Tanaka (2001) analyzes copyright law and concludes that not all P2P filesharing technologies can be outlawed as Napster was, and agrees with Garnett that legal copyrights must be supported by technological solutions via DRM. The other side of the legal questions of copyright involves the concept of "fair use", the question of what a consumer is allowed to do with media content they have purchased. Samuelson (2003) analyzes DRM limitations imposed by record companies to combat P2P filesharing, and concludes that they infringe upon fair use rights reserved to consumers by law. Heverly (2003) examines information goods and P2P filesharing systems in light of the theory of semicommons (Smith, 2000), and concludes that this theory provides guidance for the fair balancing of private and common uses of digital information goods, a position which provides some support for the use of P2P filesharing systems. Moore and McMullan (2004) surveys college students at the School of Criminal Justice, University at Albany, and finds that a majority of the sample do not consider filesharing to be either illegal or unethical, a finding with striking implications for the future, especially in light of the fact that 55% of the respondents of the study were Criminal Justice majors, who have thus shown interest in a vocation enforcing the law.

Political

Political factors (Porter, Rassenti, & Smith, 2004) are those which modulate access to and control of P2P markets via the exercise of power. This would include not only the power exerted by the executive branch of government through enforcement of copyright laws, but also the relative power exerted within and between particular communities and institutions with an interest in P2P networks (Lessig, 2004). Interested stakeholders are industry and consumer groups, lobbying organization, government bodies (legislative), regulatory bodies (FTC, FCC), and perhaps unions as well. A prominent example would be the industry-driven writing and passage of the Digital Millennium Copyright Act (DMCA 1998), which has become the basis for a number of actions against P2P filesharing systems. In P2P technologies there is an open-source community power effect at work. For example, as each new copy protection system is introduced (and at times even before it is officially introduced), the broad community of technically skilled P2P users goes to work on circumventing it.

Political power has come into play in P2P markets as interested institutions have lobbied Congress to pass legislation which would outlaw technologies which would have the effect of "inducing" users to engage in copyright infringement (http://www.corante.com/importance/archives/INDUCE.html). Groups both for and against P2P filesharing activity have presented briefs to the Supreme Court on the case *Grokster v. MGM* (http://www.eff.org/IP/P2P/MGM_v_Grokster/summary.pdf). While discussions of the political forces at work in P2P are common in the popular media, relatively little discussion has yet taken place in peer-reviewed journals. Pamela Samuelson looks at this case and the relevant law, and concludes that the appropriate forum for resolving the controversies over P2P markets is properly a political one, the U.S. Congress, and not a judicial one.

Psychological/Cognitive

Psychological factors (McCabe, Rigdon & Smith, 2003; Tversky & Kahneman, 2001) are those which govern how users understand and employ the features available in P2P networks, both concretely in terms of the actual graphic user interfaces of specific P2P applications, and more broadly construed as P2P networks in general. Cognitive apprehension of a P2P system by a user would thus involve not only Human-Computer Interactions, such as the graphic design of P2P applications, but also questions such as understanding market mechanisms, discovering how to effectively trade content, how to price products, and what information to reveal to the market (Lang & Vragov, 2005a). One example of the importance of this factor is the way in which content search is handled. Early P2P systems had very primitive search capabilities, through keyword search of user-generated metadata only--with the result that the networks quickly began to self-organize into virtual communities of users with similar interests. By 2004, this effect had generalized to particular tools, such as the early popularity of BitTorrent with fans of animé video content.

When the first round of lawsuits was filed by the RIAA, it became apparent that not all users were fully acquainted with the operation of the P2P tools they had been using. This is consistent with the finding of Good and Krekelberg (2003), who did a cognitive review of the Kazaa filesharing interface, and found that the majority of users did not know what files they were sharing, and often mistakenly believed that they were sharing no files at all. As the requirements of DRM, copyright restrictions and fair use become more specific and complicated, the burden of P2P markets to overcome cognitive limitations becomes increasingly important.

