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Michael D. Mehta

Don Best

Nancy Poon

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Peer-to-peer sharing on the Internet: An analysis of how Gnutella networks are used to distribute pornographic material

Michael D. Mehta,[*] Don Best[**] and Nancy Poon[***]

Introduction

By our very nature, humans are creatures that communicate and network. Over the past several decades much of this communicating and networking has been facilitated by developments in information and communication technology. The social and economic transformations resulting from developments on the Internet have created several challenges for policymakers, lawmakers, courts and a wide range of other kinds of institutions. Some of these challenges are associated with the technologies and applications themselves. Other challenges result from content made available on the Internet and how users exchange data. Recent developments in peer-to-peer data exchange bring these two sets of challenges together.

The advent of the World Wide Web in 1994 ushered in a new information age. In the Western world, many of us were brought up with access to television, radio and telephone. Television and radio (in conjunction with print-based media like newspapers) connect us to the world in a passive way. As recipients of broadcasts, we have few opportunities to participate in the creation of news. By contrast, use of the telephone is highly personal and maximises opportunity to make a contribution, albeit to a much smaller audience (usually one other person). The World Wide Web was expected by many to create a new social space. It was assumed that access to the Internet and the ability to create a space in the form of individual websites could perform a valuable social function; namely, the opportunity for individuals to exchange their views with a larger audience. The Internet, with a range of applications (e.g., World Wide Web, Usenet, email, chat, etc.), was expected by some to act as an agent of democratic and social reform. By transcending time and space, it has been suggested that such technologies are facilitating new forms of human interaction in a domain known as "cyberspace". Of interest to sociologists and other social scientists who specialise in cyberspace are the paradigmatic changes seen in the constellation of power relations between individuals, governments and other kinds of social institutions. This new wired world is expected by some like Mark Poster[1] to facilitate the demise of modernist forms of governance[2]. For Donna Haraway[3], cyberspace is a medium for emancipation and offers the possibility of transcending physicality. This assumes that individuals can compete equally with large, traditional producers of content, and that the Internet would remain free from many of the constraints posed by the marketplace and political (and legal) concerns. Much of this utopian-like thinking is in a process of revision[4].

With the rapid growth of the Internet, debates over access and distribution to two general types of material have emerged: contentious and copyright protected material. Although several kinds of contentious material can be found on the Internet (e.g., obscene, child pornography, hate, seditious and treasonous), the availability of obscene content and child pornography has garnered the most attention. Recently, the development of file sharing applications like Napster, for exchanging music (.mp3 format), has shifted attention towards the issue of copyright violation. Centralised file sharing applications like Napster are no longer considered a serious threat due to well-publicised court rulings against Napster. However, a new breed of decentralised file sharing application, based on peer-to-peer data exchange, is likely to reignite concerns about the distribution of copyright protected and contentious material. In this study, we discuss peer-to-peer computing and provide

data from an analysis of 507 pornographic video files made available by peer-to-peer sharing. The legal and policy implications of our findings are discussed.

What is peer-to peer sharing?

Peer-to-peer computing (P2P) is of increasing importance to those watching developments of the Internet. P2P technologies are seen by some as the next big thing to hit the Internet, and computing in general. The Gartner Group indicates that "by 2002, more than half of the global Internet users will regularly sign on to at least two P2P Internet applications." Less dramatically, the Forrester Report predicts that "by 2004, 33% of the online population will use P2P services."[5].

Peer-to-peer technology is not new in practice or concept. Networking individual computers together is an idea that occurred to early users of computers. The developers of ARPANET, which eventually became the Internet we know today, seized the incredible power available through connectivity. One of the first well-publicised examples of P2P technology is the SETI project[6]. Developed by David Gedye and Craig Kasnoff, SETI@home was launched in 1999. This project takes advantage of wasted CPU cycles by using a client that runs in the background on computers. More than 2 million individuals from around the world use their personal computers to analyse data gathered by a large radio telescope. These computers analyse small portions of data and then send it back to SETI's server. As a result, over 500,000 years of CPU time has been utilised by SETI@home as of December 16, 2000[7].

