PLUG IN … AND READY?

Believing the advertisement of many manufacturers, building a streaming network is easy. In reality it often turns out to be different: abbreviations, sinister TCP/IP addresses and obstinate technology spoil the fun. We explain all the necessary basics and show you how to avoid demotivating pitfalls.

It's been exactly ten years since the streaming age hit us: in August 2008 we presented all Linn network players "en bloc" and, at the same time, had T+A's E-Series with the network-compatible "Music Player" in the editorial office. A shock! Not only because Linns Klimax DS ranked among the best sources we had heard up till then, but also because we were rather clueless for the first days.

Together with their streamers, the Scots brought us a box full of WLAN routers, switches, LAN strips, a "PDA" (the Neolithic ancestor of the tablet) and a small box called "NAS". Many of these were unknown to us, and it took us some time to get a grip on the equipment. Since then, the technology has done some huge evolutionary leaps forward. Sound formats such as DSD and MQA were added (see page 16), and streaming in the local home network faced competition from web-based subscription services. Many things are smoother nowadays, especially the controls. However, some things have remained the same, as for example that newcomers are faced with a mass of abbreviations and computer terminology. We want to clear up this mess on the following pages.

THE HEART OF THE CHAIN

The central term is "streaming", which describes all forms of signal transmission. No matter if you are sending binary data across the network or copying image and video files from a USB stick to your computer, these are all variants of the same technology. In a HiFi-environment, the executing device is, of course, the streamer. While the Anglo-Saxons also call it renderer (in the meaning of "translator"), the pseudonym "network player" has become established in Germany. However, this is only partially correct. Of course, the network plays a decisive role, but the streamer is first and foremost a media player that transfers formats such as FLAC, WAV or MP3 into S/PDIF signals that can be processed by the D/A converter. Whether it gets the data from the network, gets it sent via Bluetooth from a smartphone or loads it from a USB stick, doesn't matter for now...

Either way, the streamer depends on data providers. In order to be able to communicate with them, there must be a universal "language" that all devices understand. It was developed under the name UPnP (Universal Plug and Play) already in the eighties and is valid until today. Just imagine a football coach, who is assigned to train players from all over the world.

▲ A typical streamer: Cambridge Audio's CXN V2 uses the UPnP network-standard. Other streaming devices recognize it automatically and interaction is possible without the user having to type in cryptic addresses anywhere.

At first he will limit himself to teaching his boys or girls basic terms such as "forward", "to the left" or "you're offline, damn it". UPnP is like this trainer: it's a set of basic instructions that cover all situations of device interaction. Far too extensive, said a consortium around Sony and Intel in 2003 and restricted the commands to the DLNA standard (Digital Living Network Association). DLNA is therefore nothing else than a multimedia summary of the UPnP instruction set. And it works perfectly: if you only have DLNA devices, the HiFi network often even works a bit faster and more stable.

Thanks to this standardization, all the user actually has to do himself is to plug all the necessary devices into his router via a LAN cable. The network distributor now briefly takes control, processes each device individually and assigns it a network address that is permitted according to its TCP/IP protocol (see box). If the streamer's remote control app is then started it should find the network player.

KEYWORD

SWITCH:
A switch expands the network with additional LAN connections. Unlike the router, it cannot assign TCP/IP addresses or perform comparable administrative tasks.

However, you won't be able to hear any music yet. As it was said above, the streamer depends on a musical data supply. Typically, a NAS (Network Attached Storage) is used, though also Windows, macOS or Linux computers could take over this task. A NAS is, however, permanently dormant in power-saving standby mode, only waking up on request of the streamer, within seconds. Desktop computers are far hungrier for electricity and also slower. NAS drives save further power with their comparatively modest processors, which are still fast enough to provide several network players with music at the same time.

WHERE TO PUT THE DATA?

Feeding of sound formats is fairly simple: under Windows, NAS drives can be controlled in the Explorer like directories of the computer. You can find them on the left in the navigation column under "Network". Apple users must select "Go to > Connect to server" in the Finder bar and enter the address of their NAS. The ripped or purchased music can then be simply copied into the gigantic storage of the multimedia or music directory. The instructions for the mass storage tell you where exactly the data belongs. These are usually available via download from the manufacturer's homepage.

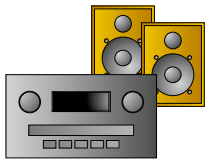
Special music NAS such as Audiodata's music server, Naim's Core or Melco's

IMPORTANT BASICS: WHAT IS TCP/IP?

The two abbreviations stand for the Transmission Control Protocol (TCP) and the Internet Protocol (IP). Their current foundations date from the seventies and even if you don't know what the abbreviations mean, you have most likely already seen the corresponding addresses. These protocols assign network participants identification numbers according to the pattern 192.168.xxx.xxx, whereby the first two digits are basically always identical and originate from a nerdy joke. These addresses work like telephone numbers and must be unique in the home network: if you, for example, assign 192.168.0.101 to your NAS, you can enter this sequence into the address bar of a web browser (Chrome, Firefox, etc.) on your computer, to easily access the web control screen of the device. Many network components have this kind of hidden control level.

