**Title:**
Why did Minidisc never get a proper grip on the market? A technical comparison of the Minidisc and other digital audio formats.

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**Abstract:**
Minidisc was hugely hyped both before and after its release. It was expected to take over from the cassette, to be the next big thing, but it never took off. The aim is to find out why this result occurred. After researching into many other types of digital audio format it became clear that the Minidisk was really nothing that new or innovative and that it, to me, seemed doomed from the start. The CD was the audio format of choice and nothing really had a chance to run alongside this.

**Introduction:**
Released in 1992 by Sony, only 10 years after the Compact Disk reached the consumer market, Minidisc was the next big thing in digital audio. It is a cross between CD and cassette, but only 7cm by 6.75cm by 0.5 cm, with the disc inside being only 64mm in diameter. Much like a cassettes you can record from any audio source and playback through headphones or a home HiFi, and like a CD the audio is stored digitally, the sound quality is excellent and it is randomly accessible. Unlike the CD and cassette though, you can record audio as many times as you wish and also move, delete and name tracks. From the above information you would imagine Minidisc to have grabbed the market, and to have challenged the cassette and maybe even CD for the title of preferred music format. But this never happened. From the release date to the current day, the Minidisc has had a slow time gaining momentum in the home music market and the aim of this paper is to compare the technologies of the Minidisc to those of other available digital audio formats, and to try and come up with reasons why the Minidisc never flourished.

**Minidisc**
Minidisc works by compressing the 16 bit 44.1 KHz digital signal, using a compression algorithm called ATRAC(Adaptive TRansform Acoustic Coding). This compression is very important seeing as the Minidisc can only hold up to 160Mb of audio data. ATRAC works by dividing the signal into 52 sub-bands in the frequency domain, these are then analysed by a psycho-acoustic transfer function which removes enough of the sound not hearable to the average human ear to compress the audio to 1/5th of the original size. Obviously compression of this kind, or any other kind, can lead to lossy, degredated sound quality, as these types of compression do not attempt to preserve every bit of data, just the acoustically important bits. When first released, the Mindisc sound quality difference from that of a CD was discernable without even a great deal of concentration. However the ATRAC algorithm has been worked on and improved greatly over the years, and now it requires careful hearing with expensive equipment to hear any difference between a CD original and an
MD recording. This lack in quality for a long while of the Minidisc's life could be one of the main reasons that the format never took off, after all CD's had been long established and still had a better sound quality.

The next new thing with the Minidisc is that you can record and re-record, up to a million times. A system much like that of a computers hard drive is used in order to make this possible. Each disc has a table of contents (TOC) which stores a list of starting/ending positions and names for each track. This means total random access is available and that deleted tracks can just be removed from the TOC and then the freed up space can be reused. This capability had only really been seen in CD-R's as CD-MO's, released in 1989, and also the Philips DCC. Although recording must be done in real time, the major advantage is that recording can take place anywhere, not just on a personal computer. When linked to a audio source, such as a CD player, microphone or tape deck, a Minidisc recorder will record in real time up to 74 minutes of digital audio. This made it possible to take your player around to a friends house and record any music you wish, and then be able to take it away and listen to it at any time. You can name and divide the tracks how you wish, and move and delete tracks when needed. There is a security mechanism, called SCMS, to stop the multiple copying of copyrighted music. This works when a Minidisc is recorded, by adding the SCMS information to the Minidisc which prevents it being copied to another Minidisc.

Two versions of a Minidisc player are available; the standard player, used only to play back Minidiscs, and a recorder, which can be used for playback and recording. The pocket sized units were very expensive when released and this is probably the main reason that sales were poor. Now the players and recorders are a lot cheaper, but are still about 2 or 3 times the price of a portable CD player. There are a limited selection of pre-recorded titles available, but these have sold and are still selling very slowly, because of the ease to record music that you do not actually own.

This sums up most of the information about the Minidisc format, and shows where it's advantages lie. This paper will now outline the other competing digital audio formats of; the compact disk, MP3's and the internet, DVD Audio, DAT, DCC and other future formats, in order to try and understand why Minidisc has not been as popular as expected.