Delaney[8] discusses a similar project currently under way for analysing DNA sequencing data. Yet another project that uses the same P2P architecture is a project examining protein folding. Like SETI@home, the protein folding project allocates small portions of work to various computers so that vast computations can be made more efficiently and quickly[9]. Arguably the most famous example of P2P computing is the music file sharing application Napster. As Napster is very relevant to the discussion of P2P, we will deal with it separately below.

P2P is also of interest to the business community. Fox[10] argues that it is inevitable that business will adopt P2P in some form or another. The many business applications that may use P2P include instant messaging, workgroup collaboration, file sharing and distributed computing[11]. These authors predict that companies will take advantage of P2P technologies to "relieve network bottlenecks, enable collaboration within ad hoc workgroups, and unleash untold computing power from underused processors throughout an enterprise"[12]. Bannan[13], lists several companies who are in the process of developing P2P applications, including IBM, Microsoft and Sun Microsystems. The inclusion of these well-established companies indicates the importance given to P2P.

It is important to differentiate between P2P with a central server and P2P with no central server. Napster exemplified central server-based P2P technology. The central server acted as an index and organisational node. Host machines (the computers of individual users logged on to the network) had to go through the central Napster server in order to find each other and share files. Such uses of P2P are more easily subject to legal actions as there is an identifiable target, specifically whoever is hosting the central server. A new breed of decentralised peer-to-peer file sharing has developed over the past few years. Commonly known as Gnutella Net, this P2P network is very different from Napster. Instead of acting as a central node, several software applications (e.g., Bearshare, Limewire) function as search engines for navigating through the host machines linked to this network. With this form of P2P no readily identifiable server can be pursued for legal action[14].

There are several positive aspects associated with P2P file sharing. Among them is the ability to search for files currently available. Contrast this with the situation found when searching the web where dead links and large, poorly indexed websites are common. Additionally, the nuances of relying on search engines for finding material on the World Wide Web become less important. This method of file sharing eliminates the need for a centralised server, which means that files can be

exchanged at a very low cost. There are several technical advantages to P2P including increased efficiency of data transfer and routing[15].

History of Gnutella

The history of Gnutella centres on a company called Nullsoft. Nullsoft's co-founders, Justin Frankel and Tom Pepper, both invented applications commonly used today by many on the Internet. Frankel developed WinAmp, a popular application that plays digital music[16]. Pepper is the developer of SHOUTcast, an application that broadcasts music on the Internet[17]. In 1999, AOL acquired Nullsoft for $100 million. AOL was hoping to use the above-mentioned applications to distribute music via their online service. According to Koplowitz, Frankel and Pepper posted Gnutella on the Nullsoft website - now owned by AOL. After a telephone call from Gerald Levin, CEO of Time Warner, AOL removed the Gnutella open-source from the website. By this time, reportedly more than 10,000 people had already downloaded it and subsequently created the Gnutella network[18].

Potential limits of Gnutella

Although the advantages of P2P networking are impressive, some problems are associated with its use. Parameswaran et al.[19] argue that P2P technologies can lead to spurious content and will almost certainly face legal challenges. Additionally, since the robustness of this network requires sharing, a "free rider" problem can be devastating. Not all users of this network are sharing files. Adar and Huberman[20] identify two types of free riders. The first are users that only download files and never share files with others. The second are users who share files, but only make available low quality files (e.g., randomly generated text files) while at the same time downloading high quality files from the network. In regards to the first type of free rider, Adar and Huberman[21] note that "nearly 70% of Gnutella users share no files, and nearly 50% of all responses are returned by the top 1% of sharing hosts." They argue that because so few users share, there will be problems in the future. They claim that for a decentralised distribution network to succeed, the level of cooperation (and trust) needed between users is high. This level of co-operation will be difficult given the perceived anonymity of the network[22], and perhaps due to legal concerns associated with distributing copyright protected and contentious material. Adar and Huberman[23] argue that Gnutella is not completely immune to legal actions. They contend that if the top 1% of sharing hosts ("top-serving peers") can be targeted as quasi-centralised servers, the network could be crippled.

Another potential limiting factor to the growth of Gnutella involves the willingness of people to purchase high-speed access to the Internet as well as better, faster computers. If more computer users have high-speed access, then a network like Gnutella will offer increasing usability. The need for high-speed access and better computers, in order to use more effectively P2P networks, may be see as a benefit by the computer industry. Something like P2P may be the answer to the question of how to boost sales of personal computers. Additionally, providers of high-speed access may welcome applications that stimulate demand for their services.

