

The Digital Music Revolution and Consumers

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Abstract:

How the advent of widespread lossy compression technologies, most notably MP3, directly affects the music consumer.

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A Timeline to Today:

The AM transistor radio first allowed consumers to listen to music when they were on the go. They could change stations, but not the songs. Portable tape players allowed more control over the selection of music, but tapes took up a lot of room and suffered degradation over time. The first true digital music revolution took off in the early nineties with the compact disc. CDs store music on a metal and plastic disc as ones and zeros. This allows CDs to be lightweight, high quality and long lasting.

Today, lossy compression algorithms can compress digital music files. The compressed files are small enough to fit hundreds on one CD, easily transfer over the internet or load onto a personal digital audio device. The widespread availability and the ease of use of this technology, has helped it to grow from an obscure technical standard to mainstream use for music listening and distribution.

Compression

Audio is compressed using mathematical processes known as algorithms. A compression algorithm can be lossless or lossy. Lossless compression is used when the data cannot be changed such as when storing text documents on a computer. Lossy compression, on the other hand, changes the data so that it is similar but not quite same as the original. Using lossy compression, a digital audio file (such as that from a CD) can be shrunk down to one-twelfth of its original size without losing significant sound quality. This can be understood by examining how the ear hears.

The Art of Hearing

One important phenomenon that can be harnessed to contribute to audio compression is called masking. When sound reaches the inner ear, it is broken up into critical frequency bands which are like groups of notes that are close to each other. The ear causes tones within one frequency band to be blurred together, causing a loss of information. When more than one tone is present in the same critical frequency band, the quieter tones are effectively masked or hidden. Since these masked tones are inaudible, audio compression algorithms can remove the masked tones, which means less information is necessary to maintain the sound quality. Another technique involved in digital audio compression is quantization. Quantization places significance on each bit of audio, giving more significance to more important or complex parts of music, and less significance to less important parts. In this way, irrelevant parts of the audio signal can be removed to additionally decrease the file's size with a small quality reduction.

The MP3 Algorithm

There are many different forms of audio compression, each with a unique way of handling techniques such as masking and quantization. The most widely-recognized and available lossy audio compression format is known as MP3, which is short for MPEG Level-1 Layer-3 Audio. The name MP3 also usually refers to Layers 1 and 2 as well. The first step of

MP3 encoding is splitting the incoming signal into critical frequency bands. Through the knowledge of these frequency bands, masking removes inaudible tones. Another process involved in MP3 compression analyzes the redundancies from the two channels of a stereo signal (which often contain significantly identical material) in order to reduce the bit rate. In addition, quantization is also performed as explained above.

In most MP3 encoding programs, the user can select the bit rate for the output audio file. Bit rate is the amount of data that is used to represent a portion of the signal over a given amount of time. A bit rate of 128 kilobits per second (kbps) is generally accepted as near-CD quality, while lower bit rates provide greater compression with an audible decrease in quality and higher bit rates provide more quality when necessary. It should be noted that using even the highest bit rate for compression cannot produce a compressed file which when played back is identical to its original digital source. MP3 coding is a lossy form of compression, so even though the human ear may not discern a drop in quality, differences do exist.

The Internet Factor

With an entire industry devoted to hardware that can play MP3s, consumers are continuously looking for new and easy ways of getting MP3s, and the marketplace has responded. Most of the MP3s in consumers' libraries, either on their hard drives, CDs or memory cards, were originally tracks from audio CDs. In the process of "ripping," software on a computer reads the audio data from a CD and compresses that data into MP3 format. MP3s can also be created directly from artists who may record their music live onto a computer, or may even create their music completely digitally. Once an MP3 is created, it can be distributed in any fashion, maintaining the quality of the original without any loss beyond what was introduced in the lossy MP3 compression itself.

The Internet is the primary medium for distribution of mp3s. Websites exist that offer MP3s to download both free and for a fee. These websites use MP3s to promote new artists that may not be signed with a major record label. The MP3 downloads spur music sales both online and in stores. One such website, MP3.com, offers both free and for-pay digital music downloads and services to artists of all genres. There are also file sharing programs that allow users to share their files with other users. Examples of such programs are Audiogalaxy and Morpheus, which allow users to interact with other users directly (known as peer to peer sharing) or through a central server. These programs allow users to expand their MP3 music collection by downloading MP3s from other people, usually in return for opening up their own MP3 music collection to others. Before high-speed internet connections, this was not much of an issue, but today file sharing of this type is rampant. The RIAA and its supporters argue that most of the music shared and transferred online is copyrighted and therefore constitutes piracy.

