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The Impact of Digital Audio Compression on Society

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Abstract

Since the mid-90s, the audio CODEC has enhanced the distribution and ease of access to music. Along with this, the transfer of illegal audio CODECs and MP3s has exploded into colleges, businesses, and homes. However, this is a convenience that has steadily taken away from music industry profits and power. This project explores the effects of the audio CODEC in today's society, and looks forward to predict its future impact on artists, the record industry, and technology.

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1 Introduction

This project will explore the perspectives of all interested parties and examine the clash of business and technology in the area of audio compression. Audio compression has gained in popularity with the technological advances in data compression, while the growth of the Internet has permitted these compressed audio files to be distributed all over the world. For many, this change has been beneficial, but a major hindrance for others. New artists have enjoyed newfound exposure, and the consumer has gained with the ease of purchasing new music. However, the consumer has also abused this new technology by pirating music and distributing it via the Internet. The accessibility of these compressed audio files has caused the recording industry to lose profits to piracy and widespread distribution. However, in addressing these issues, the recording industry has taken legal action, but technology continues to press forward.

This is a topic that deals with the many controversies of digital music and the Internet's interaction with society and business. For the most part, technology is seen to be a positive in society, giving us access to knowledge, making our lives easier, and presenting us with more pleasurable conveniences. Nevertheless, issues and dilemmas are always brought up with the emergence of any new advancement, many of which we are never made aware. There are those that deal with the business world, from how one technology may rival or overlap another, or how another technology could give rise to a company and create business for them. Other issues may deal with society itself and how the common person has to alter his/her way of life to accommodate a new trend and technology. This project takes the new idea of compressed music and its Internet distribution, and looks at exactly how it affects and will affect all of the groups involved.

Throughout the century, in a time that has contributed so greatly to the musical revolution of our society, we come across a major step and turning point once again. Past issues and controversies have always dealt with the changing of styles or ideas in music, or how the music can be recorded, stored, and controlled for the enjoyment of listeners and protection of the music industry. For the most part, the music industry has always been in a controlled atmosphere, allowing expansion according to what the tastes of the artist and listeners are, and controlling the distribution of the music to fund the artists and producers. Now we face the beginning of the age of computers and a time where information of any kind, is available to anyone.

This juncture in music technology may perhaps forever change the course of the music industry. The distribution of music may change format and expand to a broader horizon and greater quantity of people. The recording industry will possibly even out, strengthening the smaller companies while initiating the demise of the larger corporations. In addition, artists' exposure may flourish, especially with up and coming bands, changing our everyday music and opening the world to all styles and genres of music.

1.1 Digital Audio and Computers

Although the compact disc was created in 1980 and made available in 1983 by Sony and Philips, looking from a hardware standpoint, the age of multimedia on the computer did not arrive until the early 1990's (Krauss). However in the late 1970's and throughout the 1980's, the development of the PC sound system had already started taking place.

1.1.1 History of PC Sound

One of the very first computers on the market for the average user with a built-in speaker was the Apple II, made available around 1980. Before this, hobbyists and programmers would utilize a system such as the Radio Shack TRS-80 to emit AM signals that would be picked up by a radio depending on what the computer was doing. Through the use of programming and its statements, the pitch could be varied to the point where simple one-note-at-a-time songs could be realized. This modest design was enhanced with the Apple II, as it could produce single note music by a combination of BASIC and assembly language programming. Programming simple one-note songs was a bit more straightforward than the AM radio method. Writing a program that very quickly jumped between two notes could create even a two-note song. This was used in a medley as well as an accompaniment (Calabrese).

As the Apple II grew increasingly popular, commercial programs became available. One of the most popular was the *Music Construction Set*, allowing you to create music by graphically entering music notes on a staff, which was quite a bit easier than programming the raw data from scratch. One could also buy plug-in cards for the

Apple II that produced FM synthesis sound — a big improvement over the computer's little built in speaker (Calabrese).

The next large leap in computer sound was the introduction of the Macintosh 128 from Apple Computer in the mid 80's. As an advancement in design, the Macintosh had four, built-in voice FM synthesizers, as well as built-in digital audio capability. Also, its graphical user interface was the perfect vehicle for commercial music programs, of which several good ones were written in the early days to take advantage of the Mac's FM synthesis. If a small $75 adapter was purchased for the Mac, it was even possible to record digital audio. It was not in stereo, and the sampling rate was fairly low, but the digital audio editing software had capabilities like cut and paste, mixing, reverb — not to far from what we use today for PC music design. A landmark in computer music software was a program called *Studio Session*, which was also released around the mid 1980's. Rather than use the Mac's FM synthesizer, it used digital recordings of instruments. You could then arrange songs using real life instruments and it sounded very realistic. *Studio Session* was the first wave-table synthesizer for a personal computer (Calabrese).

In the late 1980's, the IBM PC and all of its clones had quickly become more popular in terms of quantity sold, especially due to the advent of Macintosh's graphical interface in the operating system known as Microsoft Windows. Like the Macintosh, IBM and Compaq also began to regard the PC's speaker as something more than just a warning mechanism. The IBM PC-junior and all of the members of the PC family, made by Compaq, started shipping with what was called a quiet keyboard. This quiet keyboard did not make any mechanical noise per se, which some people found very annoying, but instead, these keyboards supplied their audible feedback to the user by making a clicking

sound on the PC's speaker. It was not perhaps quite as satisfying a sound as the mechanical click of the standard IBM keyboards at the time, but it had the advantage that it could be changed or completely turned off. Sound-wise, this internal speaker was no more advanced than the Apple II of ten years earlier (Krauss).

Using the PC to produce sound has come a long way since the days of the quiet keyboards, thanks in part to the computer gaming industry. An attempt to make computer games more realistic resulted in the development of sound cards in the late 80's, adding high quality FM synthesized music to the computer through a product known as the *Adlib*. Creative Labs then shortly after introduced their first sound card, the *Sound Blaster*. The *Sound Blaster* also had FM synthesis, which was compatible with the *Adlib* card, but it added 8-bit digital audio capability. This made the *Sound Blaster* the card of choice, and eventually *Adlib* faded out of sight (Calabrese).

The release of the 16-bit sound card in 1993 allowed the PC to play CD quality sound (assuming that the user had external speakers). The appeal of using a PC as a music platform increased greatly, not just with the gaming industry, but with the music industry as well (Krauss).

1.1.2 Analog to Digital Conversion

Sound consists of analog (continuous) signals as seen in smooth flowing waveforms. But the problem with computers is that they cannot handle continuous signals, as a waveform to a computer would be considered an infinite amount of data. This is why music must be broken down into a discrete representation of data, digital samples, which is a series of incremental numbers. The sound card of a PC comes into play here as it is comprised of an A/D converter and a D/A converter. The A/D converter

(analog to digital) is used to transform a sound from a microphone or another analog source into a digital bitstream, and a D/A converter (digital to analog) is used to convert the digital waveforms back into an analog domain for the speakers. Software works with the sound card to control the coding and decoding of the waveforms.

Computers digitalize sound waves by taking "snapshots" of that wave at regular intervals. The number of snapshots the computer saves for each second of audio is known as the sampling rate of the sound clip. This number is usually given in Hertz (Hz). For example, 10,000 Hz means that it was sampled 10,000 times per second, and a 1/10 second wave signal was sampled 1000 times (Krauss).

To picture the sampling process, mentally take a wave of any form, and divide it up by drawing a bunch of vertical lines through it. At each point where these lines cross the wave, draw a dot. The coding software at that point will record a binary number to best represent the height of each dot. When dealing with an 8-bit sound card, the binary number will be 8 bits long, and there will be 256 possible values (00000000 to 11111111) for each specific height. A 16-bit sound card will allow you 65,536 possible heights (Brain).

Now if you take all of the intersection dots, and connect them by straight lines, this is the digital representation of the wave. If the sampling rate here is too small, then the digital representation of the wave will be very boxy and have a difference known as the sampling error. But with a large enough sampling rate such as at 44,100Hz (the sampling rate of a CD), and a 16-bit sampling precision, the sound essentially seems "perfect" to most human ears (Brain). Shown below in **Error! Reference source not**

found. is a depiction of the sampling process, and how the overall curve becomes more and more accurate as the sampling rate is increased.

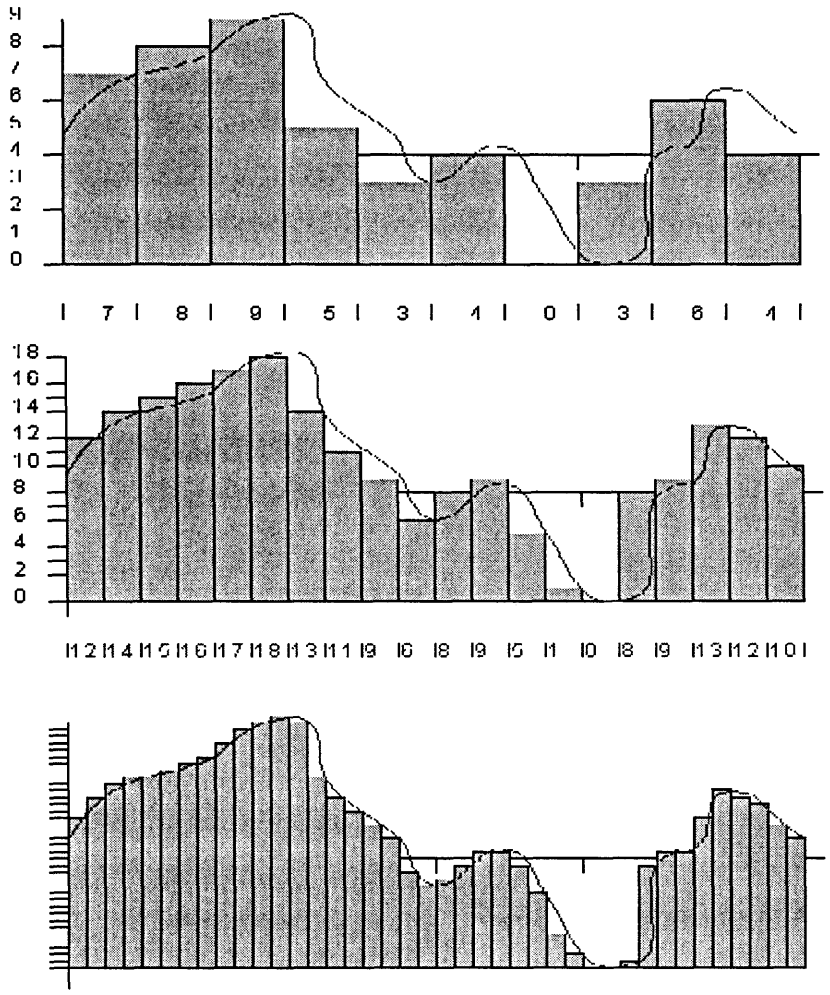

Figure 1: Sampling of an audio signal at three different sampling rates
Reference: www.howstuffworks.com

This is essentially the power behind the sound heard from the compact disc or other forms of digital sound representation like a DAT. Never, will the exact sound be heard as if it were live, but the ears can be tricked in such a fashion that they do not know the difference if the sampling frequency is high enough. Of course, with modern day technology, a piece of music can be sampled at a much higher rate than 44.1 kHz, but if

the ear will not recognize the difference, it is just a waste of data. The best possible sound at the lowest sampling rate is desired. This theory, as part of the world of psychoacoustics, is dealt with in even a larger fashion when compressing data and removing part of it and is explained in the next section.

Stereo sound is achieved by adding a second complete audio channel to the file, effectively doubling its size. What you have, in effect, is two similar audio files playing simultaneously. The slight differences between the tracks create the illusion of depth to the audio that we have come to associate with stereo. If you look at the size though of one 74-minute compact disc in stereo, you are dealing with 783,216,000 bytes! This is a lot of data to be stored on a computer or sent over the Internet, which has brought on a need for data compression and decompression (Krauss).

1.1.3 Data Compression

The term compression usually refers to the process of bit rate reduction in the field of Digital Signal Processing. Compression is required in applications where the storage or communications capacity available is smaller than the raw signal data rate. There are trade-offs between the complexity, compression rate, and the quality of the compression algorithm. The kinds and amounts of compression impairments that a listener will tolerate in speech, video, and audio applications mostly govern these trade-offs. In speech, large impairments may normally be ignored, while in audio a small impairment in bandwidth or nearly any audibly noticeable quirk is grounds to poorly rate the impairment.

1.1.3.1 Source Coders

Historically, the coding methods of compression have been based on mathematical methods using the same approach, removing redundant or predictable parts of the signal by creating a mathematical or statistical model of the signal source. The general types of these source coders are entropy coders, linear predictive coders, and filterbank coders.

In general, for an entropy coder, a statistical measure of the input signal is taken from past inputs by considering the chance that the sample or a sequence of sample will occur. After this measure is formed, a codeword is assigned for the input signal value, and is then transmitted. In elementary entropy encoders, the codewords are set and cannot be changed. More involved entropy coders may keep adjusting the codewords in parallel with the encoder (Jurgen).

Linear predictive coding creates a model of the device that generates the sound and transmits the model along with an approximation of the original signal. The model, calculated from the original signal, is used directly by the linear predictor. The remains of the original signal, not included in the model, are then calculated and transmitted along with the model. This coder requires a lower bit rate for transmission because the signal from the linear predictor is smaller than the original signal.

The filterbank coder uses a filterbank that imposes a constant set of models on the signal source and each sample is quantized and outputted separately. Since most signals have frequency shaping or a line spectrum, the filterbank coder can gain in bit rate relative to the PCM (Pulse Code Modulated) signal by coding the components in each bank appropriately (Jurgen).

1.1.3.2 Perceptual Coders

The perceptual coder uses a model of what the listener can actually hear and removes those components of the signal that the listener is unable to detect. Instead of removing redundant and predictable parts, the unperceived parts of the signal are removed. The perceptual coder is a lossy coder where noise is added to the original signal in a way that the listener does not identify it.

Use of psychoacoustic principles for the design of audio recording, reproduction, and data reduction devices makes perfect sense. Audio equipment is intended for interaction with humans, with all their abilities and limitations of perception. Traditional audio equipment attempts to produce or reproduce signals with similar fidelity to the original. More appropriately, the goal should be to achieve the fidelity perceivable by humans. Basically, the perceptual coder removes sound we cannot hear and only reproduces sound we can hear (Philips Electronics).

The threshold of hearing is constantly changed by the sounds heard. For example, an ordinary conversation under normal conditions can be heard easily. However, the same conversation accompanied by a loud noise, like an airplane flying by, is impossible to hear due to the distortions introduced to the hearing thresholds of the people in the conversation. When the loud noise is gone, the hearing thresholds return to normal. Sounds that are inaudible caused by changes in the hearing threshold are said to be masked.

This effect occurs in all aspects of sound, but it is particularly noticeable in music. A loud orchestra instrument will, more or less, make the sound of some other instruments inaudible to the human ear. When the music is recorded, however, all the frequencies are

incorporated into the recording. When it is played, the masked instruments will not be audible to the listener, so they might as well not be there. The parts of the recording that contain inaudible data can better be used for audible data. In this way, the amount of storage needed for the music is reduced without any noticeable loss of audio quality. (Philips Electronics). This perceptual coding is the technique employed by the MPEG standard.

1.1.4 MPEG

Many advances in digital technology allow digital audio and video to be used in an increasing number of applications. This increase led to the need for a common format for coding audio and video signals. In 1988, in response to this need, the International Organization for Standardization (ISO) established the Moving Pictures Expert Group (MPEG) to develop standards for coding moving pictures and the associated audio.

The MPEG standard was developed to provide digitally compressed full motion quality video for uses for low-end video and even for high end HDTV (High Definition television). The first output from this effort was the MPEG Phase 1 (MPEG 1) coding standard. It provided for bit rates up to 1.2 Megabits per second for video and up to 256 Kilobits per second for the two-channel audio. These bit rates yielded video quality comparable to a VCR and two-channel audio quality comparable to a CD (Jurgen).

In 1990, the second phase of MPEG's effort (MPEG 2) was started in order to create extensions to MPEG 1 to allow for more diverse input formats, higher bit rates from 3 Mb/s to 60 Mb/s for higher quality video, and digital audio at lower sampling frequencies in various multi-channel forms.

MPEG contains a multiplexed bitstream that consists of both a compression layer and a system layer. The compression layer contains the data for the coded audio and video signals, while the system layer allows for synchronous display of or multiplexing multiple bitstreams.