Fortunately, DHCP (Dynamic Host Configuration Protocol) is part of TCP/IP: this tool enables the router to automatically assign a network address to connected devices and to communicate this to all other participants. If DHCP has been activated for all devices (which is nowadays standard in the factory state), the user is off the hook. However, this raises a new problem, because occasionally one needs this important address. There are different ways to find it out: in the menu of many streamers there is a tab called „Network Status" (or similar) where you can access the sequence of digits. If you open Windows Explorer and select the „Network Environment" in the navigation column on the left, all active devices are displayed in the main window. Right-clicking on the streamer or the NAS and selecting „Properties" you get the same address. You can also log into the web mask of the router. There is a DHCP register which lists the addresses of all active participants. Finally, you can also download an app like the free „Fing" on a smartphone or tablet that sniffs through the network and shows all found participants with their TCP/IP addresses.

THE TOPOLOGY OF A STREAMING NETWORK

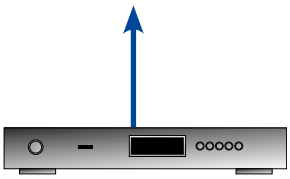


▼ HIFI SYSTEM

PERSONAL COMPUTER

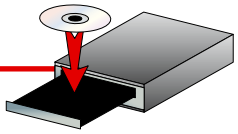
The computer with monitor, mouse and keyboard is still the best working environment for importing CDs, editing ID3 tags or administering everyday data management (moving, copying and deleting files). Whether it is a desktop model or a laptop is irrelevant. ▼

CAPTION
- USB
- LAN or WLAN
- Analog or digital audio



▲ USB DAC

If you want to play the music directly from your computer, a USB-DAC can significantly improve the sound quality. There are models in all price and quality classes. Some applications (iTunes, JRiver etc.) even allow remote control of the PC via a tablet app.



RIPPING DRIVE ▲

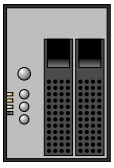
Whether it is a model in a computer case or a separate USB drive, the „Ripper", with its scanning quality and error correction, plays a decisive role in how genuine CDs are imported into the computer.

▲ SMARTPHONE/TABLET

Portables can be used as remote controls via special apps. Some streamers also tap the portable devices as a data source.

◀ ROUTER (WITH INTEGRATED MODEM)

The router is the central management interface of the network. It assigns a TCP/IP address to each connected device and establishes the connection to the Internet. In most cases, four components can be connected, but the connectivity can be extended at any time via „switches".

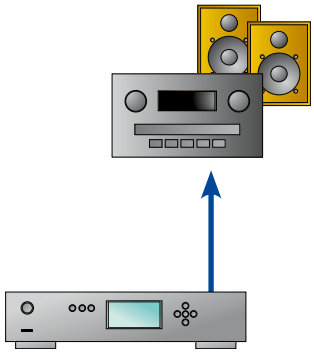


▲ NAS

The NAS serves as a huge data store accessible by renderers and computers in the network. While a PC could also perform this task, using specialized network mass storage devices will result in significantly less power consumption, if you want to keep them switched on permanently.

▲ INTERNET

In the past, the web only served as a supplier for Internet radio and additional data (ID3 tags, etc.). Since streaming in CD quality or higher is available with services like Qobuz or Tidal, the Internet has become a legitimate hifi source. A comparatively „lame" DSL connection from around 6.000 kbps is often sufficient enough for music streaming.



▲ NETWORK PLAYER

The Streamer is a media player that requests music files via its network interface. It doesn't care whether the data comes from a PC, from the NAS or from the Internet (web radio, etc.). To tap web-based streaming services it, however, requires a special software. Streamer models are available in a wide variety of designs and sizes, including variants in kitchen radio format.

models also offer the possibility of importing CDs directly. Naim and Melco have the additional option of importing large USB mass storages without the detour via your computer. Simply back up your music collection from your desktop PC onto an external hard drive, plug it into the NAS, import everything, and enjoy the fact that you have, at the same time, generated a backup copy.

In terms of sound, too, such special computers often have the edge. The models of the three providers mentioned are specialized to music reproduction. They don't even know features such as web-sharing. Since their operating systems have been reduced to basic functions, they can work stress-free. Standard NAS like those of QNAP or Synology burden their already weak processors with many additional tasks. The investment in a proper HiFi NAS can be worthwhile for audiophile music lovers.

▲ A NAS stores huge amounts of music data (often several terabytes) and can make it available to several network players simultaneously via the home network. Models like Audiodata's music server (fig.) or Melco's N1A can even rip CDs themselves. Others are fed from the computer or via USB hard drive.

