

Update

Oct 2010

Due to the speed at which computer components go obsolete, many of the components suggested in this paper are already unobtainium. Nevertheless, the recipe has already been updated. Please download the RMAF Oct 2010 issue of the Absolute Fidelity newsletter for the latest information.

Building an Absolute Fidelity™ Music Server

*By Gary Leonard Koh
Genesis Advanced Technologies*

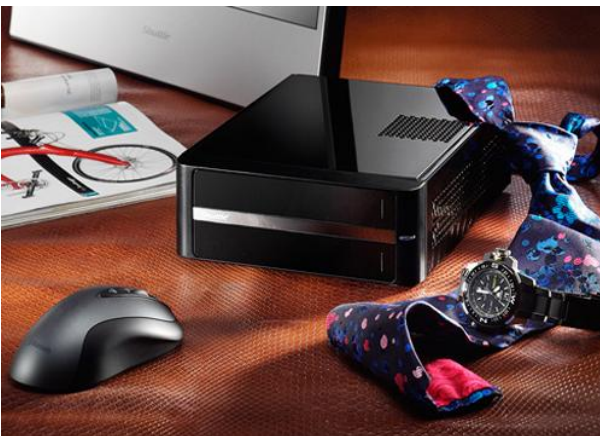
With the increasing availability of high-resolution music downloads, and improvements in DACs and interfaces, it is almost mandatory that audiophiles who are not “vinyl only” build a music server*. However, there are a couple of obstacles to successfully integrating a computer as a high-end music server into an audiophile’s music system.

Some of these obstacles include:

- 1) Physical noise and vibration caused by computer’s fans, hard discs, CD drives, etc. intrude into the listening room, the vibrations will also degrade the sound from audio components when placed on the same rack;
- 2) Electronic noise in the ground and EMI/RFI emanating from digital circuits and switched-mode power supplies intrude into other audio components;
- 3) Using the correct software, settings, and components to ensure bit-transparency and proper timing during sampling for the best sound.

This White Paper takes a stab at guiding readers towards building a ***dedicated*** audiophile Windows-based music server. This means that the server is used only for serving music, and very little else. It is by no means comprehensive, but there is much information available on the Internet to help. It is also not a “cookbook” or recipe as computer components go obsolete extremely quickly. Hence, some recommendations may no longer be available by the time you read this paper. Nevertheless, the nature of computer components is that the alternatives and replacements will be cheaper and better!!

This White Paper is based on experience learned from the years spent developing the Absolute Fidelity™ CD (Black CD) burning process and building and refining the music server that we have used for demos during CES and RMAF for the past 5 years. Properly configured, a music server sounds way better than even a Black CD plus high-end transport, and will cost substantially less.



Shuttle X27D mini-PC

Hardware Configuration

In order to overcome the first obstacle of physical noise and vibration, we need to build a ‘silent PC’. This is a PC built without fans and spinning drives so that it can be placed in the audio rack without degrading the other components residing in the same rack. A recurring theme you will find me talking about is “cooling”. This is because heat is one of the biggest problems in making a successful Audiophile Music Server – either your server burns up, or you have a lot of noisy fans.

* It is funny that when we demo’ed using a digital music server during CES2005, we were universally laughed at. By CES2009, the music server was almost expected in all good demo’s.

Approach 1: The almost silent PC – this is based on a mini-PC, like the one used by Genesis, using a barebones kit – one example is the Shuttle X27D (the original XPC X100 used at Genesis is no longer available). These are mini “book-sized” PC’s with external power supplies. There are other brands besides the Shuttle, but it is up to the reader to explore them. Try newegg.com and tigerdirect.com – while I have absolutely no affiliation to either of these companies, these are the two websites I use most often for computer components at a good price.

Starting with a book-sized barebones kit simplifies things; due to the small size cooling is a problem. They usually have a small and noisy fan that kicks in when the CPU gets too hot. Nevertheless, serving music is not very CPU intensive, and it is usually possible to slow down the internal fan to reduce noise. The Shuttle has one of the quieter fans, but when it kicks in, you will notice it. There are also larger mini-ATX sized kits with external power supplies that can be built fanless, or with an even quieter fan.