The system coding for MPEG 1 consists of one or more packs of bitstreams that share a common time base. For MPEG 2, the system stream of MPEG 1 is used only where there is lower possibility of the occurrence of errors. When the chance of errors is greater, a transport stream is used to combine the packs of bitstreams into a single stream in the error prone environments, such as transmission. (Jurgen)

1.1.4.1 MPEG Layers

In order to support many different applications with varying complexities, a three-layer concept was developed to appropriately match the task with the simplest coding to handle it. The Pulse Code Modulated (PCM) input audio signal is converted from the time domain to the frequency domain in all three layers using a 32-subband filter bank. The bitstream is coded using a psychoacoustic model in layers I and II. Layer I is intended for the simplest of applications, where the data rate does not have to be very fast. Layer II is a little more complex, by including an algorithm to remove redundant bit patterns found in the bitstream to compress the signal further than Layer I.

Layer III is the most complex of the layers. It generates a higher frequency resolution by using a hybrid filter bank in each of the 32 subbands that employs a linear transform to increase the frequency resolution 18 times higher than that of layer II. Other features that increase the compression of the MPEG coding of Layer III include non-

uniform quantization, adaptive segmentation, and entropy coding of the quantized bit samples (Baron).

Sound Quality	Bandwidth	Mode	Bit Rate	Reduction Ratio
Telephone Sound	2.5 kHz	mono	8 kbps	96:1
Better than	4.5 kHz	mono	16 kbps	48:1
Shortwave				
Better than	7.5 kHz	mono	32 kbps	24:1
AM Radio				
Similar to	11 kHz	stereo	56-64 kbps	26-24:1
FM Radio				
Near-CD	15 kHz	stereo	96 kbps	16:1
CD	> 15 kHz	stereo	112-128 kbps	14-12:1

Figure 2: Typical Performance of MPEG Layer III
Reference: http://www.zdwebopedia.com

Typical performance data for MPEG Layer III is provided in Figure2. Using MPEG audio, a typical data reduction of 1:4 can be achieved by Layer 1 (corresponds with 384 kbps for a stereo signal), from 1:6 to 1:8 by Layer 2 (corresponds with 256-192 kbps for a stereo signal), and from 1:12 to 1:14 by Layer 3 (corresponds with 128-112 kbps for a stereo signal), while still maintaining the original CD quality sound.

1.2 Audio Codecs

1.2.1 Background

With the increasing popularity of the Internet and its data transmission capabilities, the exchange of information, files, and software has become an integral part of everyday life. However, the demand for this exchange is expanding while the technology has its physical limitations. Most users transmit and receive data via the telephone line, limiting the transmission speed primarily due to the poor quality of the telephone line. Since the demand is ever increasing, data compression has become a common way to augment the amount of data that can be passed at a given transmission speed. The storage of data files has also been an important issue in this age of the computer, where our computer systems are limited to a particular amount of storage space whether it is on a hard drive or floppy disks.

When dealing with audio on the computer or on a compact disc, the size of the files, as stated earlier, can tend to be rather large. This poses a problem with the storage and transmission of audio files. With other files such as text files or j-pegs, these files can be compressed or 'zipped' as commonly known, into a smaller size. This luxury does not exist with the wave-file format since it already is in a fairly compressed state and is still of a very large file size. A zipping of such a file would essentially have no real effect on the compression of the wave-file.

With this all in mind, a new type of compression was developed for the use of audio files, eventually compressing them at a compression ratio of around 10 to 1. As explained in the last section, unlike other forms of compression, this was done by removing the redundant, predictable, and unperceived waveforms from the overall sound

file, leaving the listener with a quality extremely close to compact disc quality. This new technology then opened a huge door for the transmission of all audio recordings over the internet and throughout the world, and finally allowed the storage of many songs and albums on a computer without filling up all of the allotted memory.

As a major audio technology break-though of the computer age, this quickly became a topic of company financial gain, consumer rights, artist opportunities, and much controversy throughout the entire recording industry. With this compression technology starting in the consumer world, free distribution and trade of audio CODECs went wild in the beginning. Web pages of the thousands and downloading times of a few minutes for free made it sometimes easier and cheaper to find a song than going down to the local music store. Any song that could be put into digital form on a computer was available to anyone with a network service and basic Internet knowledge. The consumer was getting what they wanted and for free, two ideal situations for any listener of music.

The recording industries of the world, in light of this mass distribution of copyrighted music and losses in album sales, immediately went straight to the judicial system to crack down on this so-called 'piracy'. Laws were brought to attention and amended, and the distribution was declared illegal in many countries. This then led to the closing and fining of any web-site that was caught distributing the illegal music over the internet, pushing the distribution to a more underground state, away from the eyes of the industry where it remains today.

Perceiving the audio CODEC as being the wave of the future for the billion-dollar music industry, technology companies began to jump into the scheme of things in search of the technological solution to this controversy, or any invention that the industry would

mold itself around. It was a perfect opening in the industry, for which any company with a strong idea or solution could make a fortune for years to come. Concerning the issue of piracy, methods of security such as watermarking compact disc music or legally sold CODECs have been looked into and developed. Such a technology could separate everything that is illegal and legal for future control of all marketed music by the record industry once again. All a company would have to do is just work in their method of encryption to serve as the standard for all watermarking.

As far as hardware goes, with the audio CODEC slowly becoming the standard for all music, sold and pirated, the consumer is going to want a portable device to serve the same purpose as the CD player, car stereo, home theater, or walk-man. With a device that is convenient to the consumer and fills all of the needs of the consumer, a breakthrough in the hardware area could really spark the CODEC revolution and be very profitable for a tech company. These are two very enticing reasons for any company to jump into this technology in the past or at this time. However, some of the hardware that has been developed and placed on the market in the last couple of years, has brought up a controversy of its own. In a protest that filled the courts for months, the record industry placed several lawsuits upon the manufacturer of one particular portable CODEC player, claiming that it was promoting the use of illegal CODEC copies. This lawsuit was eventually shot down, allowing the player to be placed on the market. In the long run, a technology company will most likely have to find a way to compromise with the powerful recording industry, in order to avoid headaches and to maximize profits, as both groups, throughout history, have always worked hand in hand. However, with a compromise comes some sacrifice from both sides.

Another group that is directly affected by the technology of the audio CODEC is the artist group itself, since they are the source of all music. Lately, for the little known or up and coming bands, the transmission and production of audio CODECs has been a blessing for their exposure. In the past, all exposure has been through word of mouth or by what the recording industry wants to hear. With the ease of CODEC production from a recording, smaller recording companies can now come into the picture, and it is possible that the entire industry may financially even out. This would allow the little known band more exposure and would bring in a greater variety of music to the world. It seems this can only help music if it goes in this direction. However, it is quite possible that the recording industry giants will find a way to take over this technology as it did with the cassette tape or compact disc, and nothing will change.

To some, the Internet and CODEC revolution may look nothing greater than the transition from the record to the cassette, and the cassette to the compact disc, but the one huge difference here is the mass distribution. Cassettes could be copied and passed around personally by hand, but with the Internet, nothing is personal. Information is information, and it does not depend on where you get it, just the fact that you have obtained it, and for free. With this sheer fact alone, the distribution of music could increase exponentially, with losses to the same degree to the music stores, recording industry, and bands. In the same respect, the Internet could also be used as a tool for sales, as it has with so many companies in the last decade, only expanding the music industry and its potential. Where it will go, we will have to wait and see, but there are many signs from now and the past that can lead us to predicting what is in store.

1.3 Methodology

The four major players in this controversy include the record industry, technology companies, new artists, and consumers. With the current conflict and the lawsuits taking place, some resolve is necessary. This resolve will, of course, not make everyone happy, but a compromise must be reached to bring an end to this stalling of technology. We intend to research each group's perspective on these issues. Possible interviews with an RIAA representative, an expert of the compression technology, and an expert dealing with the piracy problem will allow for these perspectives to be developed. A survey of consumers may further help to recognize the demand for the products of this new technology and also the degree to which piracy is occurring and will occur in the future.

New artists appear to benefit from this new technology. They are able to have their music heard by more people and will probably earn a higher percentage of the profits of their music because they do not have to sign with a major record label. However, in the long run, will piracy and the availability of this music cause these artists to earn less money? Furthermore, if fewer profits exist for artists, what will happen to the quality of the music that is produced? The fact is that most musicians are in this line of work to earn a living. Fewer people would be motivated to write and perform music if the monetary compensation diminished.

Obviously, consumers benefit from this new availability. The Internet has enabled them to obtain the music they want at the click of a button. The music would also prove to be cheaper if it were distributed over the Internet as well. However, the consumer is responsible for pirating the music, the major downfall of the current technology. Is this piracy that much more damaging than the piracy that has occurred in

many other areas of the information society? The opposing sides of this issue will answer this question very differently but there is no doubt that pirating music has some effect on the music industry. The real question is if and how this effect will grow in the future.

The fact that technology companies have a good amount to gain by developing products concerned with this technology has been presented. However, it is also true that these companies are embracing certain aspects that are opposed by the record industry. The legal power of this industry could overpower many of these technology companies who do not possess the same power. How much opposition by the record industry can these companies handle? After a number of lawsuits, it may not be economically feasible for these companies to continue with their developments. Will the major powers of the technology world become a major player in this venture? Since the company that can create a standard format will enjoy the profits from the creation, it seems that each company interested in earning a profit will participate in this effort.

The RIAA will, of course, attempt to thwart any efforts that would cause them to lose money. If pirated copies of their copyrighted music are distributed, they stand to lose profits. In the same manner, if artists' dependency on the six record industry giants decreases, the members of the RIAA will stand to lose money. Is the RIAA stalling technology to help its members maintain hefty profit margins? It seems natural that companies would do whatever is possible to keep earning money, but it is also natural for companies to adapt to changes in technology in order to keep earning money.

The goal of this project is to analyze the arguments and justifications of the major players in this controversy. We will explore the financial interests of each party and the

impacts of possible outcomes concerning these issues. We will search for solutions and compromises to allow technology to continue moving forward and study where it is heading in the future, so that we may draw upon a conclusion as to where the music industry and all of the technology concerning this issue will be five, ten, twenty years from now. There are those telltale signs at this moment, and there are those lessons and similar issues that were dealt with in the past, all of which can be collaborated into one vision of the future.

2 Technology

2.1 Software

The ideas of digital compression, source coding, perceptual coding, and the creation of the audio CODEC have been technologies that have been in development since the late 1970's and early 1980's when digital audio was in its beginning stages. However, exposure to this new format of digital audio, for the average computer user, did not really occur until the middle to late 1990's. Therefore, it is a fairly new concept in the eyes of the world and the Internet.

Regarding advancements in technology, there have been a lot of developments, ideas, and breakthroughs in audio CODECs. Some of them have slowly come into the view of the common CODEC user, and many are still in production to be released at the right moment according to how technology, the consumers, and the music industries react to the concept of the audio CODEC. So, where is the CODEC and the software that surrounds it heading, and what exactly is available for this technology at this time?

2.1.1 MP3

Thanks to the Motion Picture Experts Group, otherwise known as MPEG, three formats known as layers have been produced in the evolution of the audio CODEC. As talked about earlier, MPEG layer-1 was the first in the series with a fairly low compression rate of 4:1 and a simpler perceptual encoding algorithm as the predecessor to MPEG layer-2 and MPEG layer-3. Layer-2 had a little more intricate psycho-acoustic perceptual coding format that decreased the bit-rate and increased the compression to

around 8:1. Then came the final and finest format of the three, MPEG layer-3, that maintained near CD quality sound, at a compression rate of 12:1 and at the lowest bit-rate of the three. (Fraunhofer-Gesellschaft)

The MPEG layer-3 format, co-developed by the Fraunhofer Institute of Germany and the University of Erlangen, under Prof. Dieter Seitzer in 1993, was published as the audio CODEC standard (Fraunhofer-Gesellschaft). MPEG layer-3 (which will be referred to as MP3), being the standard when the audio CODEC became popular, was quickly adopted and has been the only format known to most CODEC users. As a result of this, the average user of today has really never utilized any other audio CODEC format besides the MP3.

Digital representation of a song is a great advantage for those that prefer to store copies of their music archive on a computer. Under the MP3 format, a song can be compressed to almost $1/12^{th}$ of its normal digital size, only requiring around 1MB of hard drive space for 1 minute of music. (Lemos) With an average song being about 4MB in size, this is a fairly small size to account for on hard drives that can hold up to 19 gigabytes or more of data. Given storage space of this kind, the computer is not just a tool for playing a user's favorite MP3, it becomes a jukebox in a sense with the ability to hold an entire collection of music.

The MP3 does not just serve as a tool for converting music into digital form. It also allows for a file that is finally small enough to be transmitted over the Internet in a fairly short amount of time. On a network line, an average file could be downloaded in about four or five minutes depending on the traffic, while a dial-up connection download tends to be longer, more likely around ten or fifteen minutes. Either way, the MP3 has

proven to be a hot commodity on the Internet for many people, and its popularity has been a method of acquiring almost any song from any artist at any time. But is all of this copyrighted data transmission legal, and should users be allowed to make copies of their favorite copyrighted compact discs?

Passed by the Congress in 1992, the Audio Home Recording Act (AHRA) states that consumers are free to copy or "space shift" copyrighted music from one format to another for their own personal use. This means that a consumer has purchased the rights, when purchasing a CD, to make as many copies as they desire, in any format that they shall choose, as long as it is for personal use. This personal use, though, does not include the distribution, trading, or selling of this copied music without proper licensing and permission (Gross). Therefore, it is legal to create the MP3, but not to distribute it. In late 1997, under pressure by the music industry, President Clinton signed into law the Net Act (an acronym for No Electronic Theft). This bill then tightened the AHRA and existing language to explicitly identify the copying of copyrighted materials for distribution on the Internet, even if not for financial gain, as a felony crime. Furthermore, it outlined penalties "sufficiently stringent to deter such a crime" (Robertson).

However, these laws have done very little against the growing popularity of the MP3 on the Internet. The Internet is too wide and vast to be easily policed. There will always be ways around authorities in illegal file transmission, unless, somehow, the world's Internet is monitored and run by one company or being. But it is unforeseeable that this will ever happen, as the world's economy and its division of power would probably never allow for it. Compressed audio, from this point on, will be as much a part of the Internet as is anything visual on any web-site or advertisement.

As discussed earlier, in order to have audio on the computer, there must be an analog-to-digital converter and a digital-to-analog converter. From an analog microphone or sound recorder the sound goes to the digital computer, and then back to the analog loudspeakers. But to convert a wave-file to a compressed MP3 format, and back to a wave-file to be played by the computer, this must all be done through the aid of software, unlike the D/A and A/D converters, which perform there tasks mostly using hardware.

2.1.2 CODEC Encoders and Decoders

As the CODEC revolution has grown exponentially over the last half decade, almost all encoders and decoders available have been created to complement the MP3 format. The CODEC encoder/decoder is, in fact, the brains and bronze of the MP3, even though most think the MP3 is simply a kind of file. While a file type is only the form that the data is stored in, the actual encoding/decoding software compresses, includes additional information, and reads and breaks down all available information into a user-friendly format.

The Fraunhofer Institute of Germany, responsible for a large part of the research into the different layers of the MPEG format, created the first well known encoder, called *13enc.* This encoder gave the user the option of encoding a song from a compact disc or any wave-file at bit-rates of 16kbs (mono), 56kbs, or 112kbs and at sampling rates of 44.1kHz, 22.05kHz, and 11.025kHz. One problem that this encoder possessed was that the encoded mono files were half as loud as they were supposed to be, where to properly encode in mono, a stereo input file had to be cut it in half (Bonnett).

Fraunhofer created a user friendly windows interface decoder in *Winplay*. This initial design, seemingly primitive to some of today's features, gave the user all of the basic features that can be found on a portable compact disc player in a visual car stereo-like display. The ability to play, stop, pause, or skip to the desired song, fast-forward to any point in a song, adjust the volume and repeat a song are all available. These were all nice features and the player served its purpose for the most part, but it was only the start of the graphical user interface for CODEC decoders.

Around 1995, a small company in Sedona, Arizona, known as Nullsoft, jumped on the MP3 scene creating a decoder. This decoder, known as *Winamp,* had many of the same features as that of *Winplay,* but included a more impressive graphical interface and the option of a play-list. This was the first decoder to actually include the concept of a play-list, which was something that was greatly desired by MP3 users. (Frankel)

With a play-list, any user can act as a disc jockey, setting up a list or multiple lists of songs that are included in an archive. Prior to this, the only option was to click on a song every time it was desired to hear it, or to highlight the icons of a group of songs and drag it over to the decoder. With the grouping of songs, it would play any number of them, but it would always be in the order that the icons were organized, and would only play them once. Any manipulation of the icon grouping, or repetition of the icons (which were actually files) would take a good amount of time and was undesirable to any user. Thus, anyone who was familiar with MP3's, in 1995 and before, desired software that could incorporate a play-list. This, the eye-catching graphical interface, and the fact that *Winamp* came out during the start of the MP3 popularity boom, were all reasons why *Winamp* was and still is the most popular decoder available. It is estimated at this time

that over 20 million copies of *Winamp* have been downloaded from the *Winamp* webpage at a rate of 1 million copies each month (Frankel).