MP3s and the Consumer

MP3s have become the modern day equivalent of cassette tapes, only perfect. An entire industry has evolved around digital music, with MP3s in the spotlight. Powerful and cheap

computers were the catalyst to start the digital music craze, having the processing power available to compute the MP3 encoding and decoding algorithms. At first, MP3s were only toys for computer savvy people, but as the software got easier to use and internet use expanded, more and more people started to get into MP3s. Digital music was first limited to the computer. Instead of playing MP3s on computer speakers, some people decompressed MP3 into a file and used CD recorders to *burn* standard audio CDs. Most CD burning software has now automated this process.

Diamond Multimedia started the hardware industry frenzy with the introduction of the RIO, which was a portable digital audio player. It used a memory card to hold about half an hour of MP3s compressed music and had a digital signal processor to decode and playback MP3s. After an initial snag with the Recording Industry Association of America (RIAA), the courts ruled in favor of Diamond and the MP3 player boom was born.

Today there are three main types of personal digital audio devices. Devices based around a memory cards, such as the RIO, are by far the most popular. These have no moving parts and are small, lightweight and unaffected by mechanical shock but can only hold about 64 megabytes (MB) of memory, which is about an hour of music. Another type of player is a combination of a portable CD player with an MP3 decoder, which allows the user to burn MP3 files directly to a CD without decompressing them. At 700 MB per fifty-cent CD, this is much cheaper, but is prone to skip if jostled too much just like a normal CD player. The third type of player contains a computer hard drive that can hold over 20,000 MB. These devices can hold more than just music files but are much more expensive and fragile.

These products allow consumers to listen to mp3s virtually anywhere for an affordable price. People can choose between the bulkier hard drive and CD based MP3 players that hold an enormous amount of music. Those who prefer a lighter, more maneuverable version of portables have memory card based products to choose from. There is an entire market of products that make listening to music a thoroughly pleasant and fulfilling experience. Furthermore, these products appeal to a wide range of people due to their ease of use and low costs, bringing technology and music to everyone.

Changing Distribution Methods

Before MP3s became mainstream, the sole way to hear new music was for a recording label to pay radio stations to play their artists' new songs. Listeners could not choose which songs or which artists the radio station played. Consumers bought CD based on songs they heard on the radio. MP3s have given artists a new option of distributing their music without having to pay promotional and manufacturing fees. It is cheaper for bands to make and distribute MP3s and custom printed CDs. The artist can go directly to market instead of going through the recording labels, which prefer artists that will guarantee them a profit. By allowing consumers direct access to artists, they are exposed to music they might not otherwise hear. Furthermore, through file sharing programs over the internet, consumers can listen to albums before they decide to buy them.

The RIAA believes that downloading MP3s violates the law and considers this piracy. The RIAA says that they will lose \$10 billion per year by 2003 due to online piracy. However, analysts believe there is no way to quantify loss of sales when no sales were made. A study by the Digital Media Association showed that 59 percent of internet music users say they've purchased music because they heard it online. Even the RIAAs said there was an 8% increase in CD sales during the boom of Napster in 2000. In either case, MP3s and lossy compression technology have created a new market for artists and advertisers that is cheaper and easier than traditional music distribution schemes. MP3s make it much easier for artists to interact with their potential audience and not worry about paying middlemen along the way.

Copying, Fair use and First Sale rights

Although MP3 technology is easy to use, mature and widespread, its use has raised serious issues for consumers, artists and the music industry. The internet and the availability of easy to use software and hardware has increased the ease at which people can create, copy and distribute music. But the act of copying music without the permission of the copyright owner can be illegal in some instances.

For instance, when Joe buys a CD, he buys a piece of plastic and metal encoded with music information. According to what's known as *fair use*, Joe is allowed to make a copy of this lawfully obtained copyrighted information as long as it is for his personal use. This can include making mix tapes, or making MP3s to store on his computer or personal audio device. What allows him to do anything he wants with the CD is called the *First-Sale Doctrine*. Once the product has been sold to the consumer, the seller no longer has control of the product. Copyright law still applies to the product but as long as the consumer follows the law, he or she can do anything with what they've purchased. Joe is allowed by the first-sale doctrine to sell a CD he's purchased to someone else because the store no longer owns it.

The music industry argues that although Joe has bought the CD, he doesn't own the music but rather has been given an individual license to listen to that music. That license prohibits certain uses of the music on the CD and undercuts Joe's first-sale rights. Although the industry has had little success in enforcing this policy with CDs, they have been using it with compressed music sales. Instead of buying a CD, Joe could have purchased an album of music online in a protected MP3 format. Then the purchase is somewhat like renting a movie that only plays in one VCR. Joe can only listen to the music on his computer or on certain types of audio players that have been licensed by the RIAA. Joe is also prevented from transferring the music anywhere else or selling it to anyone even though he has purchased it.