Gnutella along with other peer-to-peer file sharing protocols offer a different way to distribute information across the Internet. Ostensibly, peer-to-peer networking bypasses commercial exchange. Users share the content of their computers with each other through these networks, and presently there are no known mechanisms for levying fees. Unlike Napster, the files shared by Gnutella include not only MP3 music, but also digitised video and software, to name just a few formats supported. The potential for software piracy is enormous. Microsoft's new operating system XP is already being exchanged through these networks.

A short history of Napster

Napster, the music file sharing service started in 1999 by Shawn Fanning and Sean Parker, is the

best known example of P2P technology. At one point Napster claimed to have 70 million users[24]. According to Webnoize Inc., a digital media research firm, Napster users had downloaded 2.79 billion songs during its peak[25]. The success of Napster concerned both the Recording Industry Association of America (RIAA) and some high profile musicians. In late 1999, the RIAA brought a suit against Napster in Federal court in the U.S. alleging copyright infringement. The rock group Metallica also sued Napster for copyright infringement and racketeering. Rap musician Dr. Dre also filed suit.

On May 5, 2000 U.S. District Judge Marilyn Hall Patel made a ruling that Napster does not fall under the protection of the *Digital Millennium Copyright Act*. This Act, passed in 1998, defines rules for copyright infringement and penalties for piracy[26]. A further blow to Napster came when Patel granted an injunction on behalf of the RIAA and shut down Napster on July 26, 2000. Two days later, the 9th U.S. Circuit Court of Appeals stayed the lower court injunction. In the fall of 2000, Napster announced a deal with Bertelsmann AG in which Napster would become a partner with the music distribution giant, and help develop a membership-base that would pay royalties to recording artists for music downloaded through their network. In consideration of the deal, Bertelsmann agreed to drop their suit against Napster and to provide their music catalogue to Napster for archiving and organisational purposes. This deal is the first of several by Napster to make their service legitimate. However, before others were made, the RIAA won another victory on February 12, 2001 as the 9th Circuit Court of Appeals made a ruling stating that Napster must prevent its subscribers from gaining access to copyrighted material[27]. In another move towards legitimacy, Napster claimed on March 2, 2001 that it would install software to block trading of a million songs that had been identified by record companies. In spite of these concessions, in July 2001 Napster was required by the courts to halt its free file sharing service.

How big is Gnutella?

An analysis by Borland[28] estimates that 3.05 billion files were shared on Gnutella in August 2001. To corroborate this data, we accessed the Gnutella network between 10-23 October 2001. Logging on at different times of the day, throughout this period we discovered a tremendous variation in the amount of data being shared. The number of files shared ranged between 115,000 and 21 billion, with a mean of 4.3 billion files. The mean amount of data shared throughout the study period was 6.1 terabytes.

The use of Gnutella and similar P2P technologies presents bandwidth problems for Internet service providers (ISPs) and institutions like universities who may see their networks slow due to increased network usage. Several universities have disallowed the use of Napster or other P2P software for this reason. As early as the summer of 2000, more than 100 schools blocked access to Napster[29]. The University of California Berkeley recently limited the amount of bandwidth that can be used in their college dorms, largely because of slowdowns associated with P2P file sharing[30]. For example, the University of Saskatchewan's Arts and Science computer labs have a policy that forbids users from downloading any software applications. Simon Khalaf, a developer of file sharing products for Novell, argues that ISPs will have to crack down on peer-to-peer services as their customers are paying for bandwidth that is supposed to be dedicated to the World Wide Web. In theory, the World Wide Web gives ISP's the opportunity to maximise their resources. While users are viewing a particular website, the network is utilised by others. In effect, users of the World Wide Web share resources in terms of how packets of information are distributed throughout the network. With peer-to-peer sharing, a steady stream of data is sent between a user and peer sharing data. The gaps are less frequent, and bandwidth requirements increase. Additionally, the cost of providing the bandwidth necessary for hard-drive based services is prohibitive[31]. It is likely that several different kinds of institutions will have to deal eventually with the challenges posed by peer-to-peer sharing. These challenges include not only network resource issues, but how best to deal with the dissemination of copyright protected and contentious material, and issues of legal liability. We now turn our attention to the issue of pornography on the Internet, and the peer-to-peer sharing of pornographic video files.