The way that *Nullsoft* cornered the market on the MP3 player at the right time encouraged many different companies to join the MP3 scene interested in both the encoders and decoders. Trying to grab a portion of *Nullsoft* and *Fraunhofer's* market, around 30 different brands of encoders have been created, over 100 different players were created, and a little over 20 encoder/decoder software packages are available at this time (Robertson). These are only all of the different brands and not versions of players/encoders. For every type, there could be as many as ten different versions that have been available to the market over the years.

Every MP3 user has his/her own preference of player and encoder (sometimes referred to as rippers), enabling all of the different software to coexist. For the most part, the basic features of all of the players/rippers are the same, and they carry the same underlying ideas. These ideas and advancements from the early versions include sound equalization of all of the different frequency bands as can be seen on the average stereo. They also include displays of frequency content and sound activated graphics for a visual music representation, minimization options to hide the player while working on other applications, MP3 browsers to aid the user in finding more MP3's, and different skins for the player and the user's preferences. Skins are a term for the visual design of the player where they can look like anything from a car stereo to a futuristic alien layout. This may not seem like that big of a deal, but it is often the only difference and major selling point for the many players that have all of the same basic features.

The encoder/decoder software package that is now widely available is a very nice option in choosing the desired MP3 software. Towards the beginning of the MP3 revolution, millions of people had the different players, but, in comparison, there was only a handful of people that actually did the encoding and all of their encoded MP3's were widely distributed on the Internet. But with the activation and enforcement of the NET Act, the widespread distribution by this handful of encoders was greatly cut down, and the average person was forced to encode on their own. With the current laws, a much larger percentage of users encode their own music, and would be more apt to download or purchase an encoder/decoder software package.

The majority of the software is freeware or shareware. This is mainly because many of these companies are trying to get their foot in the door and to attract a customer basis for future power and advertising advantages. The more customers at this time, the more people that will be exposed to their website and services, and the more money other companies will put forth in advertising to their website. Also, if one of these companies can somehow control a large enough portion of the market, it could mean millions of dollars in future earnings. All of this software, though, will mostly stay free as long as the audio CODEC stays free and is not controlled by record companies, major corporations, or industry standards.

2.1.3 ID3

The audio format, MP3, has no native way of saving information about its contents, except for some simple yes/no parameters like "private," "copyrighted," and "original home" (meaning this is the original file and not a copy). A solution to this

problem was introduced with the program "Studio3" by Eric Kemp in 1996, which would later be known as ID3v1 (version 1). By adding a small portion of extra data in the end of the file, one could enable the MP3 file to carry information about the audio and not just the audio signal itself. The placement of the tag, as the data was called, was probably chosen, as there were little chance that it should disturb decoders. (Nilsson)

In order to make it easy to detect, a fixed size of 128 bytes was chosen with the following layout:

Song title:	30 characters
Artist:	30 characters
Album:	30 characters
Year:	4 characters
Comment:	30 characters
Genre:	1 byte

The sum of the size of all these fields,30+30+30+4+30+1, equals 125 bytes, not 128 bytes. The other three bytes can be found at the very end of the tag, before the song title. These three bytes are always "TAG" and are the identification that this is indeed an ID3 tag. The easiest way to find an ID3 tag is to look for the word "TAG" 128 bytes from the end of a file. (Nilsson)

But, with the ID3 v1 tag, there were still some obvious limitations and drawbacks. For instance, since not every song title or artist name is 30 characters or less, such as with "P.I. Tchaikovsky's Nutcracker Suite Op. 71." This would cause abbreviations and chopped up remarks, which could both be annoying and confusing to a user. The other major drawback was that since the position of the ID3 v1 tag was at the end of the audio file it would also be the last thing to arrive when the file is being streamed. Any user would want all of the song information at the beginning of the song or decoding process, and not at the end. (Nilsson)

Both of these features were corrected in 1997 when Martin Nilsson & Michael Mutschler created ID3v2. First of all, the overall size of the tags increased greatly as the size allows the inclusion of text, graphics, lyrics and other forms of information in an MP3 audio file. Features include 1MB tags (and up to 256MB of total tags), multi-language and UNICODE (symbols that are used in other languages) support, streaming compatibility, and dozens of information fields. (Johnson) All of these capabilities could open up a huge world in the area of audio CODECs and the MP3. This information would all be moved up to the beginning of the file, unlike version 1 of ID3. Again, this would allow the players to identify any information before the actual MP3 file is played. All ID3v2 MP3 players will automatically skip over this information in the beginning to get to the actual MPEG headers, so the players will not time out during the search. With this, each part of an ID3v2 player will search out and identify the exact type of file or information that it is looking for. (Zoest)

ID3v2 is still the latest version of ID3 available at this time because there has not been a demand to expand its capabilities. Such features could be massive for a purpose such as a popularity meter to keep track of how many times a song is listened to over time and then use that information in the future to automatically construct play-lists of a user's favorite songs. Other information could include a place to buy the audio CD, fan club web page, and maybe even touring information or other music related items. (Robertson) No matter what it is used for, ID3 is a crossover from using the MP3 as just an audio tool, to having an informational music database on a computer.

Practically every form of MP3 software incorporates the ID3v2 tagging format today, as it has for the last few years and will continue to use. Some methods of song

tagging have been proposed by different organizations such as MP3.com (the leader in the world of the MP3), but all tagging is of course up to the individual doing the encoding. This could be a problem for decoders that are designed specifically to accommodate certain ID3v2 features where not every MP3 is encoded with those features. In a world with no real MP3 standards, any luxury is as good as what has been encoded into the MP3 file. This is one possible way how a company could be prosperous in the audio CODEC market. If they could propose a standard for encoding and decoding MP3's that gave certain amazing features and enticed every MP3 user, then it might be feasible that they could control a large portion of the market. This may be why there are more and more encoder/decoder software packages available to all users today.

2.1.4 MPEG-4 Structured Audio

Although the compression rate and sound quality of the MP3 is beneficial to its use on the Internet and has gathered a huge following of supporters, it is only really the start of the audio CODEC technology. Downloading time for most college students and their network connections may take a few minutes to download the average 3.5 to 5.0 minute song (which is around 1 MB per minute). But for the average user who has the standard 28.8kbs or 56kbs modem, this downloading time may take up to 15 minutes, or sometimes more. Attempting to download a song at peak Internet time frame could take as much as an hour. For this technology to expand into every household, and become a standard in the music industry and music sales, either the average person would need a faster connection, or the audio CODEC technology and its compression rate has to improve.

One possible solution is MPEG-4 Structured Audio (referred to as Structured Audio), developed by the Media Lab of the Massachusetts Institute of Technology (MIT). Simply worded, Structured Audio means transmitting sound by describing it rather than compressing it. This idea is not new, as it has been pondered for many years, but the Media Lab was the first to initiate a strong effort to make it a practical reality and a possible substitute to compressed audio.

Rather than transmitting sound as a "stream of bits," Structured Audio describes the sound in a flexible language and is then synthesized, or turned into sound on the user's computer. The description of the sound is much smaller and easier to transmit than the sound itself, and so this novel idea leads to much faster download times. For example, an average song in a wave-file may be 30 MB, or 3 MB with MP3. But with Structured Audio the song could be merely 300 kB in size. Figuratively speaking, this would allow 100:1 compression, and download times over a modem in a matter of seconds. (Reece)

Using synthesizing, a technology that has been around since 1983, Structured Audio also addresses limitations presented by traditional sound cards. Existing PC sound cards and transmission methods for synthetic sounds make use of only a single, fixed, method of sound synthesis. The Structured Audio method allows the description of any method of synthesis, or the creation of entirely new methods. When a Structured Audio file is downloaded, a set of "virtual synthesizers" is created which allow these new synthesis methods to be used for generating music. It does not designate a particular synthesizer as the best way to generate sound, instead, it designates a language for

describing synthesizers and any current or future synthesizer may be described in MPEG-4 Structured Audio. (Kahn)

While existing audio standards represent sound as a stream of bits, in Structured Audio content is stored and delivered as a computer program in a flexible language called Csound and then translated into sound on the user's computer. Because transmitting data, as a program, is far more efficient than transmitting streams of bits, this method enables a radical increase in the quality and efficiency with which sound is delivered. (Kahn) With this, Structured Audio will most likely prove to be the answer to the MPEG audio streaming desires, and possibly much more, too, such as replacing the MP3. Audio streaming is something that is found in applications such as Internet MPEG videos, Internet radio, and even website audio sampling of artists and speakers. Up to now, the quality of the audio in streaming has been almost comparable to listening to AM radio, due to slow steaming bit-rates and a low level of audio quality to fit these bit-rates.

2.1.5 MPEG-4

The Moving Picture Experts Group (MPEG) is made up of hundreds of researchers, engineers and industry experts from around the globe. MPEG is chartered with the development of industry standards for the compression and decompression, processing, and coding of moving pictures and audio. Following the wide-scale industry acceptance and implementation of the MPEG-1, MPEG-2, and MPEG-3 standards, the group is now developing MPEG-4 in partnership with the MIT Media Labs, AT&T, Sony, Dolby, and the Fraunhofer Institute, to be the next version of the MPEG standard. (Kahn)

The MPEG-4 standard, as the future "global multimedia language" will incorporate a coding and compression scheme known as Advanced Audio Coding (AAC) developed by the Fraunhofer Institute, along with newly developed Structured Audio in the future. Inspired by today's demand for multi-channeled sound, as in 5.1 channel Dolby (right, left, center, left rear, right rear, and subwoofer), AAC has set an unprecedented stage with the option of recording in 1 channel sound all the way up to 48 channels (Fraunhofer-Gesellschaft). Such a technology allows sound and signals to be broken up into as many channels as desired where audio objects may be given a location in a 3-D sound space. This gives a user the ability to customize a sound to fit the environment it is being played in, which could be the next big step in the movie theater sound industry. (Coenen)

AAC, although very similar in many ways to its predecessors, does have some key differences. Using a method known as Modified Discrete Cosine Transform (MDCT), and entropy coding, the filtering of the redundancy of sound has surpassed previous models and has made further improvement of the coding efficiency. This means clearer sound, and compression rates up to 16:1, compared to the 12:1 of MP3. Also, utilizing Temporal Noise Shaping (TNS), it shapes the distribution of noise in time by prediction in the frequency domain, benefiting from the fact that a certain types of audio signals are easy to predict. Voice signals in particular experience considerable improvement through TNS. (Fraunhofer-Gesellschaft) All of this ensures that MPEG-4 and all other formats equipped with AAC will be well prepared for future developments in the audio sector.

One of the big perks of MPEG-4, besides the obvious improved sound quality of the compression rates, will be tools that let people create single recordings coded with different tools, or synthetic and natural hybrid coding of information. Such technology will allow for the choice of the particular mix best suited to an environment. For instance, a listener might choose to hear a mix with muted highs and less reverberation when playing the song in their car. Amazingly, these mix options do not add to the song file size. MP4 will also have native intellectual property protection options built in (an issue that will be discussed in more detail later on). As another example, one could note in the MP4 file that one company owns the flute portion, another company owns the vocal, a third company owns the algorithms that are used to process the flute and a fourth company owns the algorithms that are used to mix all of these components together. (Reece) This will ensure that MPEG-4 is a standard that complies with all laws, other standards, and probably future regulations.

One of the other great benefits of MPEG-4 is that the user not only has the option of encoding and decoding in mono or stereo, but they would be able to incorporate a system similar to that of Dolby surround. Sound and signals can be broken up into as many channels as desired where audio objects may be given a location in a 3-D sound space. This gives a user the ability to customize a sound to fit the environment it is being played in. (Coenen)

Although, in December of 1998, MPEG-4 was declared as an international standard for audio and video, and the first versions of it were released, it is still in the process of being improved. (Fraunhofer-Gesellschaft) The MP3 is still the standard for audio, despite the improved technology, and will be until MPEG-4 can gain popularity.

But since the MPEG-4 format can accommodate all of the previous formats (MPEG-1 up to MPEG-3), all the user would have to do is download or purchase MPEG-4 software, and they can still run everything that they possess plus everything they would acquire in the MPEG-4 format.

2.1.6 AAC and MS Audio

In response to the development of the MPEG-4 standard, several other major companies have moved into the audio CODEC software scene in hopes of capturing the next standard in compressed audio that will supersede the MP3. AAC, developed by the Fraunhofer Institute in 1997, and recognized as being the next standard in audio digital compression, has led these companies forward in their development of a better encoder/decoder to replace the MP3. What differs from all of these AAC encoders/decoders is not in their compression and filtering technology, but more their watermarking, cryptography, and how they are marketing their products to entice the consumers, artists, and record companies. Cryptography, in audio, is a method of encrypting the compressed audio file in a language so that only a particular type of player/decoder can decode it. This technology, along with a few other quirks allows retailers to sell music over the Internet and aides in the control of piracy, which will be discussed in further detail later.

In March of 1998, AT&T, one of the companies that contributed to the development of AAC, was the first to actually develop a software system that could incorporate AAC. This technology called a2b delivers the highest rated, best sounding music currently available through digital distribution, producing a sound virtually

indistinguishable from the CD. At a 15:1 compression rate (or 96KBPS), the improvement makes downloads 25% faster than MP3 files. A 3-minute song takes up only 2.25 MB of memory and 7-9 minutes on a 56KBPS modem to download (9-12 minutes on a 28.8 modem). (Orr)

The a2b music format is based on three core technologies from AT&T Labs. Along with AAC, AT&T created the *CryptoLib Security Library*, which encrypts compressed music for secure transmission via the Internet; and *PolicyMaker*, an electronic licensing system which controls how music is distributed and used across the network. (Jakobsen) Both of these topics will be discussed later in more detail under the Secure Digital Music Initiative (SDMI), but serve as a start in the fight against piracy, and good advancements in the technology.

Another type of software available, with use of AAC and under SDMI, is the *Liquid Music System*. What began as a small company in Silicon Valley, Liquid Audio has slowly become one of the powerhouses in the software format battle. Although their encryption technology is not very different or more extravagant than a2b, they do posses a number of nice features. *Liquid MusicServer* utilizes standard protocols to deliver high-quality, scalable, Dolby-encoded audio and media over IP networks. The server can provide any number of audio streams from Unix platforms, Intel, and Windows NT platforms. *Liquid MusicPlayer* provides a media-rich musical experience which allows users to view art, lyrics, and credits as well as production, agency, and copyright information while listening to high-fidelity music on the Internet. *Liquid Express Delivery* provides a complete, secure solution for Web-based approval and delivery of broadcast-quality audio tracks. Media production professionals can exchange high-

quality audio files as easily as sending e-mail. Also, Liquid Express Library provides a secure solution for Web-based archiving and search and retrieval of professional audio content, including special effects and music. (Woods) Lastly, *Liquifier Pro,* as a mastering tool, is a professional encoding software that allows artists and record labels to prepare and publish professional-quality copy-protected music for purchase and delivery via the Internet. (Ryan) All of these reasons support why Liquid Audio is the first major software company to strongly adhere to the needs of the recording industry and online music sales.

Since 1996 (when the best encoding/decoding technology available was MP3), when both Liquid Audio and a2b were founded, a fairly large number of recording artists have released songs and albums through these two formats. This has enabled consumers to enjoy Internet singles and experience album promotions, and has been a low cost and effective method of advertisement for these popular and up-and-coming artists. In each format, artists have released album samples by the tens of thousands and songs by the hundreds of thousands, showing that it is not simply a fad but a start towards a standard in audio and the music industry. (Ryan)

With this new power in the audio and music world, both companies have also endeavored in making the use of their products more user-friendly to the music industry. These are solutions and ideas that enable audio production professionals to increase the speed and reduce the costs of production and distribution, while giving them more options and techniques for exposing their musical product. The more music companies that they can draw into the use of their products, the more power and financial stability they will have in the industry.

In January of 1999, a small company, Global Music Outlet L.L.C (GMO), also adopted the AAC format to create a new software CODEC audio system of their own. Not to be confused with MPEG-4, GMO (under great protest of those in favor of the MPEG-4 standard) created what is known as MP4. By combining the proprietary a2b format with an executable file, the resulting song file requires no additional software to play and cannot be used with any other audio application, which affords a certain level of security. This allows copyright owners to control the release of their material in a secure fashion. With the added executable file as part of the MP4 file, it would seem that the size would increase greatly and slow down downloading times, but MP4 still maintains a 16:1 compression ratio along with fast download times. MP4 also includes color-coordinated graphics, scrolling text, and digital watermarking similar to its competitors. One problem, though, with this format, is that each song has to be individually launched since there is not an individual player to run a play-list. (Robertson) Possibly offering a small play-list program for users could solve this problem in the future. Until then, though, the format is seems flawless in song sampling from music stores and sites.