ROUTER REQUIREMENTS

And also for the router applies: the fewer devices are active in a network at the same time, the more relaxed can the central management unit pass around its instructions. You should therefore keep the complexity of your home network to a minimum. Should the rest of the family protest against an impending internet lockout, it is possible to set up a small hi-fi subnet using a separate router. Our listening rooms are isolated from the huge publishing house network in the same way. Your local computer shop around the corner should be able to explain to you how the installation works.

Since there are no specialized hi-fi routers, you can otherwise have little influence on this device. We prefer AVM (FritzBox) models, which have proven to be extremely reliable in our listening rooms and amortize their additional costs through longevity, high speed and intelligent features. Another tip are Netgear's large routers, which can also establish stable radio connections over long distances due to their many antennas. We nevertheless do not deviate from the core statement in the "Some Words About Wlan"-box: Wlan is only suitable for audio transmission in absolute emergencies!

Nowadays there is also with Streamers a choice of different versions: standard models such as Cambridge Audios CXN V2 or Yamaha's NP-S303 combine their versatile media players with a D/A converter. Cheaper devices such as Sonos' long-running Connect, Bluesounds formidable Node2 or Elacs Discovery have their own DACs, but are also suitable as an upgrade basis. Accustic Arts Tube DAC II allows a Node2 to play eye-to-eye with devices of the 7000 Euro class. Pure streaming bridges are fully specialized in this area. Auralic's Aries models, for example, have no D/A converters. Instead, they concentrate on their comprehensive knowledge of formats and offer outstanding app controlling – a separate DAC is however mandatory in this case!

KEYWORD

SUBNET:
The name is to be understood literally: a subnet is a small network of its own within a more complex network.

PUT IT ON THE INDEX!

Once a new network player is up and running, the first thing it needs to know is which data pool to obtain the music from. If you want to, for example, use a web streaming service, you must enter your account data in the device settings. Typing cryptic passwords is usually much easier with the app. However, if you want to stream music exclusively (or in parallel) from the NAS, there are two basic approaches:

One of the many secrets of Apple's iPod was that it browsed the entire music library and compiled the meta-data of all titles in a quickly retrievable table. It was then able to display the collection alphanumerically by artist, album or genre and respond quickly to search queries. This analysis of music is called "indexation". Each NAS drive today has at least one musical index service pre-installed. Twonky and Asset are among the more prominent examples. Classic streamers like Linns 2008 DS or Marantz' NA8005 can call upon such UPnP index services (they are displayed as a source in the app) and retrieve the contents tables. The sorting criteria are specified by the index service of the NAS. Usually one can influence the display and the available sorting criteria in the web mask of the minicomputer (enter IP address in the browser).

This method is wonderfully simple, but it has two annoying side effects: music may have been added or deleted since the last connection to the NAS. Therefore, the table must be recalled each time the streamer contacts the NAS, giving the operation, especially with large music collections, a little sluggish touch. In addition, the indexing service may send more table entries than the streamers and app process. This occasionally leads to disconnections. Then you have to go back to the app's source register and select the UPnP index again.

More and more manufacturers therefore prefer to implement their own indexing services in their devices. The classic example of this is the Sonos concept, which has always managed its music collection according to its own gusto. This procedure is usually faster and more

stable, while also allowing for some colorful enrichments: since Naim's streamers also index themselves, they know the contents of the music library, enabling them a comparison with the service provider Rovi, who contributes additional title information (digital booklets, web links or artist photos) via the Internet. At Elacs Discovery, it is the paid service provider Roon that adds highly detailed metadata, biographies and unique sorting options. As grand as it sounds, this contains two of the most treacherous hurdles you can find in a streaming network:

In order for the streamer to scan and analyze the contents of the networked NAS, it must know which directory the music is located at. To do this, one must first define at least one storage location, which is to be permanently monitored, in the settings. This requires the entry of a network address according to the pattern "192.168. xxx.xxx\music" or "QNAP\public\music". We strongly recommend to do this basic setting on your computer. Sonos, Bluesound, Linn and some others have a desktop version of the remote app. If this is missing (e.g. in Auralic), finding the "backslash" ("\") can turn out to be a challenge, especially on Apple portables. In such cases, we have already helped ourselves by writing the necessary input on a PC and subsequently sending it to the portable via e-mail. Everything else can then be done smoothly via "copy and paste".

The second obstacle is that the default directory path must not change. Otherwise the streamer will not find the music. If, for example, a new router is bought, it automatically assigns new TCP/IP addresses to the found network participants. The same can happen if it is reset for some reason – the directory paths must be checked and re-entered if necessary.

If you are already annoyed by all of this and don't fancy messing with computer directories, network addresses and the like at all, there's an alternative for you: get a music server! Machines like Burmester's 111 or X-odos' "xo|one" combine network player and NAS in one. It's even cheaper with devices like Auralics Aries Mini or the Altair. Both are delivered as bare streamers, but can be extended to servers via an optional hard disk. All you need is a simple WLAN connection for control via tablet or smartphone. The three musical NAS specialists from Audiodata, Naim and Melco mentioned above could also be a simplifying alternative: if they are connected via USB to an optional D/A converter, they can also act as media players and replace the streamer.