Previous studies of pornography on the Internet

There have been relatively few studies of pornography on the Internet. The first study of pornography in Usenet was by Mehta and Plaza[32]. In April 1994, Mehta and Plaza analysed 150 randomly selected images from 17 alternative newsgroups. Since the National Science Foundation of the United States had just stopped administering the central "backbone" of the Internet, and new rules regarding commercial services would soon replace the previous "acceptable use" policy, Mehta and Plaza were interested in seeing how commercialisation influenced the type and amount of pornography available. Of the 150 images analysed, their study revealed that 65% were of non-commercial origin, 81% were colour rather than black and white, and 92% were digitised photographs instead of cartoons or drawings. The most prevalent themes they discovered were close-ups (43%), images with an erect penis (35%), fetishes including lingerie and high-heeled shoes (33%), and masturbation (21%).

Mehta and Plaza were also interested in discovering whether there were differences in the type of material posted by individuals or commercial outlets. They analysed the prevalence of themes by source and discovered that commercial distributors of pornography used Usenet to advertise their products and services. Mehta and Plaza concluded that commercial vendors of pornography were willing to take risks by posting explicit images so as to attract customers to their pay-per-use services. In an era of weak regulation, such activities were low in risk, while the potential benefits of free advertising in Usenet were significant.

Another study of pornography is the infamous Rimm[33] report. After publication, considerable debate over the study's accuracy and originality, as well as the ethics of the researcher were raised. Rimm claimed to analyse the descriptions given to 917,410 images found primarily on private bulletin board services. Using what he called "linguistic parsing software," Rimm analysed pornographic images based on their descriptions alone. His study coded only for the presence of dominant themes. Since most images contain multiple themes (e.g., oral sex with bondage and the use of a foreign object in the same image), Rimm's study tended to inflate the prevalence of certain acts, and underestimate others. Although still referenced as a legitimate study in several venues, the Rimm study is widely considered to be fraudulent.

A study by Mehta[34] explores 9800 randomly selected images from 32 Usenet newsgroups between July 1995 and July 1996. The study concludes that an increasing percentage of pornographic images in Usenet come from commercially-oriented sources, and that commercial sources are more likely to post explicit images. Pornographic images containing themes that fall under most obscenity statutes are more likely to be posted by non-commercial sources. By examining themes most commonly found in the sample, it was also concluded that the vast majority of images contained legally permissible content. Only a small fraction of images contained pedophilic, bestiality, coprophilic/urophilic, amputation and mutilation, and necrophilic themes.

The current study

The majority of studies done on the kind of pornographic material available on the Internet have concentrated on still images (e.g., .jpg, .gif format) and on distribution through Usenet. The current study extends methodology in this field by analysing the content of pornographic videos (e.g., .mpg, .avi, .wmf) found on Gnutella. Peer-to-peer sharing creates a new set of methodological challenges and opportunities that we turn our attention to in the methodology section that follows.

Methodology

Sampling

During the months of July and August 2001, we retrieved 1521 video files from the Gnutella network using a freely available software package known as Bearshare (version 2.1.0). When accessing a decentralised network and conducting a search, it is important to note that applications like Bearshare search for files within what is known as a "horizon." A horizon represents the range of computers sharing data, based on how efficient connections are between these computers and a set of servers involved in caching data. The horizon of sharing computers accessed through the network changes continuously. With Bearshare, and other Gnutella applications, users can specify how many hosts they wish to connect to, both minimally and maximally. A smaller number of hosts mean a narrower horizon with fewer computers sharing data. Setting your software to include a larger number of hosts expands the horizon. It is necessary to balance the size of the horizon with the desired efficiency of the search. For a large horizon with efficient searching we selected a range of hosts between 12 and 15. Using a Pentium III machine (866 MHz, 256 Mbytes RAM), connected to a high-speed Internet account (University of Saskatchewan's coaxial), we were able to survey a large horizon and download approximately 25 video files per day over the 60 day study period.