AT&T, Liquid Audio, and GMO are all fairly large and renowned companies that all have enough power in the software industry to make an impact. But they, and everyone else in software, are of no comparison to the size and power of Microsoft. It is no surprise that they moved into the CODEC audio software revolution with MS Audio 4.0. In May of 1999, Microsoft released MS Audio 4.0 as a possible replacement for MP3, with half of the size of an MP3 file, powerful encryption, and music files that are copy proof. Also, this technology, unlike the other new formats, does not utilize AAC,

which affords the greater compression than AAC. Reviews of MS Audio reveal how good the quality is and the high fidelity. (Barry

One big advantage that Microsoft has with any of its software, including MS Audio 4.0, is that it owns the Windows operating system platform. This means that the MS Audio software could be on almost every computer if it is built into the Windows operating system, and it would allow for a great advantageover the rest of the audio CODEC software industry.

2.2 Hardware

The new freedom and availability of music to the public via online distribution has prompted consumers' demands for other methods of playing these compressed audio files than simply playback on a computer. This has led technology companies to create devices to fill the need. One of the first efforts at fulfilling this need was attempted by Diamond Multimedia. Their product, the Diamond Rio PMP300, is a portable, lightweight digital MP3 music player for mixing and storing up to sixty minutes of digital quality music and up to twelve hours of voice quality audio from the Internet or a CD. The device uses MP3 compression and features a simple interface for easily transferring and converting files. (Robertson)

The Rio PMP300 is smaller than an audiocassette and has no moving parts (Solid-state) so it will not skip, even during extreme movement. It runs off a single AA alkaline battery for up to 12 hours of continuous playback and features add-on flash memory upgrade cards that are available in half-hour and one-hour configurations. (Robertson) This product caused immediate controversy over the legality of such a device. Some held that it was a mechanism to distribute pirated music while the manufacturer maintained that this product was solely intended for legally downloaded compressed audio files. This controversy then found its way into the courts.

On Oct. 8, 1998, the Recording Industry Association of America filed a lawsuit against Diamond claiming the company's Rio portable MP3 player was in violation of the Audio Home Recording Act of 1992, which was enacted to regulate the manufacture, importation and distribution of digital audio recording devices. The RIAA sought temporary and permanent injunctions against the Rio for this alleged violation (Reece).

The RIAA was successful in obtaining a temporary injunction. However, the court ruled that the Rio's operation is entirely consistent with the act's main purpose: the facilitation of personal use. This ruling allowed other companies to see that they too could participate in this market with less fear that a big organization, such as the RIAA, would pursue them legally.

With the fear of great legal costs having diminished, many firms started exploring the options and extensions in this new market. One of the biggest hurdles encountered with this developing technology is memory storage for solid state players. However, the price of this memory has limited the storage capacity of players of this type. Most players on the market today are limited to 64 MB of Flash memory. The DAP player, just recently released by Swedish Right Technology, is the first player to offer a 128 MB player, but it is not likely that too many companies will follow soon because of the cost of flash memory (Reece).

A typical MP3 song file is around 4 MB and with the limits imposed by flash memory, the current portable players are only able to store 13 to 25 songs at one time. This lack of storage is the major disadvantage of the flash memory devices. To remedy this problem, other companies have abandoned the solid state concept and altered the current portable compact disc player technology to be able to play MP3 files as well.

Tagram System Corp. is currently entering the market with its MAMBO-X MP3/CD player. This unit, which uses durable laser reader (DLR) technology, can play regular CDs and MP3 CDs burnt using a writeable CD drive. While such disc-based players do not offer the solid-state construction or compact size of their flash memory

counterparts, many consumers have been waiting for a portable, inexpensive player capable of playing MP3 CDs (Reece).

With Flash and Compact Flash running more than $1 per MB, comparably priced flash MP3 devices can only hold about one to two hours of music: a problem not likely to go away in the near future because of supply issues. Meanwhile, Tagram will leverage its CDRW format to let users store and play more than 100 songs on a single, inexpensive disc. However, the lack of commercial MP3 CDs on the market, combined with the large number of people who do not own CD burners, are limiting factors for companies developing this technology.

Members of other aspects of the market do not experience these limiting factors, though. More and more car players are emerging onto the scene. Most contain a hard drive and user interface to control operation. One such player is the Empeg Car Player. Designed to fit into a car like any other car audio unit, it is pullout removable, which is handy for security and for updating tunes when you connect it to your PC. It has an FM tuner, as well, to accommodate listeners who only have room for one head unit in their car and would still like to be able to listen to the radio (www.mp3.com).

The unit's software has been designed so that one cannot retrieve music from the unit and use it with other types of players. The company stresses the fact that the product is a player and not a mechanism to support music piracy. However, one does have complete control over the music held on the player. Once it is connected to a PC, the Windows software allows one to view, add, delete and categorize tracks to one's liking. The player is controlled using a credit-card sized remote control and may be played using random playlists, year playlists, mood playlists, artist playlists, and so on

(www.mp3.com). An expansion of the technology in a way such as this will, indeed, lead to a large growth in the industry.

With this industry, including portable solid-state and moving parts players, MP3/CD players, and car players, the consumers' demands for more diverse listening means are being met. The expansion of the market will draw in more consumers to the audio compression technology and, of course, when there is a demand for a certain type of products, more and more companies will make an effort to fulfill that demand.

3 Regulation

3.1 Pre-Regulation

Currently, with the MP3 rising in popularity and its broad use on the Internet, both legally and illegally, great concern has arisen in the past few years pertaining to the control and regulation of illegal possession and distribution of copyrighted material. After the signing of the NET Act in 1997, the record industry was allowed to search out, shut down, and prosecute all web sites and people that infringed upon their copyright rights. This has led to a growing market in digital encryption, watermarking, and anti-copying software to satisfy all laws as the technology and music industries work towards a more secure online music world.

What was Internet and MP3 distribution like before the regulation, and what exactly caused the record industry and governments around the world to enforce restrictions and to regulate distribution? What was it like at the beginnings of the so-called 'MP3 Revolution'?

3.1.1 Piracy

The 'pirate,' as we refer to, is any person that makes a copy of copyrighted material and distributes it, or obtains and possesses a copy of copyrighted material that they, themselves, did not purchase without the consent of the copyright owner. To the record industry, or any profit industry on the Internet, these people are regarded as thieves, hence the name 'pirate.' This is a term that can be used on all levels. From the person that has just one illegal file to someone who may possess a whole archive of illegal files or programs.

The pirate is not just someone that is involved with MP3's, though. Pirates existed during the beginnings of the Internet, as well, and will forever be a part of our society with varying degrees of magnitude. But who exactly is it that is involved with the pirating of MP3's? How does a pirate go about obtaining illegal MP3's? Where on the Internet does this happen and where are a pirate's resources?

3.1.1.1 Who?

Pirating as a whole will never be fully controlled or removed as the same kind of computer intelligent person that creates software for companies exists in households and colleges all over the world. Although, at this time, only a small fraction of the world's population has the know-how and ability to decode or crack any secure system, every year the knowledge of the average user increases. The more people that understand computers, the more corruption and chaos can occur on the Internet as well as the increase in pirating software.

The pirating of wave-files of songs has always existed since the beginning of the Internet. But it had only been on an extremely small level due to the size of the files and the long downloading times. It was so small that it virtually had no effect on the recording industry and its music sales. This luxury ended in the mid-90's with the popularity boom of the MP3, a time still relatively new to the computer age. Computers were slow, networks were slow, software was still fairly primitive, in comparison to our standard today, and there were less computer literate people.

This was a computer industry that would grow exponentially, in a matter of a few years, with new software and hardware technology becoming available faster than the average consumer could remain current. It was around this point when the MP3

technology was released and gained in popularity. Prior to this time, the distribution of songs and albums on the Internet was practically unfeasible and out of the question. The pure size of the wave-files would take forever to download over the Internet. There were some that would do it, but they were so scarce that their movement of illegal songs had little to no effect on the recording industry's sales. The audio CODEC had opened up an entire world of audio on a visually based Internet and computer world.

In the mid-90's when the MP3 began to take off, mostly college students supported the format. The Internet was on the rise greatly at this time, but only about 16% of the United States households and other common societies actually had Internet access or availability compared to about 35 to 40% today (Maguire). For the most part, Internet connections were slow to the common household. The average college student, on the other hand, was, and still is, given access to high-speed network lines, some of which are ten times faster than a modem. With that kind of speed, the downloading of anything, anywhere, anytime was popular and still is in most college atmospheres.

College students often view the computer as more of a toy or gaming system than a work tool, especially since some of their social life includes the computer or Internet. As they have grown up with computers, it is part of their everyday life. It is part of their education, part of their communication, and part of their entertainment. Being around computers as much as they are, it is highly practical to have a music archive on their computer for their enjoyment. They spend a large amount of their time either on the computer or in the same room as the computer, so it can serve as a computer and a stereo system in one.

In comparison to the work force and older generations of society, the computer has been around for a smaller percentage of their life and has been used primarily as a work tool and communication tool. The average working person only really spends time at work (where the downloading of material such as MP3's is usually frowned upon), with the family, or out with friends a few nights a week. This makes it hard to show each other the ins and outs of the Internet and what MP3's are all about when the computer is rarely a part of their social life. The younger part of society that is in grade school does not have a life much different to this either, even though they have been exposed to computers for the majority of their lives. Computers, in their eyes, are an activity that aids schoolwork and will serve as entertainment for maybe a few hours per night at most which only accounts for a fraction of their social life.

3.1.1.2 How?

As stated earlier, the time to download an MP3 using a modem could take upwards of around 15 minutes. This is a long time to wait for one song and presents a large time slot for servers to stay stable and not temporarily pause or shut down. Network lines on the other hand can download a song in a matter of minutes, at a rate of almost a minute per megabyte. Multiple songs can be downloaded at the same time and rather large archives of music can be built up in hours.

With this kind of speed and convenience, students spend countless hours each day downloading their favorite songs from their favorite artists. An old classic that they always loved, a fun dance tune that they remembered from a past party, the newest tune on the radio from the newest band, or, even more so, a one hit wonder song that was on an album that they would have never bought in the first place. Students literally would

fill up their hard drives with only music to listen to while they study and use their computer.

One of the other reasons why the use of MP3s spread so widely in the college atmosphere, besides the speed of the connections, is how everyone lives in a compact society close to everyone else. If one student knows something about computers, five people that he/she knows soon knows that same thing. Then, all of the people that those five people know eventually know about that same thing. Soon this escalates into the entire campus community obtaining this knowledge. College students not only have friends, but live with their friends and see them 16 or more hours a day, every day. That kind of an atmosphere is set up to aid learning and the sharing of knowledge.

Another reason for the college popularity is a college student's exposure to the Internet. With almost all students now either owning a computer or having a roommate or friend in the room next door with a computer, and all of these computers being connected to the Internet, a student gets to the point where they know the Internet extremely well. The more familiar they are with the Internet, the more they know what is available from the Internet and what the newest fad is. They can talk to someone in a chat room, see an advertisement on a web page, or stumble across a topic while using an Internet browser. The Internet can often be no different than the television where there is great exposure to commercials, news, and informational programs to know what is available in the world.

3.1.1.3 Where?

Since there were no laws that existed in the mid-90's, either against the distribution or possession of MP3's, it seemed as though every college student had an archive of their own. Some only had a few songs while other students compiled archives that measured in gigabytes.

Most of the acquisition of MP3s would occur when students would open their archives up to each other and trade files. This was more on an inner-college platform over the school's network neighborhood. Students would either search out other student's computers and grab any shared MP3 that interested them from it, or would hear an MP3 that they liked in someone else's room and ask that person to send it to them or share it. Essentially, people of the same school would carry the same songs and archives, and would work as a team to acquire MP3s.

Sending files over a school's network is also faster in comparison to transition over the Internet where it would take mere seconds to transfer an MP3 file. To be able to build an archive up so fast would entice students to use this method of finding MP3s over the use of the Internet. The incredible speed would also allow students to stream the music over the network where they would be able to listen to a song off of another person's computer before they downloaded it to their own. This would come in handy sometimes when a student wanted to just listen to a song and did not want to download it, taking up their own hard-drive space.

Another major method of MP3 acquisition was through web sites and anonymous FTP (File Transfer Protocol) sites that other people (mostly other college students) would make available. An anonymous FTP site allows access to a machine without having to

have an account on that machine (i.e. there is no user ID or password required). These anonymous FTP servers contain software, documents of various sorts, files for configuring networks, graphic images, song lyrics and all sorts of other information. An enormous amount of information is stored on these machines and is ready for anyone who is seeking it. (Rovers)

Web sites by the hundreds existed with some of them bearing hundreds of thousands of MP3s to be shared out to anyone who would stumble upon them, along with lists and search engines for other web sites and anonymous FTP sites. Overall, this was the best method of finding a particular song. The only problem, though, was that web-sites would have limitations as to how many people could download from the site at the same time. The person who would create the site (as it was connected to his or her own computer) would specify this. Some sites would allow ten or twelve, while others may allow one hundred. Either way, it was a common occurrence to be waiting to download a file, sometimes having to hit the site at really odd hours to even have a chance.

The other technique of getting MP3s would be through Internet chat rooms. A lot of people that had MP3s on web-sites and FTP sites would password lock them, only allowing certain people to access them. When people access a computer to download files, it uses processor speed and slows down the computer. This turned many people off from exposing their archive to the entire Internet. Basically, people would talk to other people in these chat-rooms and would trade or give out passwords and web addresses to only the people that they wanted to. The type of person, though, that would deal with some of these chat-rooms tended to be a more advanced and knowledgeable computer operator. With this it was probably the least popular method of acquiring MP3s.

3.1.2 Music Sales

With the popularity of MP3 distribution rising and rising from 1995 until around 1997, companies that promote the sales of music and the RIAA (Recording Industry Association of America) began to worry about how it was effecting their business and taking away from their sales. Even though the amount of people contributing to the pirating of MP3's was minute compared to the music sales customers, they were concerned that people (mainly the college students) would download a song or album instead of purchasing it. A loss in income was a loss in income, and at the rate that the popularity of MP3s was growing, it had the potential to be a problem in the music industry's eyes.

With the bulk of MP3 distribution taking place in the 18 to 22 year old age group, how much was it really effecting the overall music sales? Shown below in Figure 3, the demographics depict a definite decline in sales from 1989 to 1997 in both the 15-19 age group and the 20-24 age group, both overlapping in the college age group. With the MP3 revolution beginning around 1995-96 and the statistics showing a decline in that time era, one could possibly say that

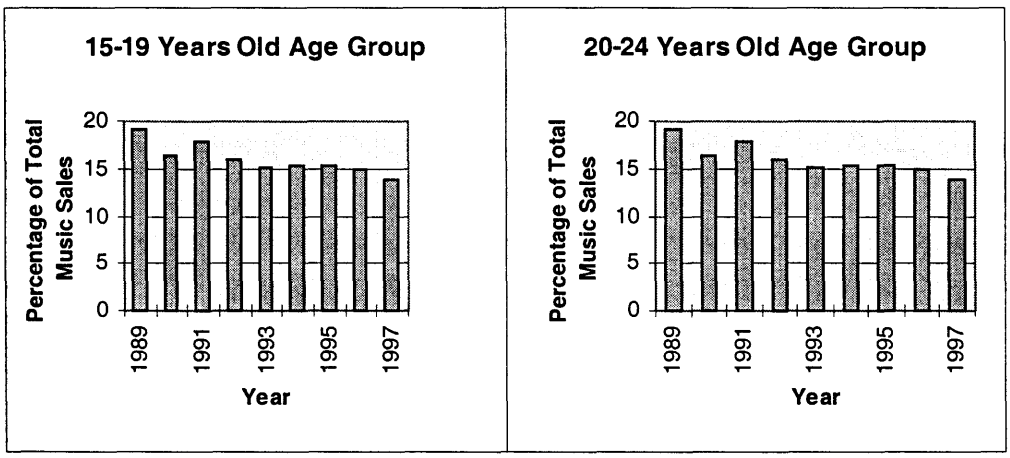

Figure 3: Statistics courtesy of the RIAA (www.riaa.com).

this particular decline is due to MP3 downloading. In looking at Figure 4, which is for the music industry's overall sales income, there also shows a leveling off of profit from 1995-96 and a decline in profit from 1996-97. But there truly is not enough proof there to show that

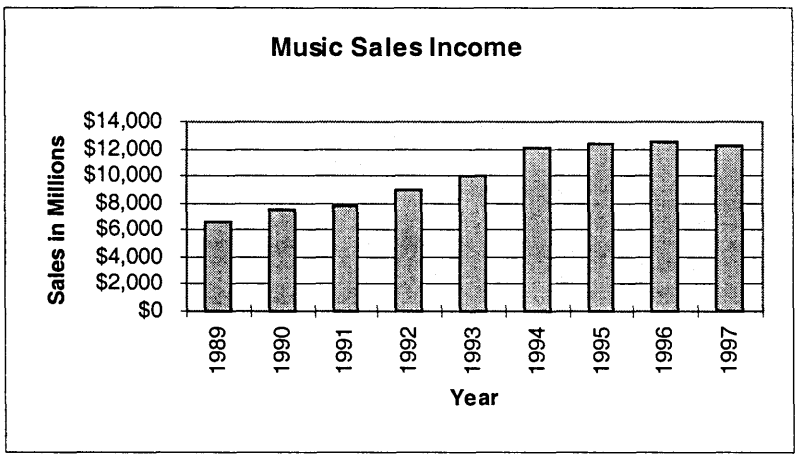

Figure 4: Statistics courtesy of the RIAA (www.riaa.com).