It is already becoming apparent that NAS drives will lose importance in the future: more and more streamers are capable of indexing multiple terabytes of music collections directly from connected USB media. We are ourselves increasingly operating media players in this refreshingly uncomplicated way. Cambridge's CXN V2 even combines this with an UPnP service. It makes the music data of "its" USB drive available to other streamers in the network – even across manufacturers. Well, if that isn't good news for the computer opposition!

◀ AVM's Fritzboxes define the high-end class of DSL-capable network routers. The devices are excellently manufactured, durable and work extremely reliably.

SOME WORDS ABOUT WLAN

Everything could be so wonderful: in the brochures of many manufacturers, the components of the HiFi chain do their job wirelessly. With streaming, this works via WLAN. All you have to do is select the desired network router from the network player's menu, enter the password (called SSID, usually written on the back of the router) and already you're wirelessly connected. However, this type of connection is fragile. Just a single door between the router and streamer can reduce the radio intensity to such an extent that an audible sound deterioration occurs.

Therefore, for us, the following rule applies: WLAN may be absolutely sufficient, in order to connect a little multiroom-speaker somewhere in the 5th-something side room. For the central HiFi chain, however, LAN is required! If the path from the router to the system is extremely long, also a single high-quality cable can be laid, using a „splitter" to separate the signals in the listening room. Even inexpensive LAN cables sound better than the most stable WLAN network. If fixed cabling is impossible, PowerLine adapters (network via home power network) are a viable alternative. By the way, it doesn't matter that the tablet for controlling the system is connected via WLAN, as no audio signals flow here.

WHAT IF IT'S JAMMED?

It can always happen that problems appear somewhere. Sometimes a streamer is not recognized by its own app, another time the NAS disappears into digital Nirvana. In that case you should first of all check the settings of both devices. Not only router resets, but in rare cases also updates can cause Streamer or NAS to forget their base settings. Often the clumsiest of all IT wisdoms also helps: "have you tried turning it off and on again?" And don't forget to restart the router. It keeps a table of all networked devices and remembers them for a long time. If you occasionally give your WLAN data to guests (which is not uncommon today), a considerable amount can quickly accumulate. And if the list of its DHCP contacts becomes too long for the router, it will start to become noticeably slower.

DATA COLLECTION

The last big topic to which we must devote ourselves is the acquisition of data or music.

The best way still is ripping your own CDs. This involves importing the optical data carriers into the computer and converting them into one of the common sound formats in the same process. The lossless FLAC has established itself as de facto standard in the hi-fi community and is supported by every streamer. The necessary programs such as "Exact Audio Copy" (Windows) or "XLD" (macOS) are free of charge. The strongest and simplest application is called "dbPoweramp" (Windows/macOS) and costs around 33 euros. However, it also offers the integration of several meta-services, including the outstanding AMG database. These tagging services are required if you don't want to manually type in the names of all artists, albums and tracks. Many service providers (including AMG in particular) also supply high-resolution cover images. And if there is a missing entry after the ripping process, one can also manually edit the ID3 tags afterwards. A fast and rather intuitive application for this is MP3tag, which is available free of charge for Windows and macOS. Another tip is Illustrate "PerfectTUNES" (Windows/macOS, around 31 Euro), a collection of small programs, which, among other things, search for missing or faulty tags and covers, compare them with the AMG database and add them to the music files.

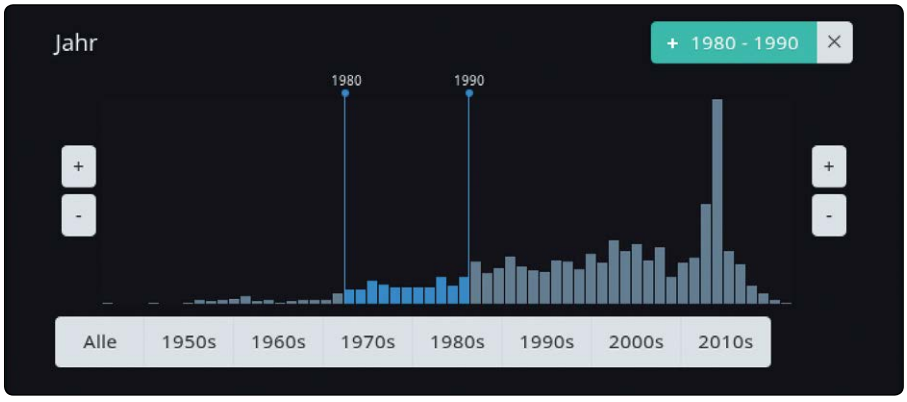
KEYWORD

RIPPING: Since the S/PDIF format of the CD cannot be processed directly by the computer, the titles must first be extracted from the medium and converted into a usable sound format (FLAC, MP3, etc.).