The big advantage to using a barebones kit like this is that it is the easiest way to start. Plug in a CPU (often supplied) and a disk drive (also usually supplied), and you’re almost ready to rock and roll. The disadvantage is that you are limited in upgrading options on CPU, memory, etc., and they usually come with “features” that you will NOT want to use, such as a 5.1-channel built in “audiophile” (not!!) soundcard.

With the Shuttle X27D and an Intel dual core Atom 330 CPU, and some storage, you have a fully-functioning PC that is a great foundation for building the Audiophile Music Server. In addition to the Shuttle, there are many other suitable barebones kits available.



I would replace the usually included 3.5” SATA drive with either a 2.5” SATA hard drive, or better, a solid-state drive (more on drives later).

Approach 2 – building the really silent PC. You will probably skin some knuckles, but almost anybody can build a PC these days. Unfortunately, Zalman discontinued their Totally No Noise (TNN-300) series of heat-sink cases that is the basis of a totally noise- and vibration-free PC, but with some careful choices, you can build a really silent PC for your music room.

Start with a decent case. With the Zalman HD160XT, you have a built-in touch-screen LCD screen. This case has lots of fans, but you can easily replace all of them with quieter fluid-ball-bearing models, and install a fan controller to reduce the speed for lower noise and vibration.

You can build a silent PC inside almost any case, and these cases can run as low as \$40. Buy one without a power supply, because you will want to install and use a fan-less power supply to eliminate noise and vibrations from this source.



Next, find a suitable motherboard. You do not need very much computing power, but dual-core is a distinct sonic advantage*. So, pick a one of the slower Core 2 Duo CPUs (which is also cheaper and requires less cooling). With a larger case, use a standard ATX (not mini-ATX) motherboard, which gives you more space to work and be easier to add more cooling by installing larger heatsinks.

The Asus P5Q SE Plus at about \$90 is a socket 775-type and will be good enough. You don't need much more than that. Add a matching socket 775 CPU – the Intel Core 2 Duo E7400 (\$120) at 65W is the lowest powered CPU in the Core 2 Duo range. A heat-sink and fan is included by Intel at this price, but you will want to ditch this small noisy freebie, and buy something that will perform better.



ZEROtherm Nirvana NV120
(\$39.99 from newegg.com)



Zalman CNPS8700
(\$64.99 from tigerdirect.com)

Cooler Master, Noctua, Zalman and ZeroTherm make some really nice ones. Get the ones rated for much faster CPU's and over-clocking so, with the small 65W CPU, it is unlikely that the fan will be needed. However, even if the fans kick on, they operate at less than 24dB (at 1m) at their lowest speed setting, so you are unlikely to hear them. Just remember that hot air rises, and depending on how you have your computer built, you will know which heatsink will work best for you.

Once you have the server built, you can run it for a bit, keeping watch on the motherboard and CPU temperatures and make sure that they don't go much above 50 deg C. The Asus motherboards all provide a software utility for you to do this. It is highly likely that with a very large heatsink, you might not need to run the CPU fan.

The next decision to make is the power supply. The power supply fan is usually the noisiest, and the one fan that you can do the least about, I would go with a fanless power supply. They can be as rare as hen's teeth, and the only one I can find currently is the FSP Zen 400 (\$129.99 from newegg.com). This is a 400W power supply, and is much more than adequate for our needs.

With either approaches above, we have the basis for a pretty silent music

server. However, starting with a barebones kit is very much simpler and straightforward. Assembling your own PC may ultimately be more satisfying, and might even perform better, but there is the risk of having incompatible components, and of course, making mistakes. Doing this for the first time, unless you are guided by an expert at building PC's, I would **highly recommend that you start with a barebones kit.**

* ...but for the life of me, I can't explain why it would be an advantage.

4GB
DDR2



OCZ Reaper 4Gb DDR2 1066
(\$49.99 from tigerdirect.com)

Storage and Memory

Simple – get as much memory as you can afford and that will fit on the board (but it depends on your operating system how much you can really use). Both the Asus motherboard as well as the Shuttle barebones kit will take two sticks of DDR2 1066 SDRAM. Get two sticks of 2GB each for 4GB – which is about as much as WinXP 32-bit can handle.

Initially, only 3GB will be addressable, but set the /PAE switch and the /3GB switch in BOOT.INI and 3GB will be allocated for user-mode processes, and 1GB for kernel-mode processes so that you can play very large high-rez files. Unless you go to 64-bit operating systems, anything more than 4Gb is useless.