MP3s, alone, have such a large effect on the music industry and music sales. In the pie chart, in Figure 5, of music sales of the different age groups in 1989 compared to 1997, it demonstrates that the college age people's music sales declined. However, other groups, such as the 35 to 39 and 45+ age groups, have grown. If these older age groups are increasing in their music sales and the college aged people are staying about the same or

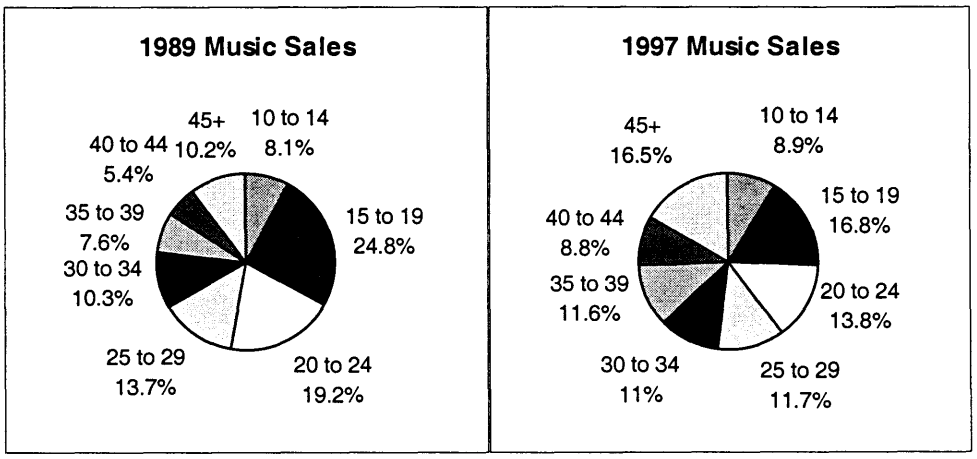

Figure 5: Statistics courtesy of the RIAA (www.riaa.com).

increasing in music sales at a slower rate, it could also look like this, too. There is clearly not enough information here to draw upon a conclusion. With the leveling off and decline in overall music sales, it could also just mean that the industry is changing and there were a few off years. Effects such as the economy, music quality, and prices all could have a part in the declining sales.

The pirating of MP3s may or may not have been the largest cause of the decline in music sales, but, no matter what, it cannot be denied that they do have an effect on sales. If someone hears a song on the radio and they are very interested in getting the song on compact disc, getting that song in MP3 form most likely would deter this person from ever purchasing the compact disc, especially if they are near their computer when they tend to listen to music. A good example of this is when someone may have heard one great song by a group and then downloaded their album in MP3 form only to find out that the rest of the album was not as good. In this case, the person would probably not buy the album and just be happy with the one song itself.

But there always is the opposite case when a person downloads a song or album and realizes that it is so good that they would like it in compact disc form for purposes

such as portability. This in turn would benefit the music industry as the MP3 serves as a sampler for people. There is also that neutral scenario too when a person would never purchase a particular album, no matter what, but they like one or two catchy tunes from it. By downloading the MP3, it has no effect at all upon the music industry.

To try to figure out how much of an effect MP3s have on the music industry, a survey of approximately 50 people who have downloaded MP3s was conducted at a Johnson & Wales University. Amidst the results were a few surprising statistics:

Bought music because of MP3: 66%
Did not buy music because of MP3: 38%
Did not buy because did not like music: (73.3% of the above 38%) 44%

Statistics courtesy of Archambault, Derek J.

According to these statistics, the existence of the MP3 could be benefiting the music industry more that it is hurting it. The only big question would be if the people who bought the music because of the MP3, probably would have bought it anyway. If these people were not going to buy the music until they heard the MP3, then the statistics show a definite plus for the music industry.

As far as the people who did not purchase the album because they ended up not liking the music, the MP3 serves as a sampler and deters the consumer from getting tricked by a one-hit-wonder. But sampling is a service that the music industry should provide to the consumer, unless producing the one-hit wonder is a major part of their income. In that case, it has to be questioned as to how much power the recording companies have over what we hear.

Even though the statistics above pertain to only a few students out of many in the world, the difference in the percentages leave much room for any errors that could throw off the data. This may not be the best representation of the average college student, but nevertheless every college in some way is a microcosm of the entire worldwide college community

A similar but larger survey was performed here at Worcester Polytechnic Institute in Worcester, Massachusetts, to compare and contrast the results with that of the Johnson & Wales University survey. This survey involved two random classes here with one in the Electrical Engineering concentration and the other in the music concentration with no one overlapping. Overall approximately 90 students took part in it answering 12 questions. Below are three question's results that relate to how the student's part in MP3 piracy has effected the music sales of America. The results from the other questions will be mentioned later and can be referenced in Appendix A.

Purchased a recording after hearing it on MP3: 67%
Did not purchase a recording after hearing it on MP3 and disliking it: 66%
Has not purchased a recording after downloading it on MP3: 60%

Survey Courtesy of WPI.

Very similar to the Johnson & Wales statistics it should be noted that almost the same percentage of people have gone on to purchase a recording after hearing it on MP3 (67% compared to 66%). This tells us that a large percentage still buy the album despite hearing it or downloading it in MP3 form, so it may not have as drastic of an effect as the RIAA thinks it is having. However, this does tell us that the remaining 33% of the people have never purchased the album after hearing it or downloading it in MP3 form,

which does indeed take away from music sales. This may again support why the overall percentage of college student music sales has decreased.

However, why exactly are these people not purchasing the album after hearing it on MP3? The RIAA and many others will claim that it is solely because people have music on MP3 and do not need to purchase it now. Although 60% of the students have at one time not purchased an album because they have it on MP3, these statistics above may show otherwise. According to the study, 66% of the students have at one time decided not to purchase an album after hearing it or downloading it on MP3 and disliking it. This further backs the one hit wonder issue where people end up purchasing an album because of one great song only to find out the rest of their album is not to their liking. Often, when radio airplay is involved, people hear one song over and over again and end up purchasing the album just because of it. Again, this is not fair to the consumer and they should have the opportunity to hear the rest of the album somehow before spending their money.

Overall, from these two studies at two major colleges in America, it has been shown that the downloading of MP3 does effect music sales, but overall, the majority of people are still buying the albums despite downloading it on MP3 or hearing it. It is also been proven that MP3's have served as a sampler for music sales and that MP3's allow people to hear the rest of an album before spending hard earned money on an album that they would not like.

3.2 Regulation Attempts

3.2.1 The Recording Industry

The recording industry is a complicated maze of activities starting with a song and leading to its eventual sale. The basic function of the industry begins when a songwriter writes a song and submits it to a publisher. Under contract with the songwriter, the publisher owns the copyright on the song. A record producer makes an agreement with the publisher to have his artist record the song. The producer makes all of the necessary arrangements for a recording session, and the artist records the song. The record company manufactures compact discs from the master tape, and then the distributors place the CDs on retail outlets or make them available via online sales. Promotion of the recording may include press releases, advertising, radio and TV airplay, live concerts, TV appearances by the artist, and a music video of the song (Fink).

Radio and TV make their profits from the sale of advertising time. The retailer, distributor, and record company make their profit from the sale of CDs. The record company pays the artist a royalty on each unit sold. The record company gives the producer outright payment, a salary, royalties, or any combination of the three. Through a licensing agency, the record company pays the publisher a royalty on each recording sold. The publisher pays the songwriter a portion of the royalties collected. A performing rights organization collects fees for all performances of the song (principally radio and TV airplay), splits the income between the publisher and the songwriter and pays each of them separately (Brabec).

3.2.2 Copyright

The 1909 Copyright Law of the United States forms the basis of the lifetime and worldwide earnings of creative works. According to the 1976 Copyright Revision Act, in the music field, the basic types of work that are coryrightable are musical works, including any accompanying words, dramatic works, including any accompanying music, motion pictures and other audiovisual works, and sound recordings. The two primary elements that a work must have in order to enjoy copyright protection are that it must be an original work of authorship and that it must be fixed in a tangible medium of expression that is now known or later developed.

The exclusive rights that a copyright owner has in an original work of authorship, subject to some limitations and exclusions are the following:

- The right to reproduce the copyrighted work in copies or phonorecords.
- The right to prepare derivative works based upon the copyrighted work.
- The right to distribute copies or phonorecords of the copyrighted work to the public by sale or other transfer of ownership, or by rental, lease, or lending.
- The right to perform the copyrighted work publicly.
- The right to display the copyrighted work publicly.

The limitation and exemptions on these exclusive rights include "fair uses" of the work, certain productions by libraries and archives, certain educational uses, certain face to face teaching activities, performances in the course of religious services, charity and other nonprofit performances, and performances in the home (Brabec).

For phonorecords (CDs, records, tapes, etc.), once the copyright owner authorizes one recording that is distributed to the public, anyone else can make recordings of the

composition regardless of whether they have permission from the copyright owner. There are certain rates that apply per composition or per minute of duration that are reset by the Copyright Royalty Tribunal. This five-member tribunal, provided by the Copyright Act of 1976, is appointed by the President and subject to the approval of the Senate. The Tribunal is empowered to adjust, set, and distribute copyright royalties in certain licensing situations.

The Tribunal passed the Audio Home Recording Act in 1992 to help music creators recover lost revenue incurred by home taping, copying purchased music on a form of media (tapes, CDs, etc). The manufacturers of digital audio recording devices and media are required from the act to pay royalties to the creators. The royalty to be paid by the manufacturer to the Register of Copyrights is 2% of the transfer price, with a minimum royalty payment of $1 per device and a maximum royalty of $12 for certain types of devices. The royalty on blank tape and other media is 3% of the transfer price (Brabec).

Most of these actions have been able to regulate the protection of intellectual property. However, there was a loophole in the law that did not penalize distributors of copyrighted material if the distributor does not earn a profit. To remedy this, the No Electronic Theft (NET) Act was signed into law by President Clinton in 1997, making it illegal to reproduce or distribute copyrighted works, such as software programs and musical recordings, even if the defendant acts without a commercial purpose or for private financial gain (www.cnet.com).

This act was seen by many in the music industry as a powerful action against online piracy. A pirate making money on an advertising or transaction basis or a college

student posting illegal MP3 files equaling a certain value would face 3 – 5 years in prison for such an offense. However, questions arise as to whether this act is enforceable and, if so, are any authorities actually enforcing it. It appears that there have been no convictions relative to the NET act.

3.2.3 Collection Agencies

The performing right is a right of copyright that applies to the payment of license fees by music users when those users perform the copyrighted music of writers and publishers. This right protects the original works, intellectual property, of the writer by charging a fee to those using music outside of the home. These performances can be songs heard on the radio or a jukebox, music in television shows and movies, and any live performance of the material. Wherever music is being played, outside of the home, the user is paying fees to a collection agency that takes a small percentage and then pays royalties to the writers and publishers for their copyrighted work. In the United States, three organizations negotiate these license fee agreements. The organizations are the American Society of Composers, Authors, and Publishers (ASCAP), Broadcast Music, Inc. (BMI), and the Society of European Stage Authors and Composers (SESAC), which, of the three, accounts for less that 1 percent of all business in the United States.

ASCAP is a nonprofit organization, formed in 1914, owned and operated under the direction of its members. BMI is a nondividend-paying corporation originally formed by a group of about six hundred broadcaster-stockholders and is presently owned by about the same number. Both ASCAP and BMI represent major songwriters, composers and publishers of all types. Although the benefits of the two organizations appear to be alike, writers and songwriters of Top 40 music tend to join BMI, while composers, lyricists,

and publishers associated with motion pictures and musical theatre favor ASCAP membership. The main qualification for membership with ASCAP is to have at least original work used by someone licensed with ASCAP. While BMI's qualifications are similar, they are not as strict and take such aspects as future potential into consideration (Fink).

In order to determine how to divide revenue among its members, these organizations must conduct frequent surveys of performances. The two methods used are census and sampling. A census involves reviewing complete lists of performances. ASCAP uses the census method in accounting for TV networks and broadcasted background/foreground music services because the TV networks account for over half of ASCAP's revenue. ASCAP uses sampling for most other types of licenses. BMI uses the census method more extensively, which makes it more attractive to newer publishers and aspiring songwriters. Both organizations use a rather complex weighting system to determine how much of the royalties that a work deserves (Fink).

In recent years, use of software to track music use on the Internet has been utilized by these organizations. ASCAP's EZ-Seeker uses Web crawlers to locate sites that play and distribute music in the most common audio and video formats. The software then identifies what artists are being played, issues license forms, and tracks compliance. ASCAP is also offering EZ-Seeker for free to other music and entertainment licensing groups around the world. They also set rate schedules for Web music sites last year, and began collecting fees. It offers music licenses to websites for as low as $250 a year (Maclachlan).

However, some sites argue that they should not have to pay any fees at all. Particularly sites that sell music in the MP3 format make the point that they are selling a digital copy of a song, (more closely related to selling a compact disc) while collection agencies maintain that the sale of music in the MP3 format is considered to be a performance of that song.

3.2.4 Recording Industry Association of America (RIAA)

The RIAA is a trade association that represent the companies that create, manufacture, or distribute approximately 90 percent of the sound recordings in the United States. In addition to being a $10 billion domestic industry, the foreign sales of U.S. recorded music amount to more than $12 billion, representing approximately 60 percent of the world's consumption of music. The RIAA maintains a large legal and investigative staff to fight against all forms of music piracy and is associated with local recording industry groups around the world to extend this fight. One of its principle missions is to ensure that copyright legislation remains adequate in light of a rapidly changing technological environment, and that appropriate conditions exist to foster creativity in music through increased investment, production, and distribution (www.riaa.com).

3.2.4.1 Diamond Rio Lawsuit

On Oct. 8, 1998, the Recording Industry Association of America filed a lawsuit against Diamond claiming the company's Rio portable MP3 player was in violation of the Audio Home Recording Act of 1992, which was enacted to regulate the manufacture,

importation and distribution of digital audio recording devices. The RIAA sought temporary and permanent injunctions against the Rio for this alleged violation (Reece).

The RIAA was successful in obtaining a temporary injunction that prevented the company from manufacturing and distributing the Rio. However, the court ruled that the Rio's operation is entirely consistent with the act's main purpose: the facilitation of personal use. This ruling allowed other companies to see that they too could participate in this market with less fear that a big organization, such as the RIAA, would pursue them legally.

3.2.5 Secure Digital Music Initiative (SDMI)

The music industry has not yet embraced the Internet because of fear of theft of digital music. However, it has been forced to act by recent technological and legal developments. The MP3 format has made storage, compression, and transfer for digital music files easy and popular. The Rio player has provided a cheap and portable device for playing and sharing MP3 files. The music industry has sought, but recently failed to obtain, a court order enjoining the sale of the Rio player. In December of 1998, representatives of the recording industry announce the Secure Digital Music Initiative to promote Internet distribution of music, and to protect copyrighted music in digital format from theft.

This initiative was intended to deliver music in all formats to the consumer while protecting the intellectual property of the artists from piracy. Many of the recording industry leaders, as well as leaders of hardware, software, and Internet companies welcomed SDMI as a positive step in delivering secure digital music to the consumer and to allow music publishers to control their songs. SDMI uses technologies to allow music

publishers to dictate when consumers can upload, copy, and play songs and CDs (Tech Law Journal).

The initiative's main selling points are security software and digital watermarks. Embedded on compact discs, watermarks would both verify that CDs were legally copied and contain a series of playback and copying restrictions. Planned installation into CD players, MP3 players, and other playback devices, SDMI security software would automatically read these watermarks and follow the instructions they contain. The goal being to limit how many times a song can be copied. For example, under phase one of SDMI, songs that have been digitized from CDs would expire after four recordings. As the initiative progressed into phase two, SDMI-compliant playback devices would reject CDs that were illegally copied (www.cnet.com).