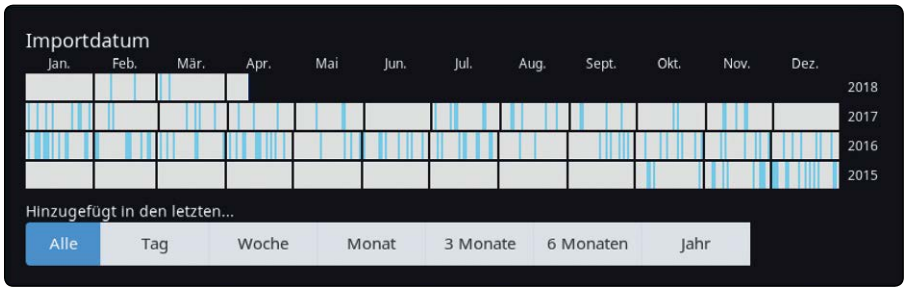
Unfortunately, there do not seem to be ideal prospects for ripping. Already one finds less and less suitable USB drives in the respective shops. Right now we can only recommend the external models of ASUS and Pioneer. These can, however, not compete with the outstanding quality of Plextor's Premium II series.

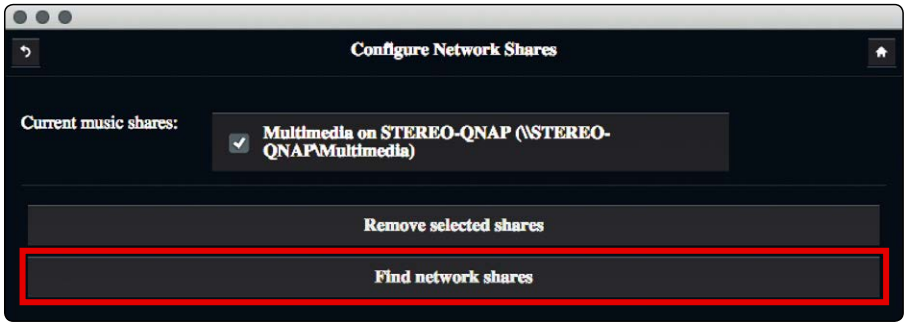
In the not too distant future one will therefore have to buy the music digitally on the Internet. This is possible in shops like Qobuz and Highresaudio and even has an advantage: both suppliers have a large selection of high-resolution music in their assortment. After the purchase you download the data onto the computer, move it to the music directory of the NAS, and after a few minutes (after all, the indexing has to be discovered first) the new hires-songs are ready to go. By the way, you are not "limited" to the hires version: for portable and other mobile purposes, it is often possible to download a variant in CD quality and MP3 files in parallel.

Carsten Barnbeck



▲ The strength of indexing by the streamer itself becomes particularly evident in the Roon concept: since it analyses the titles meticulously, it offers not only extensive meta data but also an option for statistical evaluation of the music collection (below) and can filter titles, e.g., by year (above). More companies should take this comfort as an example!





▲ Many newer streamers (here Bluesounds Node2) take care of the music indexing themselves. For this purpose it is necessary to assign the app to the cryptic directory path of the NAS. However, Bluesound also offers an automatic search (frame), which works reliably at least with UPnP standard mass storage devices like those of QNAP.

WHAT ARE ID3 TAGS?

Metadata, i.e. additional information (artist, cover image, web links, etc.) attached to a music file, must adhere to a formal framework so that it is understood by as many media programs and network players as possible. This standard is called ID3 (IDentify MP3), and it was introduced – as its name suggests – together with MP3. However, it is now used for almost all sound formats. Because the multimedia possibilities of MP3 have constantly evolved since the early days of MP3, the ID3 tag also had to be updated in various stages. The current standard v2.4 allows, for example, multiple entries that can assign a single song to different genres. However, streamers often use the outdated (but proven) v1.x variants, which isn't a problem since ID3 tags are downwards compatible, meaning older players can read current tag versions. They simply ignore the newly added possibilities (such as multiple genre tags). For more information, visit www.id3.org.

GLOSSARY:
TECHNICAL TERMS EXPLAINED SIMPLY

Sampling rate: Indicates the frequency with which "samples" are taken from an analog signal during its digitization. The higher the sampling rate, the more precisely the original is digitally reproduced. At 44.1 kHz, i.e. 44,100 samples per second, a 5 kHz oscillation already consists of only eight samples (44,100: 5,000). If the signal is sampled at 96 kHz, on the other hand, it's 19 samples (96,000: 5,000). Since an oscillation always consists of one positive and one negative half wave, at least two samples are required to display it digitally. The maximum frequency a digital medium can reproduce is consequently half its sampling rate. A CD can therefore play a maximum of 22.5 kHz (44,100: 2), the DVD manages 48 kHz (96,000: 2).

apt-X: A lossy sound format that, unlike MP3, is not based on a computationally intensive spectral analysis, but uses a series of fixed mathematical calculations that reduce the output signal in a fixed 4:1 factor. Due to its fixed operators, the encoders and decoders work very fast, which results in small computational delays. Since it requires little processor power from the devices, the format is also extremely power-saving. Besides the classic aptX, which shrinks a CD audio file from 1411 kbps to 352 kbps, there is the newer aptX HD, which reduces signals from 24/48 (2304 kbps) to 576 kbps.