Staying with the theme of cooling, some of the more expensive memory sticks have a built-in heatsink for greater reliability and long life. Examples include OCZ Reaper and the Mushkin. Both of these will fit the full-sized ATX motherboard, but might not fit into micro-ATX motherboards due to the size of the heatsinks. They will definitely not fit into the Shuttle due to the tight space.

Having more main memory means that the operating system does not need to do much paging to the hard-drive. This would result in smoother serving of the music files, reducing jitter. Having 4Gb of main memory set up as above, it is possible to turn off Windows memory paging totally if the PC is only used as a music server, and only one application is run at any one time.



With high-rez files weighing in at 400Mb for 24bit/192kHz sampling, a large hard drive is absolutely necessary for storage. While hard drives are cheap these days, it is an unfortunate fact that solid-state drives sound better. I have no idea why, but they do.

Hence, for the primary drive from which you will be playing the music off, invest in a good Single-level Cell (SLC) Solid State Drive (SSD). At the date of this writing (Dec 2009) they are available at up to 256Gb for about \$800. SSD's do have a limited lifespan with respect to the number of times each cell can be written to, so do not use it for Windows paging memory and do not defragment it often. They can be read an almost infinite number of times, but writing deteriorates the drive relatively quickly. With Windows memory paging turned off, the

SSD can be used as the main drive in the music server.

Store your music on a normal spinning hard disc drive (HDD), and bring it over to the SSD for critical listening. This way, you can have multiple very large HDD's for archive, backup[#] and storage, and a smaller SSD for playback. Your main music library could even be stored on Network Attached Storage so that you can access it from anywhere.

[#] I cannot emphasize enough the need to backup your music server. Computer drives are inherently unreliable, and a hard disk crash could decimate your precious music collection – or at least cause you lots and lots of inconvenience, not to mention music-less nights!

If you don't want to spring for a large SSD, it is also possible to use SDHC or Compact Flash cards (especially if you have a notebook computer with these ports) for storage of your music. These come in capacities up to 64Gb these days, and that stores a respectable amount of music – even high-rez music.

Ground and other Electrical Noise

One major problem with computers is the dirty, noisy digital ground generated by the switched-mode power supply and also the digital electronics. Just plugging the computer into the same power bar as the rest of your hifi gear will degrade the sound – even when playing vinyl!!

I recommend a separate power conditioner for the computer gear. I use a dedicated IsoTek Mira on the computer and monitor, but almost anything will do, as long as it is external to the power conditioner that you use for the rest of your system. If the DAC you use does not effectively separate the ground of the signal from the incoming connection to the computer, this could be a source of contamination as well. In this case, be sure to properly ground the DAC, and use a power conditioner on the DAC that removes ground noise and isolates the DAC from the rest of your system.



IsoTek Mira
(\$495.00 from kosmic.us)

Another problem is the radiated EMI and RFI from the digital electronics. Whether you are using a bare-bones kit or building your own, it is unlikely that the case will be well shielded. Putting the server on your equipment rack is likely to degrade the performance of the other components on the rack even if it does not vibrate.

A simple solution is to use a spray-on EMI/RFI shield on the inside of the case, and properly ground the case. The picture shows MG Chemical's Super Shield, which is a conductive nickel coating, but they also make a silver-copper and a pure silver version – both vastly more expensive!

Some power conditioners have a grounding post that is a one-way gate to sink the noise in the ground to earth. This is the best solution for grounding the case to reduce the radiated digital EMI/RFI.

Software and Settings

This is usually a major issue as there is so much confusion out there. It is unfortunate that software developers are so rarely audiophiles for many of the decisions made in the software will affect the sound.

My preferred playback software is Foobar2000 for its flexibility (but it is not as user friendly). This is free user-supported software, and the community of users are always improving it and fixing bugs. Other available software include MediaMonkeys, iTunes, the Windows Media Player, etc.