SDMI began experiencing some major setbacks. One of primary driving forces of the player distribution was illegally copied songs. Also, a player that screens a song before playing adds no value to the consumer. It actually limits what the consumer is able to listen to with the player. Furthermore, the technology is still evolving which makes it very difficult to develop a secure standard for delivering the music.
In order to play digital audio, a computer program, such as WinAmp, still sends the data in raw form to a sound card. It is rather simple for anyone with a somewhat good understanding of programming to capture this data and save it, rendering the watermarking or encryption useless. The software industry learned this lesson 15 years ago the hard way. A number of companies were spending millions of dollars and tens of man-months to protect their software only to find it cracked weeks after release. Most of these schemes did not deter the hackers but proved annoying to valid customers. Software

companies eventually gave up and decided to spend their money and time on making good software products instead of protecting their intellectual property. Today, less than 1% of software has any significant form of copy protection on it (www.mp3now.com).

3.3 With Regulation

With the introduction of laws concerning the distribution of copyrighted music over the Internet, the direction that the MP3 and digital music was heading has been skewed. No longer is the MP3 allowed to be a part of free trade and distribution in the world. Distribution has become more difficult, companies have endeavored into the relationship of security and digital music, and the MP3 has begun to be a platform for future music sales. Will the regulation damper the overall use of digital music on a free market basis, or will people still find a way to get whatever they want, at any time for free? The regulation has given birth to a new battle in the MP3 revolution between the record companies and the pirate. There will always be music pirates of some magnitude. What happens to the rest of the digital music industry and online sales will depend on how much the industry wants to press for piracy prevention without hurting their own online sales.

3.3.1 Encryption

As mentioned in earlier sections, with the passing of the Net Act and the commencement of the SDMI initiative, several different technical companies have jumped on the chance to create the best MP3 encryption tool. With a decent encryption or watermarking program and enough support from the record industry and artists, a company could corner the market in digital online music.

Watermarking is a technology often mentioned when talking about securing music. It is the process of labeling music in such a way that it does not affect the quality of the music, but still contains some hidden identifying text. This text can be used to trace back to the original owner or copyright information. A good analogy is using a big black marker to put your name on a basketball. This does not affect how the ball bounces and it does not stop anyone from stealing your basketball. It does, however, help if you track down the school yard bully and need proof that the basketball he has is yours. Watermarking has applications as a passive deterrent, but by itself, it cannot secure music. (Robertson)

Encryption, on the other hand, is a way to scramble data to make it unreadable if it is intercepted. Once it is received, it has to be unscrambled to be used and loses its security blanket. An example would be a phone call. You can use encryption to scramble a phone call between me and my bookie so that anyone trying to listen in would only hear static. (Robertson) This type of technology can be used to produce a piece of encrypted digital music that is unique to a specific player and can only be decoded by that player. The music industry and technology company would require a purchase to be made on the digital song or album itself and possibly the decoder as one is worthless without the other.

Another method of security is to produce files that do not allow themselves to be copied, or files that track the copying of themselves, sending information back to the company or creator. To download a song is to copy it from another person's archive, so this feature would oppose transmission of digital audio over the Internet.

The major companies today that are trying to incorporate such a technology into their own CODEC format (as spoken of earlier) are AT&T's a2b *CryptoLib Security Library,* Liquid Audio's *Liquid Music System* and Microsoft's *MS Audio.* To thrust themselves into the market, all three have signed on or taken in artists and/or major recording companies to produce music through their software systems. Some artists have recorded or passed on recordings for free, while others have signed financial contracts and agreements as they would with a standard recording company. Overall, digital music sales using download forms with some degree of security are increasing rapidly as the music industry is beginning to embrace the digital platform and Internet.

Many in the music industry believe that securing music on the Internet is the only way to establish a viable business selling digital tunes. "Securing" is shorthand for "preventing users from copying music". But security experts are in fairly strong agreement that it is not possible to secure a PC due to its open architecture and the fact that it is user serviceable. The owner can easily install any software or plug in any cable to achieve a desired effect. If there is a bit somewhere in the software code that prevents copying, it can be identified and switched to the other position. This occurred recently with the crack being distributed for Liquid Audio and a2b called a2b2wav. This program actually adds a "Record to wav" menu item to the Liquid Audio and a2b programs permitting users to save songs directly to the hard disk in free and clear wave format. Newer Liquid Audio and a2b players seem to be largely immune to this program, but similar such programs are sure to be released in the future in this never ending cat and mouse game. (Robertson)

Of bigger security concern than hacker cracks for music is the fact that for it to be useful on a computer it has to be output to speakers. Once it makes the jump to sound waves, it is susceptible to being copied. In fact, it is quite simple for any computer user to capture any melodies played on their computer. Every modern computer comes with a "sound out" and "sound in" plug. And it is no secret that a simple 1/8 inch male to male $3 cable from Radio Shack is all it takes to connect the two. (Many PCs come with this cable out of the box.) There are many free recording utilities for both Mac (MicNotePad) and Windows (Willow Media Player). Now, any content that comes out the computer's speaker, including streamed music that never resides on the hard disk, can be captured in unprotected digital form or by an analog recording device. (Robertson)

The recording industry and digital online sales companies such as Liquid Audio, a2b, and MS Audio will continue to try to impede piracy by creating a better, more secure format for their digital audio. However, is there a point when producing such secure and restricted digital music will actually stifle online sales or a desire for this secure music? Users would most likely be reluctant to sacrifice features and control that they now possess to move to a more controlled environment. The consumer would see it as a step backward. Instead of getting freedom to enjoy and use digital music in more ways and get more value from their music collection, they would be more restricted and therefore, get less value. (Robertson)

3.3.2 Piracy Adaptations

With the MP3 being forced off of the open Internet, MP3 pirates have sought elsewhere to trade, download, and upload illegal MP3 files. The open Internet was a

forum that all people, regardless of their knowledge of the Internet and computers, could easily search out and obtain a favorite song or album. Many people would use Internet search engines to find a website with MP3's, but most would use an MP3 search engine from a website to track down the songs on various other sites and anonymous FTP sites. With the enforcement of the NET Act by the RIAA, most of the open web sites on the Internet that possessed illegal MP3's and advertised anonymous FTP sites were asked to cease distribution or shut down as pressure was placed on web and server administrators to do so. At this time, pirates had to adapt to alternate methods of distribution via the Internet.

The RIAA thought that enforcement of the NET Act would highly deter the pirating of MP3's and would eventually fade out the MP3 downloading craze. There is no doubt that they have made the acquisition of illegal MP3's more difficult for

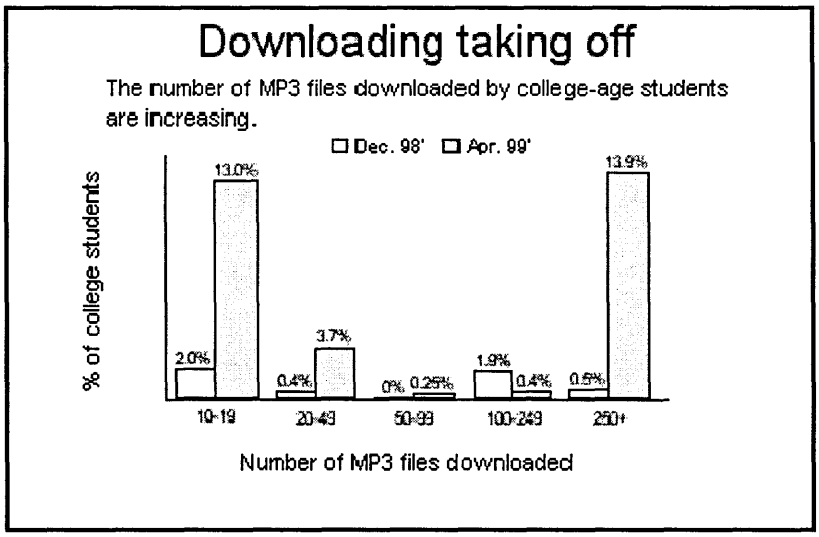

Figure 6: Statistics courtesy of www.webnoize.com.

everyone, but, according to recent statistics, the downloading of illegal MP3's is still on the rise. In Figure 6, in a comparison between 1998 and 1999, the number of MP3 files that were downloaded, increased tremendously in all but one category (which is the 100-

249 files category). The rather large surges at the 10-19 and 250+ ranges show that more and more people are starting to download MP3 files for the first time, while others are having no problem finding access to MP3 files and building up their archives to be extremely sizable. 250+ files correspond to around a gigabyte of space that a person would need to have on their computer. With the size of hard drives growing at an almost exponential rate, this becomes more and more conceivable.

In another survey, performed in February of 2000 at Worcester Polytechnic Institute, the results showed that regulation is not slowing down the growth of people's archives (Appendix A). Shown below are the results from the 92 people that took the survey (which will be discussed in more detail later on):

Number of MP3's possessed:	
0	**13%**
1-25	**7.6%**
26-100	**18.5%**
101-250	**14.1%**
250+	**46.7%**

Statistics Courtesy of WPI.

A very strong majority of the people surveyed possess over 250 MP3's. This demonstrates that these people have easy access to other people's archives and can still download the songs that they desire at will. Removing those who were surveyed that did not posses any MP3's, the 250+ category goes up even larger to 53.7% to reveal that the majority of people that download MP3's posses over 250. This equates to over 25 albums worth of music and around $400.00 worth of compact discs per person. If these people were going to purchase these albums until they downloaded them, that means a heavy loss of revenue for the music industry.

Very similar to the pre-regulation period, college students, and working class people did and still do rely on the high-speed company and school networks for the trading and acquisition of MP3's. It was the easiest method before, with the fastest download times, and it has continued to be the easiest and most popular method of downloading files. Anyone who knows how to point and click a mouse can search a network and download an MP3 file. Networks such as these are also isolated from the World Wide Web and are for the most part immune to regulation and law enforcement except for those who maintain the networks and have a problem with the illegal trafficking.

The networks allow people to swap all of their existing archives of music with one another, but after a short amount of time everyone begins to have the same archives and same songs, assuming their musical tastes are similar. The only way that these networks now expand is for people to purchase a compact disc and encode it into MP3 form or for others to find a method of reaching out to other people outside the network who may possess different songs and have encoded different albums.

One way that this is done, as spoken of earlier, is through chat rooms and the trading and distribution of FTP site addresses and passwords. Forums and chat rooms through programs such as MIRC, ICQ, Instant Messenger and Yahoo would allow people to communicate to each other as to what they had to offer for files. Some people will eventually give out passwords or put others on their account if they get to know them well enough. Others will allow downloads of files as long as they receive uploads of files in return onto their computer in more of a bartering scheme.

Even if only one person out of a hundred in a network utilizes chat rooms and FTP sites as a method of downloading MP3's and then shares the songs out, it is not inconceivable that all one hundred people will also soon have this song. This is what makes high-speed networks in colleges and at companies such a crucial link in the pirating of MP3 software. Also, as time goes on, more and more people will become familiar with chat rooms, and the chat rooms will become more popular and make the high speed networks a virtual library of MP3's.

Chat rooms have been a communication forum that enforcement agencies such as the RIAA's CyVeillance of Arlington Virginia do not take the time to deal with and lock down on (Robertson). Web sites and large anonymous FTP sites are easy to search out and find, while locked and password protected FTP sites require an agency to trap a person through a chat room into giving out access to their sites for proof. This is something that can take a sizable amount of time, money, and effort and is not performed by the enforcement agencies to date.

Of recent controversy, a software program known as Napster, from Napster Inc. of Silicon Valley California, was released in the fall of 1999. This program, which is a simple interface for users to chat, play, and store song files, most importantly allows the searching of other users' music archives. The number of files available for download via these programs correlates directly to the number of people using the program simultaneously and the size of their MP3 collections that they have opened up to other Napster users. For instance, when MP3.com logged onto Napster on Nov. 3, 1999, 521GB (129,073 songs) were being offered by 1,227 "libraries." A single search for R.E.M. returned more than 300 (many duplicated) song files. (Reece)

According to Eileen Richardson, the CEO of Napster Inc., "we're all about music community right now, and what we want people to do is come to Napster and share legal music, discover new artists and grow the record industry from whatever billions of dollars it is today to some order of magnitude above that" (Reece). But, as expected the RIAA has become enraged over such a program and the amount of pirated files that were being transferred through it, and decided to take action. In December of 1999, the RIAA filed a lawsuit against Napster trying to show that the company was aware its product was being used for copyright infringement and significantly participated in that infringement. This was a lawsuit solely against Napster and not the users of Napster since the company did not maintain user logs and individuals could not be tracked (Reece). At this time, the lawsuit is still being battled in the courts and Napster continues to grow in popularity.

Other software programs on the market that are similar to Napster are GlobalSCAPE's CuteMX, iMesh, Freenet, Wrapster, and Gnullsoft. They have not gained the same popularity as Napster itself, but are slowly becoming major players in the current MP3 searching industry. The big difference between Napster and its sister programs is that Napster utilizes a central server to aid the searching of other computers, while the others do not. The other programs take advantage of an IRC format where they just pass out the software that sets up the chat rooms, and the individual user's computers find each other upon command. (Copperman)

3.3.3 Current Enforcement

The RIAA in partnership with CyVeillance of Arlington Virginia and OneHouse LLC of Los Angeles California has embarked in a massive effort since 1997 to shut down

all illegal MP3 websites and FTP sites (Robertson). To shut down every site and inhibit every pirate is a task that is inconceivable, and it would take too much time, money, and effort to even come close. The Internet is just too broad of a world with too many forums, websites, and people to ever be capable of totally policing it. However, the RIAA and other enforcement agencies understand this and the fact that they will never do away with piracy, but can only hope to contain it.

The best solution to the RIAA's enforcement has been to hit the problem at its root instead of taking it head on and dealing with every individual. Such a task is done through the server owners and ISPs (Internet Service Providers) (Robertson). As a result, there are basically four simple steps that the RIAA can do to shut down a website or anonymous FTP site. For example:

1) First is the verification of unlicensed content using a search engine on the web. As easy as it is for the pirate to find songs, it is equally easy to find for policing purposes. The quickest way is to use one of the many search engines that have the ability to locate MP3 files specifically. Once they find a song, they will then proceed to download it to assure that it is a complete song. (Robertson) (A full-length song is considered illegal, but a partial length song is considered a sample and is seen as being acceptable in the RIAA's eyes. No one who likes a song only wants to hear part of it all of the time, so a sampling such as this would most likely not take away from music sales. It may instead result in the sale of music if the person likes the song enough and desires the full version. Partial length MP3s are also something that many online music sales companies use to allow the public to sample a song or album before purchase. So by disallowing it would only go against their sales strategy.)

2) The second step is to locate the server containing the suspect music. If they move their cursor over the file name, the lower left hand corner of the browser will display the name of the server on which it is located. If this is not possible, then they can click on the file as to attempt to download it and watch for the URL which subsequently appears in the location field on the bottom of the browser. (Robertson)
3) The next step is to identify the actual server owner by finding out that person's name and contact information. This is done through a traceroute. A traceroute is a way of looking at a road map of how to locate where the server is physically located. To do a traceroute, they can go to Network-Tools in any Windows based system and enter in the exact server address (name or number) that they identified. This will get them a map to the server listing each intersection (called a 'hop' by computer geeks), and within the listing, all of the domain (company) names. By going back into Network-Tool and by using the WWWhois command, both the email address and phone number for the person to contact will show up. (Robertson)
4) The final step is for the RIAA to get a hold of this web administrator and to inform them of the person's illegal actions. Most web administrators are eager to help once the problem is brought to their attention, and the websites are either shut down or the person is informed or threatened to withdraw all files and illegal activity (Robertson).

This method of enforcement by the RIAA handles many pirates who maintain websites and anonymous FTP sites, but one of the huge problems lies within college networks as spoken of earlier. Since these are networks that are isolated from the World Wide Web, there is not a whole lot that the RIAA can do to go after these individual

college students and their illegal trafficking. One thing that the RIAA has done and will continue to do is go after a school's network administrators and threaten them with lawsuits if they do not police the networks for illegal files. In December 1999, the University of Florida's network engineering coordinator reported that the recording industry had contacted the school in March 1999, pressuring it to police MP3 piracy on the network. Also in November 1999, representatives from Carnegie Mellon University said that the RIAA (in spite of claims by the trade association to the contrary) had repeatedly threatened them with legal action for not being more proactive in monitoring illegal music traffic (Reese).

In another issue discussed earlier, the MP3 searching software Napster has grown in popularity with pirates everywhere. To go along with the current lawsuit against Napster, the RIAA is also continuing to pursue colleges to block out Napster. With college students serving as the primary users of this software program, the RIAA is thought to be attempting to hit the problem at its root again. Due to pressure that is believed to be placed on system administrators, both the University of Indiana and Oxford University have complied with the RIAA and have set up firewalls within their networks to make it impossible for students to use Napster. Both universities argue that the reason for shutting down the use of Napster is due to bandwidth concerns and system congestion where so many people are using the program and downloading files (Reece).