The choice of words used to search for these files is critical. Since the searching performed by applications like Bearshare functions like a search engine, it is easy to introduce biases in the sampling process. For instance, entering a keyword like "teen" will result in several thousand files being found at any one time. The labelling of files available for sharing is somewhat idiosyncratic and follows few known conventions. Unlike sampling in Usenet where the entire set of files within a newsgroup can be sampled using random proportionate sampling techniques like those developed in Mehta and Plaza[35] and Mehta[36], the existence of a horizon where only files invoked by a keyword become available is problematic. To minimise the introduction of such biases, and to expand the pool of words used in the search for video files, we used a unique feature in Bearshare. Bearshare allows users to see, in real time, the search words being entered by other users in the horizon. A list of these actual key words scrolls by on the screen. Since several hundred key words may pass through a particular horizon in less than a minute, pausing of the key word flow is useful. This feature of Bearshare allows researchers for the first time, to our knowledge, to examine the nature of content being exchanged and the demand of users for particular types of content. Using paused segments of this flow of key words, we identified (subjectively) 25 key words that were likely to be linked to a search for pornographic material (e.g., lolita, sex, porn, blowjob, facial etc.). These identified key words were used on a session-by-session basis to search for video files. To ensure consistency of our sampling throughout the study period, we stopped our search after 30 seconds. A random number generator was used to extract a particular file from the range of video files identified by key word.

The original sample of 1521 video files (13.4 gigabytes in total) was sub-sampled so as to reduce further any biases. We randomly selected 1-in-3 from this set to yield a final sample of 507 video files.

Coding

Based on coding schemes developed in Mehta and Plaza[37] and Mehta[38] we performed a content analysis of the video files. The following categories were included in this analysis (see Table 1):

Table 1: Categories used in the content analysis of video files

Bestiality
Extreme depictions of bondage, discipline or rape
Depictions of mutilation or necrophilia
Pedophilia: depictions of sexual activity (or an emphasis on the genital region) of pre-pubescent children
Urophilia or coprophilia

Anal sex
Cunnilingus
Fellatio
Homosexual sex: male with male or female with female
Visible signs of orgasm (ejaculate)
Vaginal penetration
Use of foreign objects (e.g., vibrators, dildo)
Length of video (in seconds)
Size of file (in megabytes)

Results

To assist in the interpretation of results, we divided the data into two broad categories: (1) themes generally considered obscene or illegal; and (2) themes not generally considered obscene or illegal. The following themes are likely to fall into our first category under the *Criminal Code of Canada*[39]: bestiality, extreme depictions of bondage and discipline or rape, mutilation and necrophilia, pedophilia and urophilic/coprophilic imagery. Table 2 summarises our findings.

Table 2: Frequency of themes by percent

Generally considered obscene or illegal	Percent
Bestiality	3.6
Bondage/Discipline/Rape	3.7
Mutilation/Necrophilic	0.2
Pedophilic	3.7
Urophilic/Coprophilic	0.8
Not generally considered obscene or illegal	
Anal penetration	9.7
Cunnilingus	8.3
Fellatio	42.4
Homosexual	7.5
Ejaculate	31.6
Vaginal penetration	23.1
Use of props (e.g., dildos, vibrators, etc.)	7.9

The mean length of video was 62.3 seconds (range: 1-23065 second) with a mean size of 6.3

megabytes (range: .1-378 megabytes).

To assess how length (in seconds) and size (in megabytes) of videos were related to thematic categories, two stepwise multiple regressions (using dummy variables for the independent category variables) was performed. For the dependent variable length, the presence of fellatio and cunnilingus were significant independent variables (see Table 3).

Table 3: Regression model for dependent variable length

	Unstandardised Coefficients		Standardised Coefficients	t	Significance
	B	Standard error	Beta		
Constant	42.79	8.03		5.33	.0001
Fellatio	35.86	12.29	.13	2.92	.004
Cunnilingus	52.50	22.00	.11	2.39	.017

For the dependent variable size, only fellatio was significant (see Table 4).