Copy Protection for Control

The MP3 format itself has no built in copy protection controls. Other system must be used to prevent copying. These technologies are known as DRM or Digital Rights Management. There are many different DRM systems, but all serve the same purpose: to control the use of music and data after it has left the direct control of the copyright owner. *Watermarking* as a

DRM scheme is pure gold for the music industry, which has been very vocal about how MP3-based piracy is hurting business. In response, they have created tools to control distribution and listening, one of which is watermarking. Watermarking hides data within an audio signal that is supposed to be inaudible and irremovable, acting like a fingerprint or ID tag. This is like the images in U.S. currency that are invisible until held to a light.

Watermarking adds information to the music signal, altering the original music. The industry has been saying that the watermark is inaudible, but many others disagree. Brian Dipert, technical editor of EDN magazine, attended a audition of watermarking schemes and was able to pick out the watermarked selection in eight of ten attempts. He says, "Why would [consumers] pay thousands of dollars for equipment... to listen to media that they perceive has less-than-optimal quality because of a watermark?"

In order to combat the creation of MP3s in the first place, the music industry has started producing copy-protected CDs. These CDs have errors introduced into the data on them that prevents most computers from reading them. Even some standard stereo equipment cannot play these copy-protected CDs. The user is prevented from exercising his or her fair-use and first-sale rights because of the errors in the CD.

The Digital Millennium Copyright Act

What makes these DRM schemes effective is the existence of the Digital Millennium Copyright Act of 1998 (DMCA). The DMCA was meant to bridge the difference between the older copyright laws and the digital age to protect copyright owners. However, many consumers and industry watchdog groups are unhappy that it was rushed through Congress with vague language that only protects the copyright owners and not the public. Of the many clauses in the DMCA, the most harmful and disputed criminalizes the creation, distribution and use of any technology that is able to circumvent or bypass copyright protection or DRM systems. This has had a negative effect on all forms of digital technology. Licensing and DRM schemes prevent the consumers from exercising their first-sale and fair use rights and the DMCA outlaws any attempts to take back those rights. Technologies exist that can remove the restrictions of DRM and even repair the damage caused by watermarking, but the use of such technologies is currently illegal. The DMCA has even affected free speech rights with programmers and researchers. The industry has used the DMCA to threaten Dr. Felten and his team of Princeton scientists from publishing academic research in this area.

Consumers should be aware of forthcoming legislation to further protect the copyright holders and the recording industry. The Security Systems Standards and Certification Act (SSSCA) sponsored by Senator Fritz Hollings will federally mandate DRM copy protection in all electronic devices owned, sold, created or used within the United States. Fred von Lohmann, Senior Intellectual Property Attorney of the Electronic Frontier Foundation explains: "According to the SSSCA, Congress will rely on technology companies and content companies to select DRM systems based on criteria set by Congress. If the industries are unable to agree, federal bureaucrats will choose. The public is not invited to participate, nor do the criteria set out in the

SSSCA require the preservation or protection of fair use, first sale, the public domain, or any of the other rights reserved for the public by copyright law.”

A New Way to Listen

MP3s are not the only or best lossy compression technology, but the MP3 format has paved the way for an entire industry, new music communities, and new marketing. The result has brought new and exciting music experiences to the consumer. However, change always comes with problems, and the MP3 revolution has raised important ethical and legal issues that are still being sorted out in the courts. It is important for consumers, artists and the music and technology industries to create and maintain an open environment that benefits everyone, even if it requires change and compromise.

Sidebar: DivX, The MP3 of Video?

As broadband internet access becomes increasingly common in homes, a new battle is forming between consumers and the Motion Picture Association of America (MPAA). Using MPEG-4 compression, full-length films can be distributed over the internet. Over the past year, the DivX file format, a modified version of MPEG-4, has become increasingly common on fast networks, like those on college campuses. Although too large to be transferred over dial-up internet connections, a DivX-compressed film can be downloaded in as little as five minutes given the right circumstances. DivX files can be burned to CDs to be saved or distributed.

Video compression works similarly to audio compression. The compression technique eliminates as much unneeded content as possible. For example, if a scene from a movie shows a woman talking to an unmoving camera for fifteen seconds, the background remains mostly unchanged. Since this background is irrelevant to the current scene, instead of rendering it thirty times a second it may only need to be rendered ten times a second. This saves frames from being rendered, which decreases the size of the video file. The audio track is compressed using a standard audio compression format, which in many cases is MP3.

With the increased use of DivX and file sharing technology, internet piracy has become a concern. The MPAA is aware of such piracy, and their organization’s web site stresses the importance of protecting copyright, specifically through the Digital Millennium Copyright Act (DMCA). The MPAA has tried to use copyright protection schemes and the DMCA to protect video such as that on DVDs. However, copy protection technology has proved to be easily defeatable and lawsuits currently challenge the fairness and motivations behind the DMCA.

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