BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	MB Docket No. 02-230
Digital Broadcast Copy Protection	)	

REPLY COMMENTS OF
EDWARD W. FELTEN

My name is Edward W. Felten. I am an Associate Professor of Computer Science at Princeton University. I have published more than fifty papers in the research literature, and two books. My research specialties include Internet software and anti-copying technology. I have served as an advisor to the U.S. Government in several contexts. For example, I was one of the lead technical advisors to the Department of Justice in the Microsoft antitrust case, as well as the lead technical expert witness for the DOJ in that case. I also serve on the Information Science and Technology advisory committee to the Defense Advanced Research Projects Agency. A full copy of my curriculum vitae is available online at http://www.cs.princeton.edu/~felten/FeltenCV.pdf.

I submit these comments to call the Commission's attention to some erroneous technical assertions made in the initial comments filed by the Motion Picture Association of America *et al*. (hereinafter, "MPAA"). Specifically, MPAA claimed:

> [Digital Television (DTV) signals are] subject to an extraordinarily high risk of unauthorized redistribution. Once received in the home, digital broadcast television content can easily be redistributed via retransmission over networks like the Internet by such means as rebroadcasting, hosting files on a web server, or peer-to-peer file trafficking. Such unauthorized redistribution can be accomplished without downloading any special software … [and] without any complex technical skills whatsoever. For example, all a person has to do is to

> select “Record” while watching TV on his or her computer using a TV tuner card, and then save the file to a publicly accessible folder on his or her hard drive, where it can be illegally redistributed to anonymous users via peer-to-peer file trafficking. Or that person can easily e-mail the file as an attachment to an unlimited number of people. Or he or she can simply place the recorded file on a personal webpage for unauthorized redistribution to others on the Internet.

(MPAA Comments, p. 7)

The MPAA’s Reply Comments carry on in this vein, characterizing Internet distribution of pirated DTV content as “instantaneous, effortless and costless” (MPAA Reply Comment at p. ii), as having “no delay … [and]no significant transaction costs”, and as allowing a pirate to “redistribute … works to the entire planet instantaneously” (MPAA Reply Comment at p. 11).

As a technical matter, these claims are simply incorrect – a significant investment of time, effort, and expense is required to capture and redistribute DTV signals in this manner. I call the Commission’s attention to these errors because the erroneous assertions underlie MPAA’s entire argument in favor of regulatory action by the Commission.

I understand that Mr. Raffi Krikorian intends to submit comments to the Commission making points similar to mine. I have reviewed a draft of Mr. Krikorian’s submission and believe it to be generally accurate and consistent with my submission.

Analog vs. Digital Piracy

To make the discussion concrete, consider the following scenario. A movie is being broadcast on television, and the broadcast lasts three hours (including commercials). A would-be pirate, not deterred by copyright law, wants to record and copy the movie and to send the copy to a friend.

Consider the pirate's options. He can record the movie on a VHS videotape and mail the videotape to his friend. This takes a few minutes of effort and costs about four dollars (two dollars for the blank videotape and two dollars for mailing).

Alternatively, following MPAA's advice, he can save the movie to the hard disk drive of his personal computer (PC). A three-hour movie, in ATSC format, requires about 26 GB (i.e., 26 billion bytes) of storage. Few if any home users have 26 GB of free space on their hard drives, so the pirate will first have to buy an extra hard drive for his computer. A 30 GB hard drive costs about $80; and his friend will also need an $80 hard drive in order to receive the pirated movie. (This assumes that both of them have the technical skills required to install a new hard drive without damaging their PC; otherwise they will have to pay for installation as well.)

MPAA's Web Piracy Scenario

Now, having stored the movie, our pirate must somehow transmit it to his friend. MPAA suggests this might be done by hosting the file on a web server. No typical user would have access to a web server that allows 26 GB files, so the pirate will have to contract with a commercial web hosting company to host the web server, and he will have to select a hosting plan that allows storage of a 26 GB file and at least 52 GB of total transfer bandwidth (26 GB to upload the file and another 26 GB for his friend to download it). This will cost at least $20 from a reputable provider. The upload and subsequent download of the file will take about five days in total.

To sum up, the MPAA's web server piracy scenario costs the pirate about $180 and takes five days.

MPAA's Email Piracy Scenario

Alternatively, the MPAA suggests emailing the file as an attachment. If the pirate does this, his email software will first make a copy of the video file, translating it

into the format (known as "MIME" or "Base-64") used for email attachments. MIME-format files are 33% larger than the original files from which they are translated, so the MIME-format file will be 35 GB in size. The pirate will therefore need 61 GB of space (26 GB for the original file, plus 35 GB for the MIME-encoded copy), and this raises the cost of the hard drive he must buy to about $125 (plus another $125 for his friend).