Table 4: Regression model for dependent variable size

	Unstandardised Coefficients		Standardised Coefficients	t	Significance
	B	Standard error	Beta		
Constant	4.78	1.10		4.33	.0001
Fellatio	3.60	1.69	.09	2.13	.034

Is pornographic material distributed in peer-to-peer networks different from material available in Usenet or on the web? Since no published studies of pornography on the World Wide Web exist, a direct comparison of our data from Gnutella with the web is not possible. However, we can compare our results with studies of pornography in Usenet. The Mehta and Plaza[40] and Mehta[41] studies of pornography in Usenet give us a reasonable foundation for comparing the prevalence of certain pornographic themes across Internet applications. Although some differences are likely to be due to time periods considered, similarity of coding schemes makes possible a general comparison. Due to the small sample size of the Mehta and Plaza[42] study, we only consider here the Mehta[43] study for comparative purposes (see Table 5).

Table 5: A comparison of the current study with Mehta[44] for categories common to both studies

Category	Mehta (2001)	Current
	Percent	
Bestiality	3.1	3.6
Bondage/Discipline/Rape	3.5	3.7

Mutilation/Necrophilic	0.2	0.2
Pedophilic	4.4	3.7
Urophilic/Coprophilic	0.7	0.8
Anal penetration	2.8	9.7
Cunnilingus	3.3	8.3
Fellatio	19.0	42.4
Homosexual	10.1	7.5
Ejaculate	13.4	31.6
Vaginal penetration	14.5	23.1
Use of props (e.g., dildos, vibrators, etc.)	N/A	7.9

Discussion

Our data suggest that the availability of pornographic video files, generally considered obscene or illegal, constitute a relatively small percentage of the overall set of video files being shared through Gnutella. The vast majority of video files shared represent themes commonly found in other sources of pornography (e.g., VHS format, magazines). However, the ease with which this material can be accessed and the sheer volume of data flowing through the network may be a concern for some individuals. Although video files defined as pedophilic in nature represent 3.7% of the sample, due to the millions of files being exchanged, this represents a sizeable number. To lend some support to this claim, we monitored a website known as Gnutellameter. Gnutellameter captures and analyses data exchanged in Gnutella and provides summaries of key words most commonly entered by users. Gnutellameter updates these summaries every 50 minutes. For instance, at 9PM (CST) on October 30, 2001 a summary on the Gnutellameter website of the top 100 keys words lists 32 adult key words. In the top 10 key word summary, 6 are adult-oriented searches (e.g., #3 porn, #5 teen, #6 lolita, #7 rape, #9 preteen, #10 anal). The first and second ranked key words were respectively divx and Windows XP, while the fourth ranked was for a variation on divx (divx.avi) and eighth was the movie Shrek. Based on Gnutellameter's summary data it is clear that the most commonly searched for files on Gnutella are either copyright protected software, movies encoded in divx format, and pornographic material, with a very strong emphasis on both child and hebephilic (sexual attraction to pubescent adolescents) pornography.

The frequency data for themes not generally considered obscene or illegal show that a very large number of video files depicting fellatio (42.4%) and visible signs of orgasm (ejaculate) (31.6%) predominate. Since file sharing in peer-to-peer networks represents the interests of users, it is very clear that users of Gnutella are exchanging pornographic video files containing these themes in disproportionate amounts. The two regression analyses performed also support partially this assertion. In the first regression (Table 3), length of the video can be predicted by the presence of both fellatio and cunnilingus. In the second regression (Table 4), the size of the file can be predicted by the presence of fellatio. The size of a file is an indication of its length in seconds, quality of encoding and format (e.g., .avi, .mpg). Clearly, the sharing of pornographic video files is heavily influenced by the desire of users for longer, better quality video files containing oral sexual themes.

A comparison of frequency data between the current study and the Mehta[45] study shows that for themes generally considered illegal or obscene, very little difference exists. There is a surprising degree of similarity in terms of percentage between these themes over time, file format (video v. still) and Internet application (e.g., peer-to-peer v. Usenet). Although a direct comparison of themes is somewhat problematic due to differences in format (e.g., a video file has more opportunity to

introduce a greater number of themes due to its length and multiple images), some trends for themes not generally considered obscene or illegal are evident. The most striking difference between the two sets of data can again be identified by the dominance of fellatio and ejaculate in video files.