4 Artists and Music Distribution

The Internet is bringing many changes to the world of music. Almost all of these changes affect the artists that create the music. Of course, the Internet has enabled artists, at all levels of experience, to make their music available to a larger audience. Logically, the more people that hear an artist's music will lead to more people liking that artist's music. This will presumably increase the sales of an artist's work, and at the same time, it will satisfy more consumers by exposing them to all types of music. However, the Internet has also spawned a new form of piracy that, with digital compression, can reach a large quantity of listeners. In the same manner of thinking, it is logical to assume that the more people that can access pirated music will lead to a decrease in the sales of an artist's music. This technology appears to be a great aide to the artist, but also a great hindrance in other aspects.

It is important to monitor the effect Internet piracy will have on the development of the legitimate online business of record companies. Why should consumers pay to download music when the same songs are available for free from the pirate sites? The threat that Internet piracy poses to the millions of dollars currently being invested by record companies and technology companies to develop e-commerce capability is evident. But, one must not forget the assistance that the Internet is capable of providing for all artists.

4.1 New Artists

For a new artist, the Internet allows them to upload their music and post it on web sites for free. They make their music available in the hopes that they will develop a

following of listeners that like their music. Once they have developed a following, they are then in a position to attempt to sell their music online and in record stores. Of course, at this time, they would no longer desire to make all of their music available for free online to force the listeners that liked the artists music to pay if they wanted to hear new music from the artist. Before the Internet, artists depended on touring and radio airplay to become known by listeners. Now, with the Internet, new artists have a greater chance of "making it big."

Thousands of artists are digitally encoding their songs so they can come online to share their creations and be heard by listeners. Still, it can be a long wait before they get signed by a record label or earn any money for their work. Without the marketing and distribution power of the major labels, the Net is not expected, at this time, to help launch the careers of one superstar after another. However, it could currently assist an increase in middle-class artists.

MP3.com has introduced a program titled "Payback for Playback." It allows users to sign a non-exclusive contract with MP3.com and to make their music available on the site. A formula is used based on the number of downloads of an artists' music to determine the percentage of the monthly $200,000 offered by MP3.com that each artist receives.

One new artist, Alex Smith's one-man band, The Cynic Project, was the top seller on MP3.com's Payback for Playback chart for a few months, earning him $4,789. Combined with his CD sales through the site, the 17-year-old earned more than $12,500 (www.cnet.com). Although there is still a "weeding out" process on the Internet, it has

provided a small percentage the chance to earn a decent amount of money and some visibility among music industry.

4.2 Accomplished Artists

In the same sense, accomplished artists can take it a step further with the Internet. One must keep in mind that as the music reaches more listeners, more will want to purchase the CD. By providing one song from a new album for free on the Internet or posting sample of songs on web sites, the artist has given the listener a taste of the artist's new works. Doing so in the hope that the listener will like the new material and therefore, want to buy the album.

Utilizing websites such as liquidaudio.com or a2b.com, consumers can perform searches of their favorite artists to sample or purchase music. The samples on the sites are free, as are some of the songs at the discretion of the artist. Other songs are for sale on these sites. The cost for a single song ranges from $0.99 to $2.99. Many artists are embracing this new delivery mechanism, but there are still many that a search is unable to locate.

4.3 Record Stores and Online Sales

In the past few years, Internet audio has no longer meant a few people sitting at their computer with a pair of headphones, and the record industry sensed a threat to its $12 billion annual CD and cassette business. The recording industry had already appeared before this time to be in a slump. The total number of units shipped (CD, cassette, and LP) has remained almost exactly the same since 1994, so the record industry can not count on a huge increase in sales that it had grown accustomed to.

In the meantime, the Internet has already had an effect on other aspects of the entertainment business, with TV audiences and newspaper circulation dropping in part because people are spending more time online. But until MP3 became popular, Net audio had never posed much of a threat because the files were too large to pass from computer to computer, did not sound good enough, and users had to sit at their computers to listen to the music.

MP3 files do sound great compared with other computerized audio files that are small enough for quick downloading. They are even a good portable format, compared with CDs played through a portable player and headphones that are prone to skip. But MP3s are not capable of delivering the same quality that a CD played through a good home stereo can deliver. Even with enhancements like extra bass, it is not currently possible to make up for the missing portions of the original audio signal that were removed for compression. However, early CDs and CD players often did not sound as good as the LP records of the time, but people embraced the format because of the added convenience.

There are many arguments that there is no difference between record stores and online sales. The difference, however, is that the Internet is more crowded than most record stores, offering far more choices to the consumer. But the Internet currently has a smaller audience than radio, which maintains sales of CDs at record stores. The advantage of the Internet is, of course, ease of access and direct contact with consumers as opposed to dealing through record companies, radio stations, and retail outlets.

This can be a win-win situation for both the recording artists and the consumers. For example, when a song is purchased and downloaded from an online music store (usually

for only 99 cents), 50 percent of your purchase goes to the store, and the artist receives the other half.

The rest of the industry is not that simple though. When a CD is purchased for around $16, the major labels usually give the artist anywhere from 10-12 percent of that amount. The remaining cash goes to pay for manufacturing and distribution costs. If an artist is associated with a lesser-known independent record label, they might see around 50 percent of the profits after paying for production and distribution costs. Musicians have a choice to be out on their own, or try to become associated with a record label. On their own, they could upload your songs and do their own public relations work to get their music known, hoping that the web site visitors will like their song enough to recommend it to other via word of mouth of ratings. If an artist gets lucky enough to be recognized by a major record label, they will receive the great publicity, but they have to really "make it big" before they begin earning the money associated with accomplished artists.

5 Future of Piracy

Piracy is an issue that has been crucial to both the success and downfall of digital audio in our society. Although compressed audio is a technology that has been around and in our midst throughout the decade, it was not until the MP3 revolution of mass piracy during the mid-90s that the concept of digital compressed audio really became an issue. MP3 piracy was an act that flourished the CODEC industry, putting the technology right into our faces and into our everyday lives. Now that the CODEC market is growing larger than it ever has and there is thought of making compressed digital audio a larger part of the record industry and music sales, piracy has become an act that in the record industry is deterring the transformation from the CD to compressed digital music. Who is going to pay for music when they can get it for free? With piracy, right now the market for the purchasing of CODEC music just is not there. This most likely will be an issue for years to come as long as the piracy of digital music is popular.

5.1 Can Piracy be Stopped?

In some ways the pirating of MP3's has helped music sales where it serves as a sampling method for them (as shown earlier in two surveys). For the most part, according to studies and RIAA statistics, it has hurt music sales since the mid-90s. The RIAA would like nothing better than to shut down all pirating and fill their pockets. They would also love to be able to expand into the compressed audio sales market now that digital compressed audio has gained popularity, and reap the benefits without pirating negatively effecting sales.

As computers become a larger and larger part of our every day lives, the idea of large masses of music being sold in compressed digital form over the web comes closer to becoming a reality. To jump on an opportunity such as this would then cut out the middle man in sales and could bring hefty profits to any recording company or software designer. Such an opportunity just waters the mouth of the Big-5 and smaller recording companies all over the world. Once again, who will purchase compressed digital music when it is so easy to get any song imaginable for free? Most people who know anything about compressed digital music or are interested in it started off by downloading free MP3s, and know nothing other than free compressed digital music. For a market and profitable industry to exist, the piracy of the world has to either be close to eliminated, or be contained. Is this a possibility and how could an organization such as the RIAA go about eliminating piracy?

If there is one thing we know about humanity, it is that if someone wants something bad enough, they eventually will find a way to get it. This holds true with piracy on the Internet. With the Internet so massive and a part of more than 1/3 of all households in America and many parts of the world, trying to police it is like eliminating crime in the streets of Los Angeles. There are just too many alleys and streets for people to hide, and too many streets to police. It can only hope to be contained, but it can never be fully controlled.

One major problem is that the knowledge that is used for designing encryption techniques and security measures is also in households and colleges all over the world. Therefore, anything that is created for protection against piracy is often quickly decrypted by a computer hacker only to be shared over the web as if it was not protected in the first

place. Just the mere challenge of cracking a code is often enough to make many people spend their personal time or hobby time fighting security systems. If a code for encryption was created, it can be cracked. As talked about previously, as soon as Liquid Audio and a2b came out on the market, anti-encryption programs for this software were made available throughout the Internet. For a technology that took perhaps months to write, it took only a fraction of that time period to crack it. It is actually very rare to find an encrypted program that has not been decrypted these days. What does this say for the future of encrypting and protecting CODECs? As long as CODEC audio is popular and free on the Internet, there will be a plethora of people that will oppose encryption and software protection. This makes it close to impossible to fully protect compressed digital audio.

Even if by chance audio software was encrypted so well that it was deemed anti-piracy, you can never take away the fact that between a computer and its speakers, audio is back to its pure unprotected waveform and easy to copy. A CODEC album can be totally copy protected and encrypted 1000 times over, but when you take that waveform and run it into an external device (after it runs through the D/A converter known as your sound card), you can easily record it. Possibly this device is another computer or stereo equipment, but the recording can also be done with the same computer. By taking the output waveform from the soundcard and running it back into the PC, it is possible to record the waveform and then re-compress it in any software platform desired. This is probably something that a select amount of people would take the time to do, but once only one person does it, the file can be passed on to thousands in a day. This is one method of copying music that will never be protected, as it is impossible to do so.

The RIAA has attempted ruthlessly to stop piracy ever since the passing of the Net Act in 1997 when it had the law on its side. Because of piracy, web sites have been shut down, people and schools have been threatened, and companies have been sued. But still to this day, people continue to find ways to distribute and download illegal MP3s throughout the Internet and MP3 piracy is only getting stronger. The MP3 platform is just too loose to ever really contain and it will last as long as piracy is tolerant of its quality.

5.2 MPEG-4 and AAC Piracy Future

One of the big questions that looms today is whether or not MP3 piracy will stick around, or if it will cascade onward to bigger and better formats as time goes on. From our study that was mentioned earlier (Appendix A), it showed that the majority of people (52%) thought that the sound quality of the MP3 was only slightly less than that of the quality of an actual CD. Also, 32% of the people thought that the quality was equal to a CD, compared to 16% that thought that it was noticeably less. This tells us that for the most part people are content with the quality of an MP3 file. Will this person that is content with the quality of the MP3 be in a rush to go out and start downloading pirated MPEG-4 audio files instead of MP3's?

MP3 is still extremely popular throughout the world and will remain so for many years to come. AAC and MPEG-4 are available after years of development and have been since 1998. Liquid Audio and a2b both run off of the technology and have been since the release of AAC. Basically it is not a terribly new technology, it just has not been taken advantage of yet like MP3 has been in terms of piracy.

Why is it that the common person has not seen the distribution of MPEG-4 audio? The encryption and copy protection of both software programs were broken nearly weeks after their debuts, so it is not an issue of the SDMI and protection working. Do people have a desire to move onward towards MPEG-4?

Quite possibly going from MP3 to MPEG-4 is similar to going from compact disc to mini-disc. Yes, mini-discs offer more capacity for songs, they are smaller and they allow people to record onto them, but they too have been out on the market for a while and for the most part there has not been a big interest shown in them. People are still stuck on compact discs, and they are comfortable with them and with what they have to offer. Eventually it is very possible that mini-disc will take over for compact disc, but it may be a long, slow process as probably will be the same for the transition from MP3 to MPEG-4.

Since Liquid Audio and a2b are really the only two software programs available today that support AAC, it may not be desirable to most to utilize these programs and pass around pirated programs with those two names on them. Passing around small CODEC files is one thing, but passing around the actual decoder/encoder is another thing. MP3 is easy since anyone can go to sites such as Winamp and download the program. However, if people do not have easy access to a MPEG-4 decoder/encoder on a website, they are not going to grow into the MPEG-4 phase. A company must take advantage of this new AAC technology without the protection and encryption and distribute it as freeware for MPEG-4 to be a major part of the piracy world. Without this, MP3 will stick around for a long, long time.

If a freeware version of AAC is developed then it also has to be able to play MP3's to be something that today's pirates will have interest in. People are so involved with MP3s right now with hundreds to even thousands of MP3's in their archives, that to have a program that will only play MPEG-4 is pointless. This would mean that they would have to start all over again in building up their archives in order to have a better quality sound at a higher compression rate. This, or the digital music on their computers would involve two different types of software for running the two types of files. To most people, this is very undesirable. People (pirates) will want to still run the MP3's that they own, still trade MP3 files, and have the power to also run MPEG-4 files as well. When the freeware and all of this is made fully available, then there will be a huge boom and a changing of the guard (so to speak) in the CODEC piracy world.

5.3 Future of Napster and Napster-type Programs

Although Napster is still in the court system at this time fighting against the RIAA's claims that it promotes piracy and should be banned, the future of this case is of extreme importance. If a program such as this and others like Imesh, CuteMX, Freenet, Wrapster, and Gnullsoft become legal, piracy will be taken to a new level. Programs have never made finding illegal MP3's so easy and quick.

It is extremely popular too as is shown in our survey (Appendix A) where more people utilize Napster (60%) than web sites (53%), FTP sites (48%) or the college network (45%). This is fairly scary considering that the program was just released in the fall of 1999 and our survey took place in February of 2000. If it has become this popular

in a matter of five months. One can only imagine how popular it will become with further advancements in the MP3 searching technology.

If Napster does win its case against the RIAA, it seems time to dismiss any hopes that the record companies had in trying to contain piracy. This would give MP3 trading, downloading, and uploading one common forum that would be stronger than the era before regulation with all of the open websites. In a sense, the whole fight against piracy could take a four-year step back in time.

Even if Napster is shut down, it does not mean that its sister programs will follow the same path. Napster and the other programs are very different because Napster utilizes a central server and the others act as an IRC program that is focused on MP3's. The RIAA will have to attempt totally separate lawsuits on each individual program, which will take months and years. Even if the RIAA is successful against each one, in the end they will have already made their mark on the piracy industry and allowed thousands upon thousands of illegal files to be distributed. For every program that gets shut down, though, another one will arise in the never-ending battle. It seems possible that all of the trouble that the RIAA is going through is only a stalling tactic until a solution can be found.

6 Hardware

The Secured Digital Music Initiative (SDMI) was scheduled to be introduced in 1999 and to be fully in place by the holidays in 1999. Months later, a watermarking scheme, created by the Verance Corporation, had been chosen to implement phase one of SDMI, and BMG Entertainment, EMI Recorded Music, Sony Music Entertainment, Universal Music Group and the Warner Music Group have licensed Verance's audio watermarking system. During phase one, SDMI players purchased will be able to play MP3 files made from current CDs and music encoded from CD by the user, as well as SDMI music downloaded during the Phase one period (as long as it is compatible with the specific file format). But, record companies will begin offering phase two content. To play this music, consumers will have to update the software on their PCs and players. Phase two SDMI player software will be available as a free download. Phase two SDMI software will recognize the embedded watermarked signals, and will use this information to determine whether the user is entitled to play the content. In other words, whether it has been legitimately obtained or pirated. If it is pirated, the portable player and the player software on the user's computer will refuse to play the music. Is this technology that has been argued over for so long finally developing into some sort of working model?

Announced deadline after deadline was missed by the SDMI. Now, months later, the Big 5 record companies are embracing phase one. With the availability of players without any restrictions concerning origin or the number of copies made of a piece of music, it seem very unlikely that consumers will embrace SDMI at all. It is hard to believe that the consumers will be willing to use a new secured digital format that offers

more restrictions than the previous format (the Compact Disc or MP3). Obviously, the consumer is concerned with what added value or feature is available with this new format. And if a consumer can purchase a player that does not impose any restrictions on types of music that can be played on it, why would anyone buy a player that could control what they were able to and not able to listen to on the player?

What will the consumer do if he or she must conform to this secure format in order to obtain music from their favorite artists? It would be safe to say that these consumers would continue to use the CD as the means to get their music. But the method in which the usage of compressed audio will be maintained is also planned to branch into the CD industry where there would be watermarks on CDs for copy protection or limitation. The copying and distribution of CDs is not as high of a priority for the music industry because the passing from one friend to another is so small scale compared to Internet distribution.

However, from the findings of this research, it appears that there will never be a secure format. The security will block the common user from any great abuse until a hacker or pirate finds a way around the security and allows this information to become public. This could be a never-ending battle between the securers and the pirates, but in most cases the decryption of a secure format is a lot easier to do than the effort that it takes to develop the encryption.

The technology is still evolving which makes it very difficult to develop a secure standard for delivering the music. In order to play digital audio, a computer program, such as WinAmp, still sends the data in raw form to a sound card. It is rather simple for anyone with a somewhat good understanding of programming to capture this data and

save it, rendering the watermarking or encryption useless. The software industry learned this lesson 15 years ago the hard way. A number of companies were spending millions of dollars and tens of man-months to protect their software only to find it cracked weeks after release. Software companies eventually gave up and decided to spend their money and time on making good software products instead of protecting their intellectual property. Today, less than 1% of software has any significant form of copy protection on it.