**Compact Disk**

Compact Disk (CD) was released in the early 1980's, 10 years before the Minidisc, and took the market by storm. The new advantages, such as; size, random access, sound quality and general practicality meant that CD replaced vinyl in many places within a very short time. An audio CD uses a 16-quantization and 44.1 KHz sampled digital audio, which is roughly double that audible to humans (22KHz). The standard for CD-DA (CD-Digital Audio) is known as the Red Book standard and was defined by Philips and Sony in 1980. It states how the disk is arranged using the familiar TOC to record the track locations, and the data is arranged in 24 byte frames. The data is not arranged in distinct physical units but frames are interleaved so that scratches will not destroy a single frame beyond correction.

The design and release of the CD-R and CD-MO where the next big step for CD-
DA. With CD-R being recordable and CD-MO being re-recordable, you could now not only play audio CD's but also copy them, with the correct equipment. CD writers, started out at quite an expensive price, but dropped rapidly as they became more popular and the available technology increased, at the moment you can get a CD writer for as little as £60. There are also portable CD writers on the market now, meaning that even if you do not own a PC then you are still able to copy CD, and you can do it anywhere. The major advantage with CD writing over writing to Minidisc is that CD's can store not only digital audio but also data. The capacity of a CD is either 650Mb or 700 Mb compared to just 160Mb for a Minidisc and the writing speed for CD's can go over 16 times meaning a whole CD can be written in under 5 minutes compared to real time for a Minidisc. Music labels are now taking advantage of the ability to write data to a CD as well as digital audio. Many modern music CD's come with extras on the CD, such as videos and artist information, something which the Minidisc is unable to do. Minidisc may be able to write anywhere but so many people have PC's nowadays that CD is often the most practical and suitable decision.

There is still a lot of research and work being done on CD-DA and this has most recently resulted in the creation of HDCD (High Definition Compatible Digital). This is a patented process for delivering on CD the full richness and detail of the original microphone feed. When listening to an HDCD recording you get a better dynamic range and extremely natural vocal and musical timbre. This can be done because HDCDs are encoded with 20 bits of real musical information compared to 16 bits for all other CD's and also Minidisc. The extra 4 bits are encoded onto the CD while maintaining compatibility with the original CD format. Although these HDCDs can be listened to on any CD player, you will only get the extra sound quality if you listen to them on a player with HDCD decoding. This may be a problem at the moment but in the future I can easily see all CD drives and players having the capability to decode HDCD as standard, further strengthening the position of the CD for audio purposes. This will also be available to Minidisc players in the future, but for the moment it available only for CD.

Internet and the MP3

Although the CD is still by far the most popular digital audio format, with the internet revolution and the availability of PCs, formats such as MP3 (MPEG Audio Layer-3) and WMA (Windows Media Audio) are becoming more and more popular. They are small enough to store a large amount in a relatively small space and the sound quality is surprisingly good when recorded at a reasonable bit rate. These files are typically only 1/10 the size of the corresponding track from a CD, that is double the compression of Minidisc. This is accomplished by psycho-acoustic data storage, much like the way in which ATRAC works. In the same way as the JPEG image format will discard certain data that is beyond the human eye's ability to perceive, so does MP3. The severity of the data loss is measured in terms of bit rate. A CD is recorded at a bit rate of 1411 Kbps whereas a high quality MP3 is recorded at 192Kbps or even 320Kbps. Most though, are recorded at 128Kbps which is enough that many people would not recognise the difference between the
MP3 and the original CD format. To save space some people will even record at 64Kbps in which the data loss becomes evident as the high and low end frequencies are lost. These types of low bit rates are where WMA comes into its own. WMA does an extremely good job of making audio recorded at a low bit rate sound decent. You may still not get amazing sounding bass, but it is a large improvement. With these files being so comparatively small, easy to record, mainly from CD (known as ripping), and of a reasonable quality, the internet is like a breeding ground for sources of MP3s and WMAs. MP3 players are available on the market that you can link to your PC and download files straight to the memory in the player. This means that you don’t have to carry around CD's or Minidiscs but instead the files can be put onto either a piece of flash memory, or sometimes just onto the player which has inbuilt memory. With so many MP3s available on the internet, the downloading and uploading of MP3 has become extremely popular, especially with teenagers who generally don’t have enough money to buy music with. Since its release there has been a lot of controversy over the MP3 format, as it allows for easy copying of copyrighted music, and then it is easy to share it with people you know and also people you don’t. The centre of controversy recently has been NAPSTER, which is a "music community" where people can share all of the MP3 that they own with anyone else who registers for the service. This ended in a court case where Metallica accused NAPSTER of allowing the sharing of music that they owned the copyright to. The ruling was that NAPSTER should be shut down, but within weeks it had been given the go-ahead to start up again. With music this easily accessible, and for absolutely nothing, MP3 players have done extremely badly in the consumer market, selling less that Minidisc, but a lot of people listen to MP3s via their PC meaning there is even less reason to buy a Minidisc player. Also there are plans to release set top boxes that download MP3s from the net and play them back, and also the Neo Jukebox which is a 3.5” 10 or 20Gb hard drive connected by USB to a PC, and can be used as just a hard drive or as an MP3 walkman.