Bit: ("Binary Digit") The smallest unit in the binary digit system. Bits are combined to so-called "data words", whose "word length" determines the set of values that can be mapped: With four bits 16 values can be displayed (0 to 15), with eight bits 256 values (0 to 255). The 16 bits of the audio CD can capture around 6500 dynamic levels.

Byte: The byte is a group of eight bits – a relic from the early days of computer technology. Although computers now work with 32 or 64 bits, the byte with its 256 values that can be mapped is still relevant because many basic units of IT are managed with it. The ASCII character table is based on byte addressing – even modern high-performance PCs therefore "only" know 256 different characters. The memory sizes are also still in bytes. A computer with one megabyte of memory can manage eight million bits.

Bitrate: Data transfer rate, expressed in bits/second, for example "100 Mbits/s", i.e. 100 megabits or 100 million bits per second. For further information go to "kbps".

Bluetooth: A power-efficient radio standard for short transmission distances. Unlike WLAN, it is highly standardized. The devices automatically detect other components and can connect easily.

D/A Converter: Often also referred to as "DAC". A special device or assembly within a component that converts digital data into electrical voltage. The DAC chip used determines which data formats, bit depths (word widths) and sampling rates the device supports. Almost all common chips process S/PDIF up to 24/192, newer models also accept DSD. In this context, "data format" must not be confused with "sound format": formats such as FLAC, MP3 or Apple Lossless must first be converted to S/PDIF by the media player before a D/A converter can process them.

DLAN: Also called "Power-LAN" or "Powerline" by some manufacturers. A network connection via the power sockets or the existing electrical installation.

DLNA: ("Digital Living Network Alliance") An organization for the certification of network devices initiated by manufacturers such as Hewlett Packard, Sony and others. DLNA is based on the UPnP network standard, but limiting its command scope to a more reasonable level. Further, DLNA devices are divided into functional groups. A DLNA network device therefore knows immediately whether its equally certified partner is a streamer or a color printer and offers appropriate options. This purpose-oriented communication makes DLNA networks more stable and less susceptible to conflict than UPnP.

DHCP: ("Dynamic Host Configuration Protocol") Automatic IP address assignment by the router for fast and uncomplicated identification of devices connected in the network.

Ethernet: The term stands for a wired network (LAN or WAN) and is by far the most common transmission standard for computer networks. Nowadays, most components offer fast Gigabit LAN (transmission of one billion bits per second). However, due to external influences on the signal path as well as a number of switching processes in the computer and router, the real speed exploitation is usually much lower. DLAN is also one of the Ethernet technologies – unlike WLAN, which requires its own constantly evolving standard due to its complex security technology and authentication (password query).

DSP: ("Digital Signal Processor"), occasionally also "Digital Sound Processor". This is a processor optimized for audio signal processing. Depending on the device, these signal processors are additionally specialized. For example, there are DSPs that only decode sound formats, but also those that calculate complex mathematical room equalizations. Although they are usually clocked much slower, they are superior to many CPUs in audio calculations.

HD: ("High Definition"= high resolution) Meaning a data resolution above the generally agreed standard. For music, this applies to everything above the CD resolution of 16 bit/44.1 kilohertz. Even a file with 24 bits and 44.1 kHz may be marked as "HD" according to this definition. For video data, everything above the PAL television or DVD standard (576 picture lines) is HD.

HDD: ("Hard Disk Drive"). Not to be confused with HD for "High Definition".

Internet radio: Radio programs from all over the world are transmitted via the Internet. Since the streaming variants of MP3 and the like are used for the transmission, web radio includes the complete

GLOSSARY

tagging concept of modern sound formats. Tens of thousands of available radio stations can be filtered in the receiver according to criteria such as preferred music style, country of origin, language or transmission quality (bit rate or data rate).

Jitter: Clock tremors, meaning slight time errors in the digital signal caused by interferences, electronic component inertia or mechanical influences. It can accumulate over the entire signal processing. To eliminate jitter, many components first collect the data in a cache and then "reclock" it according to their own clock settings.

Kbps: Kilobit per second - a unit specifying the data bandwidth and transmission speed of a digital signal or digital interface. 512 kbps means that 512,000 bits are transferred per second from point A to point B. Multiplying the kbps value of a sound format by the length of the song, you get its effective space requirement on the hard disk. 320 kbps MP3 titles with a playing time of 3:02 min (182 seconds) occupy 58,240,000 bits, which corresponds to about 7.2 megabytes (one byte contains 8 bits). Comparable units are Mbps (megabits per second) or Gbps (gigabits per second).