On top of these difficulties, the email system will not transmit 35 GB files. Most providers put a limit of 10 megabytes (i.e., 10 million bytes) or less on each email message, requiring our pirate to break the file up into at least 3500 separate email messages, each containing about 0.03% of the MIME-encoded file. Even if the pirate has the patience to create 3500 separate email messages, and even if his friend has the patience and skill to reassemble them back into a single file, the transmission process will take several days at best. Most likely, it will take much longer as the friend's incoming mailbox will overflow and messages will be lost, requiring many retransmissions.

To sum up, MPAA's email piracy scenario is probably impossible for ordinary users to pull off. Even if it did somehow work, it would cost the pirate about $250 and would require several days of elapsed time.

MPAA's Rebroadcasting Piracy Scenario

Alternatively, MPAA suggests that the pirate might "rebroadcast" the captured video file. It is not clear what this means. Certainly the average user, with no special equipment and no special technical skills, would not be able to broadcast a television signal through the airwaves. The Internet does not support the postulated type of "broadcast" or "rebroadcast" functionality. Regardless of what "rebroadcast" means, it would require at the very least the purchase of two $80 hard disk drives; and any Internet means of transmission would take about three days to transmit a 26 GB file over a typical home broadband connection.

MPAA's Shared Folder Piracy Scenario

Another scenario suggested by MPAA has the pirate put the file in shared folder, which he then makes available to his friend. This will not work if the pirate or his Internet Service Provider (ISP) use a security firewall to protect the pirate from hostile attacks – many firewalls block outside attempts to access shared folders, since such attempts typically represent security breaches.

Even assuming no firewall interferes, sharing a file in this way would violate the Terms of Service of a typical home broadband ISP contract, as those Terms usually forbid the user from running a server on his home machine. Many ISPs police their networks for such violations; and a violation involving such a large (26 GB) file transfer would be very conspicuous.

Assuming that there is no firewall, and that the ISP somehow fails to notice the Terms of Service violation, this approach might work but would require the purchase of two $80 hard disk drives and about three days of elapsed time.

MPAA's Peer-to-Peer Piracy Scenario

The last piracy approach suggested by MPAA involves the use of a peer-to-peer file sharing system to transport the file from the pirate to his friend. This suggestion relies on the dubious assumption that it is even feasible to transmit a 26 GB file over such a system. Assuming that it is possible, this approach, like the others, requires the purchase of two $80 hard disk drives and requires about three days of elapsed time.

Summary of MPAA's Piracy Scenarios

All of MPAA's piracy scenarios are expensive and time consuming, with a cost of at least $160 and elapsed time of days required to transmit a single three-hour movie from one pirate to one recipient. Transmitting the pirated file to more recipients, or

transmitting more files to the same recipient(s), would raise the cost and the elapsed time to even more prohibitive levels.

By contrast, a traditional analog TV signal can be pirated much more easily by sending a VHS videotape through the mail. This takes about as long as the digital piracy but costs only four dollars and requires much less technical expertise.

I conclude that, contrary to MPAA's assertions, DTV content is currently ***much harder and more expensive*** to pirate than analog TV content.

Effect of Technology Change

MPAA may argue that technology change will eventually lower the cost of DTV piracy to the point that such piracy becomes practical. This claim is misleading, for at least four reasons.

First, not all of the barriers to DTV piracy can be removed by technological speedups. Firewalls will still block file sharing; ISP Terms of Service will still ban servers; and the ten-megabyte limit on email message size is unlikely to be lifted. These and other practical impediments to DTV piracy are unlikely to change soon.

Second, DTV piracy is currently so difficult and expensive that incremental improvements to technology will take a very long time to make them practical. Even if the cost per byte of disk drive storage is cut in half with every new generation of disk technology, it will still take at least five technology generations before hard-drive storage of DTV-format television will be cost-competitive with today's VHS videotape. I also note that, as other submitters (including Public Knowledge and Consumers Union) observe, the "last mile problem" makes major increases in the bandwidth of home broadband connections quite unlikely.

Third, piracy of low-resolution video will always be easier to perpetrate, and harder to detect, than piracy of high-resolution formats. Larger files are more expensive and more difficult to handle, so that even Internet pirates will always have an incentive to pirate low-resolution video.

Fourth, and most important, MPAA's technology projections, even if accepted at face value, can prove *at most* that DTV piracy will some day be as cheap and easy as low-res, non-DTV piracy. They do not – and cannot – show that DTV content is somehow easier to pirate than non-DTV content. Accordingly, they do not support MPAA's argument that the advent of DTV poses *new* piracy risks that require new regulation.