**DVD Audio**

Since the release of DVD the main use of DVDs has been for movies. Although you think of movies when you think about DVDs they can also be used to store data and to store digital audio (DVD Audio). DVD-Audio is a format designed to provide the highest possible audio fidelity capable on DVD. The audio fidelity of DVD-Audio far exceeds the quality of conventional CD's. DVD-Audio provides for audio in stereo and in multi-channel surround in a wide range of specifications. DVD-Audio PCM (Pulse Coded Modulation) can be recorded with a range of frequencies that are more than four times that of a CD, and has a larger dynamic range, making sounds louder and quieter. Also with much greater capacity than a CD a lot more music can be recorded. The recording can have a much larger sampling rate and sample size than that of CD or HDCD for a better quality sound. Unfortunately these disks will have to be played in a DVD-Audio player to get the extra quality out of the music. DVD-Audio may not have yet reached fruition but is definitely a format for the
future. With DVD writers not really a viable option yet because of the cost, DVD as an audio format will not interfere with the market but when the prices come down there is a good possibility DVD-Audio will be up there with CD-DA.

DAT
The DAT standard, which was created in 1987, is a digital recording format which offers 3 hours of digital sound on a tape half the size of a cassette analog tape, with the same format as a CD (44.1 Khz sampling frequency and 16 bits). The advantage over Minidisc is that it does not use data compression. This means that the entirety of the signal is retained. The copy of a CD is a real clone. The quality of DAT format is such that professional studios very quickly adopted it and made it the digital standard for recording. Moreover, DAT offers a comfort of use infinitely higher than that of an analog tape. Thus, indexing of the tape and rewinding are extremely fast (50 seconds for a 120 minute tape) and facilitates the location and access to any place on the DAT tape. Unfortunately, although the format sounds very advantageous it soon dwindled and has almost disappeared totally now. With the design of other digital formats the DAT was put on the back shelves.

DAT was a good idea but I think the ability for total random access and the grip that other formats already had on the market caused the failure of this format. It may have be better quality than Minidisc but it is just not as practical.

Conclusions :
I am sure there are many other digital audio formats that I haven't mention so far, but the ones I have mentioned are the most frequently used and most realised formats that are out there. From the listed advantages of all of the different formats previously discussed I can easily see why the Minidisc has never been that popular. With CD being so widely available, recordable with the correct equipment, and of a higher sound quality than Minidisc, I could never see myself purchasing a Minidisc recorder. In fact I can't really see many people at all purchasing Minidisc equipment, unless it was for the reason that they just wanted a new "toy". As a quote from an article called Navigating the music maze(wired.com) says : "MD? It seems like a dated solution. Not quite where I thought I'd end up in the age of digital music and the internet." - Chris Oakes. After completing my research I can quite easily see how the Minidisc never grabbed the consumer market even after all of the hype from both Sony and the press. My advice to anybody wanting to purchase a player for a format of digital audio would be the same as that of Brian Fenton, the executive editor of sound and vision magazine - "Buy whatever you think is cool, and assume you'll have to replace it in a couple of years". The technology is moving so quickly and improving so much that if you were to buy a Minidisc player now there would be bigger and better gadgets out there within the next few years that would make your player outdated. I myself have a friend who bought a Minidisc recorder only a couple of years ago. He hardly ever uses it anymore, but it cost him nearly £300.

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