Early use of peer-to-peer networks like Gnutella probably follows the pattern of adoption common in many technologies. Younger, males with a high-degree of comfort using information and communication technology[46] are likely responsible for rapid growth of Gnutella. These early adopters are also the same population targeted by the pornography industry. Consequently, it should not be surprising to find pornographic material in Gnutella. The same general pattern can be seen in a range of technologies. Anecdotally, it is reported that early users of the VCR and satellite dish technology created a market for these technologies by purchasing a significant number of pornographic videotapes and access to adult-oriented programming. If the early adopter model applies to Gnutella, it is likely that the nature of material exchanged through this network will shift to match the interests of a more heterogeneous population of users. Based on an examination of Napster, this suggests that peer-to-peer sharing will increasingly involve an exchange of material likely to be copyright protected. Although likely that pornographic material will continue to remain available, a more diverse set of users will search for digital music and videos, as well as proprietary software. In a sense, the early adopters of Gnutella are helping to work out some of the problems associated with peer-to-peer sharing by exchanging pornographic material. Later users of this technology are likely to have a more robust (in terms of network issues like bandwidth and stability) system and access to a network that has survived (perhaps temporarily) the legal challenges associated with peer-to-peer sharing of copyright protected material.

Conclusion

Use of the Gnutella network to share data is growing rapidly. On any given day, millions of files containing pornographic or copyright protected material are exchanged. Early attention to the sharing of copyright protected material focused on identifiable targets like Napster. As stated earlier in the paper, Napster was used exclusively for exchanging digital music. Being a centralised service, Napster was easily targeted for legal action. Decentralised peer-to-peer sharing applications are a tougher target for such actions.

Many of the applications used to access Gnutella facilitate the exchange of copyright protected music and software, as well as pornographic material (which may or may not be protected by copyright). The recording and motion picture industry associations, along with artists, are likely to launch legal challenges against individuals identified as top-sharing peers. Internet service providers may also be included in any such challenges. It is unlikely that similar kinds of challenges will be mounted for disseminating pornographic material through these networks. For several years now, pornographic material, both copyright protected and non-copyright protected, has been widely available in Usenet, World Wide Web, FTP sites, etc. The legal challenges that may come along will probably have more to do with the nature of this material (its content) than its status as intellectual property. Also, such actions are likely to have a significant impact on how the Internet unfolds in coming years. Will the Internet become a tool for democratic dialogue and a forum for a revitalisation of what Jurgen Habermas[47] called the "public sphere"? Or will it become the electronic equivalent of a shopping mall with accelerated convergence with traditional broadcast media (e.g., WebTV)? Clearly, decentralised peer-to-peer sharing, and its role in determining the future course of the Internet, poses a range of social and legal challenges that we encourage legal scholars and social scientists to investigate.

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* Back Dr. Michael D. Mehta is Associate Professor of Sociology at the University of Saskatchewan. He specialises in the sociology of cyberspace, environmental sociology and risk communication and perception.

** Back Don Best is a M.A. student in Sociology at the University of Saskatchewan. His areas of interest are in information and communication technology. His thesis examines the political economy of search engines.

*** Back Nancy Poon is a Ph.D. student in Sociology at the University of Saskatchewan. Her areas of interest include criminology, penology and corrections, and Aboriginal women in the criminal justice system.

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1 Back M. Poster, *The Second Media Age*, (Cambridge: Polity Press, 1995).

2 Back See generally B.D. Loader, ed., *The Governance of Cyberspace*, (London: Routledge, 1997).

3 Back D.J. Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature*, (London: Routledge, 1991).

4 Back See generally M. D. Mehta, & E. Darier, "Virtual control and disciplining on the Internet: electronic governmentality and the global superpanopticon" (1998) 14 *The Information Society*, 107.

5 Back S. Varone, & C. Rytz, "Peer-to-Peer Networking and Perspective" (2001) 79:4 *Comtec*, 3 at 4.

6 Back G. Fox, "Peer-to-Peer Networks" (2001) 3:3 *Computing in Science and Engineering*, 75 at 76. B. Delaney, "The Power of P2P" (2001) 8:2 *IEEE Multimedia*, 100 at 100.

7 Back Delaney, *supra* note 6 at 100-101.

8 Back *Ibid.* at 101.

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