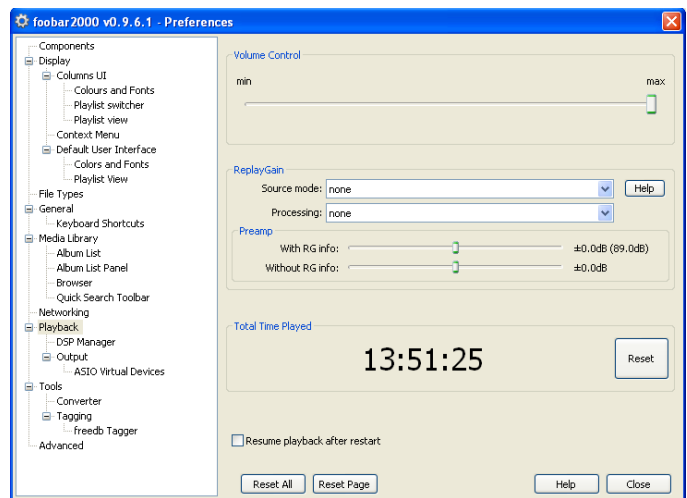
MG Chemicals Super Shield
(\$31.63 from alliedelec.com)

The problem with computers is that can only do what programmers tell it to do. When music is properly ripped off a CD, it is in a PCM format that has 16bit resolution with 44.1kHz sampling. Unfortunately, the native rate for many DACs is 16-bit 48kHz (in fact, a lot of music is recorded at 16/48!). The operating system (Windows in this case), makes this “transparent” to users by re-sampling the 44.1kHz bitstream to 48kHz – a non-integer resampling. Unfortunately, to us audiophiles, this is by no means transparent, and we can hear the deterioration.

This re-sampling is courtesy of the internal Windows kmixer – which is to be avoided at all costs. The way around this is to use ASIO* (audio stream input output), a plug-in which is available for Foobar. It is easy to hear the difference between Direct Sound, Kernel Streaming, and ASIO using Foobar.

Suffice to say, you need two pieces of software – both available for free. The player from www.foobar2000.com and the USB DAC ASIO driver from www.asio4all.com. Some DACs come with their own ASIO drivers, and if they do, try both and use the one that sounds better.

A few settings in Foobar to note – turn the volume control to max, and turn off gain processing. This is in the **Playback** option under **Preferences**. Also in the Playback menu, make sure that there are no active DSP’s under the DSP Manager.



The Operating System

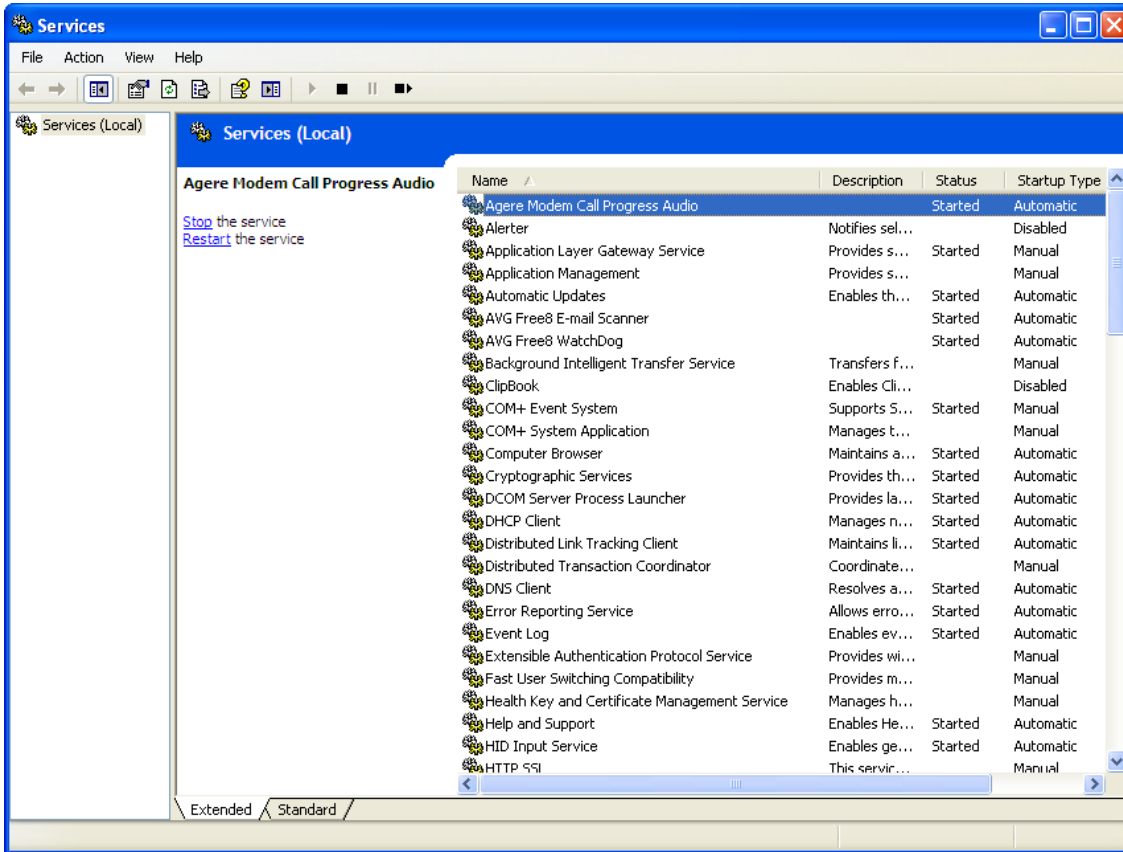
For simplicity, I use WinXP Media Center Edition Service Pack 3. This has a couple of “hooks” that allow the use of a remote control with Foobar to select tracks, play, pause and stop. A better user interface for the remote control can probably be written, but at this time, I have not bothered to do this.