Most of these schemes did not deter the hackers but proved annoying to valid customers. BMG Entertainment attempted to put copy protection on all of its CDs sold in Germany in the beginning of 2000. The effort backfired as many paying customers discovered that their legitimate CDs would not play on some car and portable players. Needless to say, that effort was halted and non- copy protected CDs were returned to stores. BMG did say that they would re-engineer the technology and try to implement it again. It does appear that these technologies that are developed to help the record industry control the distribution of their music are not very consumer friendly. So these technologies that seem to be easily bypassed by experienced computer users and cause problems for consumers do not make sense to many people. One wonders if it would be easier for the Music Industry to change its business model to embrace the Internet and utilize different avenues for profits.

There are also many hindrances in the Hardware Industry that seem to block many consumers from using and purchasing compressed audio. At this time, many secure format guidelines allow playback of a purchased song on only one player. The song would not be able to play on another identical play or any other player for that matter.

Because of this, a consumer would have to purchase a song multiple times to be able to listen to the song at home, on a portable player, and in the car. If there were some sort of memory card that could be transferred from player to player without allowing widespread copying, more consumers would probably be interested. However, current memory limitations, mostly because of price, keep most portable memory cards at or below 128 MB. When, some day in the future, it is possible to afford a 1 GB memory card that could carry hundreds of songs and still be small enough for high portability, it seems that interest in compressed audio would increase greatly.

Currently the ability to transfer or store compressed audio files by burning the files onto CDs or using a Zip or Jaz disk is useful for computer to computer use. But, music is listened to away from the computer in many aspects of daily life. Also the emergence of more CD players capable of playing MP3 files on the market would stimulate the compressed audio industry attracting more consumers. These technological advances in hardware and many others in the near future will greatly expand the industry.

7 Scenarios

Some strong speculations and predictions can be made as to where the CODEC market and CODEC piracy will go in the next few decades, but, for the most part, there is no clear cut path as to what will happen in the near future. Undoubtedly, within the last five years, the MP3 market has grown strongly, up to the point where it is beginning to effect the music industry. Looking at the college level in our survey (Appendix A), 87% of the people who took it have MP3s in their possession. But where does it all go from here? Will the audio CODEC only gain popularity in the piracy world? How will the RIAA react to piracy in the future, and what will become of the Big-5? Will the audio CODEC ever take over the music market and fade away the compact disc?

This section will highlight some interesting scenarios that may happen in the future, and bring up some topics and issues that may open up the mind. The overall issue of the audio CODEC revolves around business profits, losses, growth and chances. One large breakthrough in technology could change the entire scheme of things and one gutsy company could skew the industry. It is hard to say who is out there that is willing to stick their neck out and grab a hold of the powerful technology of the CODEC, and very hard to predict. However, the possibilities can be looked at right now for the preparation of the future.

7.1 Scenario #1

What will it take right now and in the next few years for a consumer to purchase a CODEC album?

With the new CODEC breakthrough that is available in AAC and MPEG-4, the sound quality is better than it has ever been. It takes a fairly good ear to even be able to tell the difference between a CODEC and a compact disc. If people are not able to tell the difference, what is keeping everyone away from purchasing CODECs right now, besides the fact that the hardware has not been taken far enough yet?

For one, the average person today is used to free MP3's, which makes it very hard for people to go out and pay money for MP3's. People involved with MP3 piracy are uncomfortable with the idea of purchasing CODECs. In retrospect, according to companies such as Liquid Audio and a2b, they are turning out profits and people are purchasing their songs and software. Yes, it is very little in comparison to the compact disc market, but it does exist. Look at our survey (Appendix A) where 10.8% have purchased music from MP3.com, 2.1% from Liquid Audio and 4.3 from other companies. These are college students, who all have access to networks and friends for downloading pirated music. What makes these people want to purchase CODECs right now?

If someone pirates MP3's but cannot find a particular album or song, and they spend a lot of their social life around the computer, then that person may be apt to purchase that song or album. To them, being able to buy the one song that they like for

$2.00 instead of buying a CD or single from $7.00 to $15.00, may be a plus and worth the investment.

What if there is a small band from across the US that does not sell their CD in certain regional areas, but consumers in these areas would like to obtain their album somehow? If you cannot find it for free on the Internet, or all of the album for free, then purchasing it for around $5.00 is a great deal and the only alternative.

Of course, there could always be that person that is against piracy, or does not know how to find pirated copies of an album. If they know how to use the Internet at least a little bit and a CODEC version of a song or album that they like is available, then they may want to make a purchase and sample CODECs.

No matter what the reason, all of the above seem to come down to the issue of whether a song or album is available for free, and if not, what the price of the CODEC is. Right now, CODEC sales mainly involve artists and groups that have not been exposed to the big music market. Their CDs may be sparse, or they are looking to someday make it big and gain popularity. With these groups, it is less likely that their albums are floating around the Internet for free than a group such as Dave Mathews Band, so there is a market for them right now, and the CODEC market is riding on them. The CODEC market can live comfortably off of them, but it will never beat out the CD market unless the big groups release their music through CODECs, and those people who normally purchase CDs, purchase CODECs instead.

It can never be expected that CODEC pirates will start purchasing CODECs, but those who are buying the CDs right now are feeding the mouths of the recording industry. Those people will always exist and they have to for the music industry to have a future.

What those people decide to do will have the greatest effect on the industry and will determine in what format music will exist.

7.2 Scenario #2

If a CODEC player is available on the market that can be used as a portable device and in an automobile, it can hold an entire archive of music, and the price of a CODEC album is cheaper than the price of a CD, will consumers then purchase the CODEC instead of the CD?

One of the biggest questions right now is exactly what will it take for consumers to prefer the CODEC market over the compact disc market? We know that the CODEC is extremely popular with pirates, but can it ever become an item that can make money for the music industry in some way?

A key limitation that exists is with the hardware that is available for playing CODECS. People desire portability with their music. They want it in the automobile, in their pocket, in the office, and in the home stereo system. This is currently available with the compact disc and has been for years, so the CODEC would have to find a way to beat this out to be a part of the market. By just being able to hold a few album's worth of music on a CODEC playing device, such as the Diamond Rio, is not enough for most consumers to prefer the audio CODEC instead of a CD. What if a company advanced flash memory enough to allow a portable player to hold gigabytes worth of music or a person's entire music archive? Couple this with the ability to take this device and

connect it to an automobile and home stereo and you then have a plateau that the compact disc can never reach.

No more flipping through CDs and taking them out of cases. No more having to choose which select CDs you would like to bring on a road trip. Everything is always with you wherever you go, whenever you want it. Could there be a more desirable situation in music collection? Something like this would change the hardware audio market around, but what would stop someone from purchasing the CD and then converting it to CODEC form?

In this case, the audio CODEC would have to be cheaper than the compact disc for people to purchase them. If everyone wants to use the CODEC players, and everyone is going to convert their music to CODEC form anyway, then people will buy the cheapest format possible before they convert it. So if the cheapest format is already in CODEC form, then people will then purchase the CODECS and the music market will forever be changed. The compact disc will end up being just another rung in the ladder.

In our opinion, this is the only way that the audio CODEC will ever take over for the compact disc market. Because there is a step down in the overall quality in going from CD to CODEC (as little as it may be), there has to be a reason that a consumer will want to make this sacrifice. Two reasons are always convenience and price and if the hardware changes and the CODECS are cheaper, then a change will occur.

There will also be those people who prefer a hard copy of an album or song no matter what. In an interview with student Danilo Sabino of Worcester Polytechnic Institute, he claimed that no matter how good the hardware gets for CODECs or how cheap the files become, he would still rather have a physical object to hold his music.

This includes cassettes, compact discs, and mini-discs. He also said that he has a sensitive ear, as many do, and he can tell the difference in the high frequencies where CODECS tend to filter it out. As a musician, the sound quality on a compact disc is very important to him.

7.3 Changing Business Models in the Music Industry

It seems from the arguments put forth that piracy can continue to grow to a point where the music industry will have difficulty collecting the revenue necessary to compensate artists for their music in the near future. With the current business model of the industry, the Internet is not embraced for the distribution of compressed audio files. While the technology world is trudging forward with the new means of music delivery and players, the music industry is trying to halt this technological advancement until a method of controlling it is in place. However, it is very possible from the presentation of the facts that there will never be a completely secure format.

The music industry appears to want to maintain its current music delivery system which they have pretty good control of it. Piracy exists in this system because of CD burners and other such technologies, but it in no way compares to the amount of piracy created by the Internet because of the number of people it is capable of reaching. As more of the insecure compressed formats reach the Internet, more people will be exposed to them. Once exposed, these users can obtain their music without, in most cases, paying for it. There are still hindrances in this process concerning sound quality and the length

of time it takes to download a song, but these issues will most likely disappear in the next few years.

Once these issues are no longer important, many consumers will be able to obtain all of the music they want from the Internet without having to pay for most of it. Of course, the "secured" formats, as proposed by SDMI, may slow down this process, but history has proven that most efforts of securing software or music have been cracked and proven meaningless. The question posed from this eventual result asks that if piracy grows larger and larger and severely hurts the music industry's revenues, what actions will they take to remedy this problem?

As mentioned previously, the music industry is backing the Secure Digital Music Initiative, which they believe will control piracy and the distribution of this pirated music. What if this effort fails because of some of the aforementioned issues? If the money is not being collected for the artists, many artists will be forced to pursue other occupations to make money. What can the music industry do to keep collecting revenues even with the existence of piracy?

Upon the arrival of the blank tape on the market, the record industry feared loss of revenues because music could be copied from its original form of media to these blank tapes. In order to recover part or all of this lost revenue, blank tape manufacturers are forced to pay a certain amount of money to the music industry for every tape that it sells. The same ruling now applies to Blank CD manufacturers as well. In following this format, would it be possible for the music industry to look elsewhere for the revenues that it loses from piracy?

It is possible for the music industry to track Internet Service Providers (ISPs) or Internet browsers in order to recover the lost revenue. The music industry might argue that these parties are responsible for the distribution of the pirated music. The ISP customers utilize Netscape or Microsoft Internet Explorer to obtain these illegal music files. Maybe the courts could decide that these parties are earning revenue as a result of Internet users downloading these files whether it is through a monthly fee or advertising revenue. It may be time for the music industry to pursue other avenues in an effort to obtain the revenue that they require.

Similarly, software such as Napster, that appears to be designed primarily for the transfer of pirated, compressed music, should be held responsible for compensating the music industry for lost revenues. While there are currently no advertisements incorporated with Napster, one could imagine that many companies would be interested in advertising with such a company like Napster based on the amount of traffic that the software sees. Napster might then pay a percentage of the advertising revenues to the music industry.

It might also be feasible for the music industry to attempt to recover revenue from hardware manufacturers. They could argue that the modem is the means of delivery of this pirated music, and, therefore, modem manufactures should pay a percentage to the industry. It might be more feasible to require compressed audio player manufacturers to pay a tax because their players are capable of playing insecure formats.

Of course, any of these suggestions would require intervention by the courts or Congress to ever become a reality. Some may even seem far-fetched or impossible. However, it does appear that piracy will not be easily stopped or controlled in the Internet

age. As a result of this, the music industry might want to accept this and change their business model in a manner that will allow them to continue earning the revenue required for the music industry to continue producing quality music for consumers.

8 Conclusion

It appears that the music industry is attempting to stall the Internet music age until it has a full control over the technologies involved. While this new age could add to the revenues of these companies and artists, it still carries with it, the fear that large-scale piracy, associated with the Internet, could ruin the industry as it is currently organized. Of course, it makes sense that the music industry would not want to abandon a business model that has bore such wealth, but the industry must remember that the consumer is still the source of this wealth. As a result of this, the satisfaction of the consumer should be a major concern of the industry.

The added convenience and lower cost of music distribution, utilizing the Internet, are very attractive to the consumer. It seems that it is only a matter of time before the music industry must acknowledge consumer demands in the form of results. No longer will they be able to stall with lawsuits and promises of secure music (SDMI). It will take action by the industry to satisfy the demands of the consumers in a form that embraces the Internet music age with all of its benefits and its downfalls as well.

When looking at piracy, the biggest question that has come up concerns its longevity and whether or not there is a future in the audio CODEC. Piracy of any software is a fire on the Internet that cannot and will never be put out. As long as data transmission exists, piracy will exist along with it, and this is something that can never be fully policed without somehow infringing on the rights of the consumer. Piracy of MP3s and other CODECs is especially large and such a huge part of this flame.

Many attempts at shutting down and controlling MP3 piracy have occurred in the last half of this decade, but it has only found a way to grow stronger. Shutting down web

sites and MP3 search engines was a minor setback for piracy, and possibly the banning of Napster may do the same for a short time. But as stated before, Napster is only the start of a series of MP3 exchanging forums. For every one that may fall to a lawsuit from the RIAA or other interested party, one more will emerge to try to capture the attention of pirates everywhere.

Why will software such as Napster keep emerging? The companies and people that are creating this exchange software can prosper from large sums of advertising revenue due to the amount of exposure that the software receives. The more piracy, the more people using these programs, the more money for software designers, the more software, and then once again, the more piracy. It is a vicious circle that keeps feeding itself and gaining momentum.

One downfall that Napster has seen is the banning and firewalling of the program from major colleges across the U.S., including WPI. Some of this is due to the controversy between the RIAA and Napster, but mostly it involves the network bandwidth that the users of Napster are taking up. Such use is lagging the networks harshly and is effecting other student's use. But this is a problem that can be dealt with by the software companies such as Napster and will soon be improved to bring the program back into these colleges. Other software programs that involve an IRC type format cannot be firewalled or banned by colleges unless the campus networks stop all file transfer from outside the networks. This scenario cannot happen since educational systems are now built upon the use of the Internet and file transferring from the outside world. Furthermore, these programs will continue to exist and be a large part of the college atmosphere for many years to come.

The MP3 is a revolutionary technology that many people have accepted as a substitute for the compact disc. But with the emergence of AAC and MPEG-4, the digital audio world is in store for many bigger and brighter things. Right now, its use can be seen in programs such as Liquid Audio and a2b. However, it has not hit the piracy underground yet. As the history of the Internet can tell us, it is only a matter of time. All it will take is one freeware company to stick their neck out and capture the MPEG-4 technology, as Winamp did with the MP3. There is too much profit and potential for a company not to do so in the next few years. To create an encoder/decoder that can play MPEG-4 as well as MP3 without security and copy protection would step up piracy to the next level, and it will happen. Perhaps not this year, but it will happen.

For every new CODEC technology that comes out, a freeware version of it will flourish, as will piracy. Side by side, the commercial CODEC industry and piracy will exist and involve the same technology. For those that perform piracy, the music that they can get for free will continue to take away from CD and CODEC sales. People that choose not to pirate music or do not get heavily involved with piracy will feed the recording industry and keep alive the CODEC market. But the CODEC market will be one of slow growth, forever burdened by piracy.

The overall issue of the stalling of the music industry versus the demand of the consumer boils down the concepts of money and convenience. It is convenient for the record industry to remain in their current business model because of the great profits it currently collects. However, the consumer wants the conveniences that the delivery of music, via the Internet, can provide at a price that is a fraction of the current price of a CD.

It has been demonstrated that the distribution of music over the Internet can not be stopped. Most likely the music industry can continue profiting using its current model for a number of years to come, but as more consumers utilize the Internet as the major source to acquire their music, the profits of the music industry will surely decline. It is because of this fact that it seems most feasible for the music industry to no longer battle with the consumer and Internet music and instead embrace this music form and work to continue satisfying consumers while finding new sources for income.

Of course, this concept is not as simple as it is presented here, but it seems necessary for the survival of the current members of the music industry. Without any efforts in this direction, it seems logical that music piracy will continue to increase to a point where the purchase of music will no longer be necessary for any consumer. Following this line would forever change the structure and distribution of money in the music industry.

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10 Appendix A

1. How many MP3's do you possess?

0 12 1-25 7 26-100 17 101-250 13 250+ 43

2. Do you realize that downloading copyrighted MP3's is illegal?

Yes 82 No 10

3. Do you feel that the intellectual property (copyright) of artists should be protected?

Yes 52 No 38

4. Have you purchased a recording after hearing it on MP3?

Yes 61 No 30

5. Have you ever not purchased a recording after hearing it on MP3 and disliking it?

Yes 60 No 31

6. Have you ever not purchased a recording because you downloaded it on MP3?

Yes 55 No 36

7. How do you compare the sound quality of an MP3 file to a CD?

Noticeably Less 14 Slightly Less 46 The Same 29

8. Have you ever created an MP3 from another source (CDs, Cassettes, etc.)?

Yes 60 No 31

9. Where do you download your MP3's from? (check all that apply)

College Network 41 FTP Sites 44 Napster 55 Web Sites 49

10. Where do you currently obtain CDs from? (check all that apply)

Store 83 Online 39 Mail Order 32 CD Copying 37

11. Have you ever purchased downloadable music from:

MP3.com 10 Liquid Audio 2 a2b 0 Other 4