LAN: ("Local Access Network") A small, local, wired network, such as a company intranet or home network. In contrast, WAN (Wide Area Network) – such as the Internet (see also Ethernet). The wireless (radio) network is called WLAN (Wireless LAN).

NFC: ("Near Field Communication") radio protocol for very short transmission distances. Utilizing this technology, Bluetooth devices can authenticate themselves in a comparatively secure way without entering a PIN.

PCM: ("Pulse Code Modulation") Method for converting analog streams into digital data, which is or has been used with most HiFi media (CD, DAT-recorder etc.). Each sampled analog voltage value is represented by a binary number of at least 16 digits (16-bit coding). The number of sampled values (i.e. the sampling rate) depends on the given clock pulse. PCM can, by the way, only process integer values. Analog voltages that cannot be "translated" into 16-bit values because they would result in odd binary numbers are rounded off by quantization.

S/PDIF: ("Sony/Philips Digital Interface Format") A digital transmission standard developed for the audio CD by Sony and Philips, which became so widespread due to the still popular optical medium that it is now virtually the industry standard in digital audio signal processing.

SSD: ("Solid State Drive") A flash mass memory that is extremely fast and reliable due to a lack of moving components. To a certain extent the expensive SSD is, so to speak, "overpowered" for storing audio signals, since the hard disk is working much faster than even high-resolution signals require.

SSID: ("Service Set Identifier") The "name" of a WLAN network.

TCP/IP: Internet protocol for packet-by-packet data transmission from one address to another, which does not necessarily have to run in the correct order: the data packets are collected at the destination address and then restored to the correct order.

USB: ("Universal Serial Bus") A bidirectional standard interface for connecting almost any device such as digital cameras, MP3 players or hard disks to a computer. The most common standard today is USB 2.0. The new USB 3.0 is significantly faster and downwards compatible.

WLAN: ("Wireless LAN") Stands for wireless networks. The transmission speed is lower than in cable networks, which is due to the fluctuating radio stability. This depends on the environment (masonry, number of other radios, etc.). Despite its similarity in name, WLAN is technically only partly comparable to LAN.

OVERVIEW:
THE MOST IMPORTANT SOUND FORMATS

Our "Who is Who" explains the most important facts and fundamentals of the common sound formats.

AAC, MP3, OGG AND WMA

Format type: lossy sound formats with additional data compression

file extension: .mp4, .mp3, .ogg .wma and others

Historical: MP3 is one of the oldest sound formats. It was developed in 1982 and was supposed to make voice and sound transmission via the, then still young, internet possible in times of lame analogue modems. Like MP3, AAC was developed by the Fraunhofer Institute and was to replace its predecessor. However, through Apple's use of it in the iTunes Store it established itself as a parallel format. OGG is a license-free counter-design by Xiph.org, who also developed FLAC. Fourth to mention is Windows Media Audio (WMA), a compression codec from Microsoft that has never established itself in the hi-fi world.

Max. Data rate: around **320 kilobits** (the multi-channel version of WMA can handle up to **768 kbps**)

File size: different

Sound: below the audio CD

Special features: Since lossy file formats work in a basically comparable way, we generalize here. However, the technologies used differ in some details, which makes them sound different. MP3 has a soft loudness touch, while the related AAC sounds emphatically neutral and open. Overall, it should be noted that the current generations (MP3 and WMA are considered to are at the final state of development) are surprisingly close to the CD at high bit rates. The difference often only becomes apparent in a direct A/B comparison.

MQA (MASTER QUALITY AUTHENTICATED)

Format type: lossy sound format with data compression

file extension: .flac, .mqa.flac

History: The sound format introduced in 2014 removes the lower eight bits of a 16-bit signal (which contain only background noise anyway) and accommodates high-resolution signal components there. Dedicated MQA converters decompile the data and play it as 24-bit files, all other devices play it back as 16-bit audio. Since the compressed FLAC is used as a container, MQA considerably reduces the file size of high bit audio: the 5.6 Mbit of a 24/96 file is broken down to about 500-700 KBit. This corresponds to about one eighth of the original size.

Max. data rate: up to **24 bits** and **96 kilohertz**

File size: not exactly determinable, but the compression is considerable

Sound: like audio CD or better

Special features: The licensor combined its sound format with a certificate to ensure compliance with minimum standards in the studio and on playback devices, while at the same time preventing data stream manipulation in the playback chain. In terms of sound, this makes a lot of sense, but the issuing of certificates for a fee and the compulsion to licensed hardware brought MQA a lot of criticism, whose emotionally charged debates and disputes often present the format worse than it actually is. Since January 2017, thousands of MQA albums are offered with the Tidal HiFi subscription at no extra charge.