The problem with WinXP is that it runs many background services for a wide variety of tasks. When used to operate a computer for general use, it’s great. However, as an operating system for a dedicated music server, it is continually interrupting itself – resulting in distortion (jitter??) to the music that we can hear.

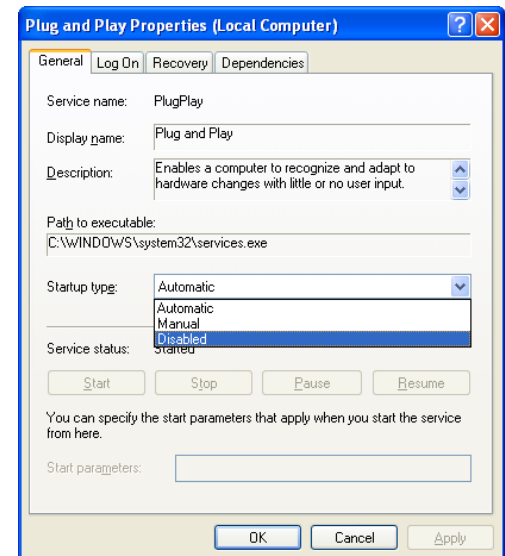
Some of these services can be disabled, and your music will sound better. To access the Services menu, go to the [Start] button, pick **Control Panel**, choose **Administrative Tools**, and click **Services**. The following menu will appear. Now, you need to be very careful, as this may completely screw up your Windows installation. **Proceed here at your own risk**. The list of disabled services here has been implemented over the past several years using my own Music Server that us used for nothing other than to rip and serve music. It is too unstable for general use, and would hang if you unplugged a mouse!

* A better explanation is available here: <http://www.head-fi.org/forums/f46/asio4all-explanation-221237/>

Double click the service you want to change, and a pop-up appears. Click the **Startup type** drop-down menu, and you can **Disable** the service the next time that Windows starts-up.



The following services can be “safely” disabled. (**Again, this is at your own risk.**)
 Alerter, Application Layer Gateway, Application Management, Automatic Updates (but be sure to update Windows manually regularly), Background Intelligent Transfer, Clipbook, COM+ Event Systems/State Application, Distributed Link Tracking Client, Distributed Transaction Coordinator, Error Reporting, Fast User Switching, HID Input, Indexing Service, Internet Connection Firewall Sharing, IPSEC Services, Machine debug manager, Messenger, Microsoft shadow copy provider, NetMeeting Remote Desktop, Network DDE, Network DDE DSDM, NLA, NT LM, Performance Logs and Alerts, Portable Media Serial Number, QoS RSVP, Remote Access Connection Manager, Remote Desktop Help, Remote Registry, Routing and Remote Access, Secondary Logon, Server, Shell Hardware Detection, Smart Card, Smart Card Helper, SSDP Discovery, System Event Notification, System Restore, Task Scheduler, TCP/IP Helper, Telephony, Telnet, Themes, UPS, uPnP Device Host, Upload Manager, Volume Shadow Copy, WebClient, Windows Audio, Windows Image Acquisition.