Socio-Cultural

Socio-Cultural constraints (Hughes & Lang, 2003) are those which stem from the beliefs and attitudes of communities and institutions which perceive a stake in how P2P networks are used. These may include group dynamics in virtual communities, mass phenomena, cultural values, social norms, gender effects, generational differences, and the formation and evolution of subcultures. It has already been observed, for example, that there appears to be a generational divide in attitudes towards digital media objects distributed via P2P networks (Pew Internet and American Life Project, March 2005). It has been proposed that the same ethical factors which have already been examined in instances of software piracy may also be at work in decisions made around P2P system use (Peace, Galletta & Thong, 2003).

This constraint may be particularly important for P2P markets, as the beliefs, norms and attitudes of a community are antecedents of at least economic, legal and political behavior. Robinson and Halle (2002) look at several ways, including impacts of P2P systems, in which digitization is transforming the arts, and conclude that "people's ability to interact creatively with products" will be increasingly important in the future. Giesler and Pohlmann (2003) do an exploratory analysis of texts concerning the original Napster as a gifting community, and produce a theoretical framework which identifies the consumption meanings of filesharing systems. Strahilevitz (2003) examines the emergence of social norms which emphasize cooperation—within a filesharing community that is embedded in a larger society that identifies filesharing of copyrighted content as illegal—and finds that the computer code of the system itself plays an important role, through the way in which it both "magnifies cooperative behavior and masks uncooperative behavior". The persistence of P2P markets to date in the face of strong resistance from powerful stakeholders in the music industry suggests that socio-cultural changes have already taken place which have significant implications for the role of digital media content in society, changes which should be more clearly identified and understood.

4. Discussion and Future Directions

The constraints on electronic markets discussed above interact not only with markets, but with each other, as market models are introduced and real-world results emerge. For example, technological innovations in P2P filesharing systems have been driven by: legal considerations, as the ruling against Napster identified the central-server index as a legal flaw; economic considerations, as innovators attempt to use software protocols to manage bandwidth supply and demand problems; structural considerations, as P2P software provides alternatives to value chain activities formerly reserved to record companies such as product bundling, reproduction and distribution; cognitive considerations, as P2P developers try to make their networks easy to use and transparent in function; and socio-cultural considerations, as different P2P tools are adopted by users groups with particular interests, such as the initial preference of animé (Japanese animation videos) for BitTorrent. Likewise, legal rulings on particular P2P systems must take into account the precise nature of the technology being used, its economic impacts, and the political relationships and cultural values which inform legal judgments.

The action and interaction of constraints on electronic markets can be seen particularly in the case of Digital Rights Management technologies. Producers of digital media products have experimented with DRM as a response to the operation of P2P filesharing networks, and business models have been proposed which would leverage the distribution power of P2P filesharing networks, while protecting the distributed files with DRM (Kwok and Lui, 2002). The relative success or failure of DRM turns upon technology; affects the economic balance of supply and demand; re-asserts the structural channel power of content producers; enforces the legal rights of copyright holders; modulates the power relationships between industry incumbents and market innovators; imposes additional cognitive demands upon users; and accords or conflicts with users' cultural attitudes and beliefs. The convergence of all these factors in DRM is complex and intense, and the outcome of DRM as a response to P2P markets has yet to be determined.

Bringing a market constraints perspective to P2P filesharing systems, we can begin to systematically research such questions as:

- how can the operation of electronic market under these constraints be modeled?
- what is the relative importance of the different market considerations at different points in the development of electronic markets?
- what are the limits (if any) upon the design space for electronic markets under these constraints?
- how do different constraints come into play for different products offered in electronic markets?

There can be little doubt, particularly from the point of view of the music industry, that P2P filesharing technologies are disruptive, and the first six years of P2P markets for digital content have been marked by both controversy and a ferment of innovation. The authors of this paper contribute a theoretical framework and analysis which allows us to understand the history of P2P markets, explain their behavior, and predict the outcomes of new designs and implementations as they appear.

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