FLAC (FREE LOSSLESS AUDIO CODEC)

Format type: lossless sound format with data compression

File extension: .flac

History: Since the year 2000, FLAC was developed by the Xiph. Org-Foundation, which is the same free programmer association that also designed the sound format OGG. In comparison the FLAC encoder works, however, completely lossless. It reduces the file size by bundling the raw audio data in the manner of an archiving program (Zip, Rar). The efficiency of the compression varies, depending on the complexity of the edited titles.

Max. data rate: Up to **655 kilohertz** at a maximum of **32 bits** are currently possible.

File size: Memory requirements are 25 to 70 percent lower than with WAV, AIFF or the original CD. On average, it saves about 50 percent of hard disk space.

Sound: like audio CD or better

Special features: Although basically lossless, FLAC forces the playing device to moderate computing work when unpacking the audio data. It is possible that this "stress" affects the sound of older streamers. We haven't been able to collect any clues yet, but readers occasionally report the format would sounds duller on their device than a comparable WAV file. By the way, FLAC uses the tagging format of RIFF (AIFF and WAV) and thus corresponds to ID3: metadata and cover image can be of any size and are reduced in data volume together with the audio signal.

APPLE LOSSLESS (ALSO CALLED "APPLE LOSSLESS AUDIO CODEC" OR "ALAC")

Format type: lossless sound format with data compression

file extension: .mp4 or .m4a

History: Introduced by Apple in 2004, ALAC is based on the same principle as FLAC. Lossless audio files are compressed into archives like Zip or Rar. However, Apple Lossless works with different algorithms.

Max. data rate: The maximum dynamic range is **32 bits**, there is no limit to the frequency.

File size: The memory requirement is 35 to 60 percent less than with the original CD. The average space gain is 52 percent.

Sound: like audio CD or better

Special features: Since the format was originally bound to Apple's licensing policy, ALAC has no significant popularity outside iOS and macOS. Since the license was released in autumn 2012, device support has increased noticeably, but FLAC still has a huge lead.

WAV (ACTUALLY RIFF WAVE)

Format type:
lossless and compression-free container format

file extension: .wav, .wave

Historical: Although the format dates from the late 1980s, Microsoft did not introduce it until 1991 with its Windows 3.1. Before, it wouldn't have made much sense anyway, since the memory requirements of a CD-quality stereo recording of around ten megabytes per minute would have exceeded the capabilities of any hard disk at that time.

Max. data rate: Theoretically, there are no restrictions on bit depth and clock rate.

File size: such as audio CD or above

Sound: like audio CD or better

Special features: WAV handles all registers of the tag management and could even attach videos to the files, since it isn't bound to size restrictions. However, this potential is not exploited by virtually any streamer or software. The support is good: almost any network player, portable and USB host can play WAV.

AIFF (AUDIO INTERCHANGE FILE FORMAT)

Format type:
lossless and compression-free container format

File extension: .aif or .aiff

History: AIFF is closely related to WAV, was developed by game-company Electronic Arts and was made a standard by Apple in the early nineties. Due to the widespread use of Apple computers in recording studios, AIFF quickly became the number one music production format. Probably this fact is responsible for its good meta tag integration, as the studio professionals wanted to implement their authorship.

Max. data rate: Theoretically, there are no restrictions on bit depth and clock rate.

File size: such as audio CD or above

Sound: like audio CD or better

Special features: Since AIFF is, like WAV, an open container format for all types of data, the tags can theoretically be as large as you like and also contain foreign file types (videos, web links, etc.).

DSD (DIRECT STREAM DIGITAL)

Format Type: Lossless and compression-free audio format with bitstream structure - DSD data is not "slashed" into samples like PCM audio, but is processed as a continuous data stream.

file extension: .dff (rudimentary format without metadata), .dsf (extended with metadata)

Historical: Originally it is the sound format of the SACD, whose development was stopped by Sony in 2005. In 2013, the licensor finally released DSD as a streamable audio format.

Resolutions: **2.8 MHz (DSD 64)** and **5.6 MHz (DSD 128**) - there are also significantly higher data rates (DSD 256, DSD 512 etc.), but these are only used for internal signal interpolation (comparable to up- and oversampling).

File Size: Pure HD audio format. The memory requirement is twice to four times that of an audio CD.

Sound: Excellent! With good recordings, DSD is one of the best formats.

Special features: DSD-capable hardware is always required for playback. Due to its special one-bit data structure, the SACD format cannot be directly processed by computers or network players. To overcome this, the "DoP"-trick is applied (DSD over PCM): The DSD data stream is divided into "words" (sequences of 16, 24 or 32 bits) and stored in a form that is interpreted by the processing devices as a PCM audio signal. A streamer can delegate this container to its D/A converter, where it is unpacked again to the DSD bit stream. Although contrary claims are circulating, this process is completely lossless and sound neutral.