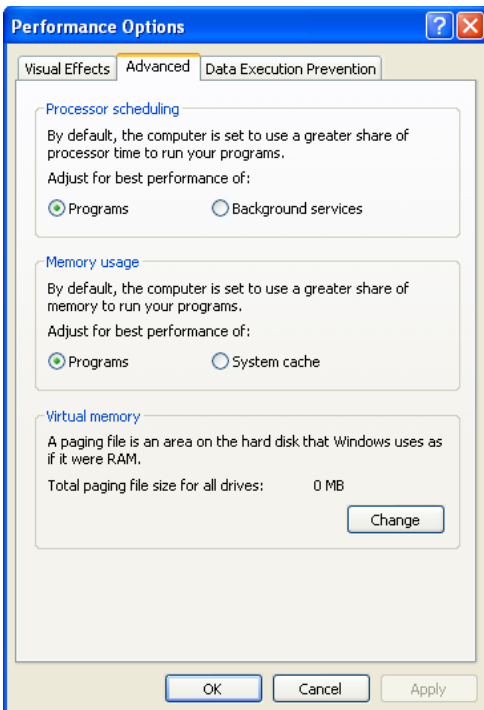
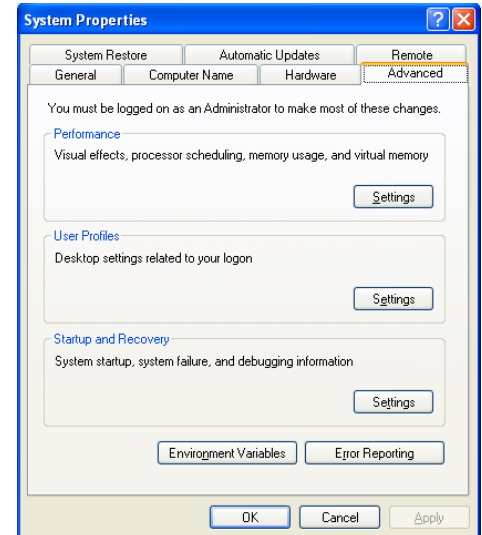


One service that I highly recommend disabling (but is not generally considered safe to do so) is Plug and Play. Once this service is disabled, the system is unstable, and incapable of USB and Firewire hot plug, and incapable of detecting hardware changes. However, this stops Windows from checking that the DAC is still plugged in before sending data, and I think results in a significant improvement in the sound – there is huge improvement in the “flow” and pace of music, and soundstage and image retrieval.

Turn Off System Paging

This is essential for the life of your solid-state drive if you are using it as the main drive of your system, and it also improves the sonics substantially even if you are using a spinning hard disc for your music storage. Do not do this if you have less than 1Gb of main memory as you will need at least this amount for WinXP plus Foobar to operate smoothly. It is fairly safe to do this with 2Gb or more of memory.

This setting can be found under the **Control Panel**, double click **System** and then the **[Advanced]** tab and you will see the screen to the right. Under **Performance**, click **[Settings]** to get to the screen left. Click the **[Advanced]** tab and you can **[Change]** Virtual memory to **[No paging file]**.



Other Software Settings

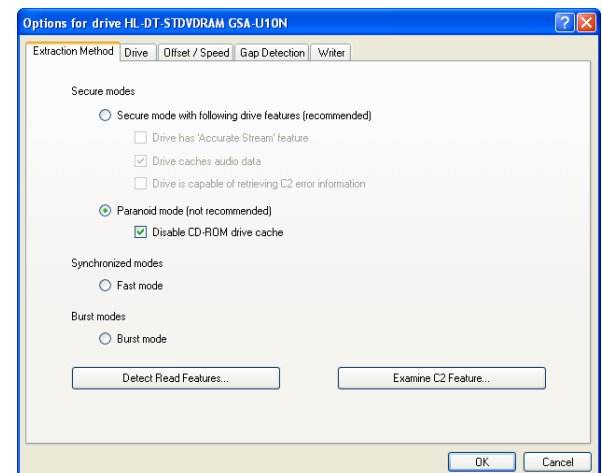
It is pretty obvious, but be sure to disable any volume controls, equalizers, “spatializers”, etc. in Windows, and any playback software. It is also best to turn off Windows sound – the beeps and clicks and whistles that are native to Windows. All they do is to interrupt your musical pleasure.

This is also done under the **Control Panel**, under **Sounds and Audio Devices Properties**. Click the drop-down menu under **Sound Scheme** and pick **No Sounds**.

Getting the Music into your Server

The recommended software for “ripping” your CDs is EAC – Exact Audio Copy –

available free from www.exactaudiocopy.de. If you own a Plextor drive, you might have access to a software called PlexTools. This has a DAE (digital audio extraction) function that is faster and as accurate as EAC – unfortunately, it only works on certain models of Plextor drives.



Using EAC, rip your CD's in Paranoid Mode (even though it is not recommended). The reason that it is not recommended is that it thrashes your CD-ROM. The solution is to buy a couple of cheap external USB CDRom drives, and chew through them while you work through your CD collection to get the music into your server. The things we do for good music ☺.

The **Paranoid** option is available through the **EAC** menu **Drive Options** (or just hit F10). Even though you are using EAC to extract the most accurate possible data from your CD's, I would still recommend that you clean your CD first before ripping it. It will rip faster too if there are no errors.

The best cleaner to use for your CDs is de-ionized water, but any acrylic cleaner will work well. An example is Novus #1. If your CD is scratched, it might be possible to remove the scratch (as long as it is not on the label side) with Novus #2 and #3. Do not use tissue or a paper towel as they will create micro-scratches on the surface. Use a good-quality micro-fiber cloth like one used to clean eyeglasses.

One of the major reasons for building a music server is so that we can listen to high resolution music. There are a number of websites that sell such music downloads. These include, but are by no means limited to the following:

- www.hdtracks.com
- www.2l.no
- www.highdeftapetransfers.com
- www.musicgiants.com
- www.linnrecords.com
- www.itrax.com



April Music Stello DA100 Signature
(\$995.00 from kosmic.us)

Getting Music out of your Server

There are a number of ways to get the music out of the server that you've laboriously built. The most obvious solution is to use an easily available USB DAC. Unfortunately, even though many of these are 24/96 DACs, the Windows driver sound device interface used is commonly the USB Audio Class Specification and is limited to 12Mb/s data rate.

Of that 12Mb/s, only about 40% or 4.8Mb/s is available for the data itself, the rest of it is error correction and "housekeeping". 24bit/96kHz * 2 channels equals 4.6Mb/s – so, that would be the theoretical limit of USB 1.1. Unfortunately, most times, we don't get to the theoretical limit, and so 24bit/48kHz is the practical limit.

There are many such good USB DACs available, ranging from the excellent \$995 Stello DA100 Signature to the \$99 Music Streamer from High Resolution Technologies.

There are also available USB 2.0 DACs that are able to pass high resolution (higher than 24/48 by using proprietary drivers or



E-Mu 0404 USB
(\$199.99 from musiciansfriend.com)

ASIO. One example is the \$250 E-MU 0404 with its supplied drivers that allows low-latency 24bit/192kHz output through a USB 2.0 interface. New chipsets are now coming available that allow for USB 2.0 to natively output 24/96. More and more will become available as this technology matures.

Unfortunately, there are fundamental issues with the USB interface that is not well understood by audiophiles. This has resulted in statements like “USB sounds much worse” than S/PDIF being published by a major magazine.

The first problem is that USB stands for Universal *Serial* Bus. I’ve italicized the word serial because that’s what USB does – it is like a bus that goes serially from one device to another device, and picking up and dropping passengers (data) as it goes. This means **JITTER** in large, big capital letters. If there are a lot of devices on the bus route, the bus will be slow and deliver data in fits and starts. Nevertheless, there are some DACs that will buffer the input datastream and re-clocks the data before the conversion to analog will perform much better as a result. But you can hear the computer-caused jitter even on these.

Secondly, because USB is a plug-and-play device, the operating system has to constantly check for the existence of a device plugged into that port before it reads or sends data. Hence, the recommendation to disable the Plug and Play service on the operating system. Both these problems introduce jitter and timing problems into the USB interface, and result in flat, dimensionless music with no pace and rhythm. There are some DACs that use the USB in asynchronous mode, that may eliminate the jitter and timing problems of the USB interface, but I have not tried any of these.

Nevertheless, properly implemented, a music server driving a USB DAC will sound far, far better than a high-end transport playing a CD driving the same DAC.



A much better interface for the computer to interface with a DAC is Firewire (IEEE1394). Firewire is also a serial bus interface, but more importantly, it can be configured for high-speed isochronous (equal-time, in phase) real-time data transfer. This is usually the interface of choice in the pro-audio world. It is widely used in studios for recording and playback devices.



Alternatively, the DAC can be made the master clock for the whole system. This means that the audio source is slaved to the DAC – not easily done with a CD transport, but easily implemented with a computer serving bits over Firewire.

A great example of this is the Weiss* Minerva – a \$5,000 DAC (the DAC2 is the cheaper pro-version) that can directly interface to a computer using Firewire and the native Windows drivers and does true high-rez 24/192kHz playback. Weiss also supplies a proprietary ASIO implementation for the Minerva/DAC2. This is currently my DAC of choice, and is a wonderfully musical component.

The great advantage of the Weiss is that it can also be used as a Firewire interface for your computer, providing AES/EBU and S/PDIF outputs – allowing you to use the external DAC of your choice if you do not like the built-in DAC (although I think that it's the best sounding DAC I've ever owned).

Since most of the music that we listen to is recorded using pro-audio components, an alternative that is worth exploring might be the \$995 Apogee FW Mini-DAC. The USB version sounded pretty good, and I would expect that the Firewire version be even better.

Using Approach 2, we could also build it with a PCI interface card that has AES/EBU or S/PDIF outputs such as the Lynx AES16 – and any DAC with S/PDIF or AES/EBU inputs. Unfortunately, all such interface cards sound different, and picking one is an exercise that I have not yet embarked upon. They range from the \$700 Lynx down to the \$180 M-Audio Audiophile 192. Both these cards have built-in ADC/DAC with analog inputs and outputs, but an external DAC *should* sound much better.

If you already own a DAC that you like, there is a whole host of USB to S/PDIF or Firewire to S/PDIF *pro-audio* interfaces that are available – from the Toslink-only \$30 Turtle Beach Advantage Micro, which is a thumb-sized USB plug; to the \$80 M-Audio Transit that is also a USB-connected ADC/DAC (which means that you can record all your LPs to the music server!!).

The world of pro-audio Firewire interfaces is much more complex, and needs more exploring. One good place to start is at www.sweetwater.com. For example, the \$280 Ediol FA-66 provides 24/192 capability, Firewire input/output, and S/PDIF out to your audiophile DAC. There are also pro-level Firewire to AES/EBU interfaces to explore.

An alternative to a direct connection to a DAC is to use a device such as a Slim Devices Squeezebox that streams music from the server wirelessly or over a network. Unfortunately, this is limited to 24/48, and it is not sonically transparent. The Slim Devices Transporter is able to stream 24/96, but this also requires some power supply and chassis mods to make it sound better.



* Weiss Engineering has its roots in the high-end recording industry, like dCS and FM Acoustics. All three companies also make fabulously high-end audiophile products.

Conclusion

Building an audiophile music server is not rocket science. This paper is by no means comprehensive, but it serves as a place to start building and start exploring.

Unfortunately, because of the transient nature of computer components, many of the components I've listed here are likely to be obsolete and unavailable by the time you read this paper. Nevertheless, there should be newer and better (and most times cheaper!!) equivalents and alternatives.

There are lots of areas still left uncharted. The first is to build a Linux-based single-purpose machine that might sound even better. The easy availability of fan-less, drive-less "netbooks" also bears exploring as an alternative platform so that we do not even have to build the server – just configure it right. From the pro-audio world, there are lots of components for music recording and editing that would bear investigation – these have largely been ignored by audiophiles as "not high end". However, three of my most important components – the Weiss Minerva, the FM Acoustics 155 phono stage, and the FM Acoustics 255 preamp have their roots in pro-audio, and they sound wonderful.

There are a lots of great resources on the Internet that are recommended reading. The following three gives you a head-start:

1. The Head-Fi.org forum on computer audio (<http://www.head-fi.org/forums/f46/>) ;
2. www.computeraudiophile.com;
3. www.silentpcreview.com - not audiophile oriented, but lots of helpful information for building your own.

Once you have a music server, and it is connected to the Internet, explore not only the music that you have, but also Internet Radio. It is an amazing source of new music. One of the best is www.pandora.com. They bill themselves as "a new kind of radio – stations that play only music you like".

Enjoy!

Gary