The Acoustic Musician’s Guide To Music Technology

An Introduction To Computer-Based Music Production

Networks

A traditional music production studio features numerous hardware components allowing the user to record, edit, manipulate, mix, and master multitrack musical performances. These separate devices are all interconnected using a vast array of cables and patch bays. Large spaces are often necessary to house all of this equipment. For this reason, traditional studios can be expensive to build and difficult to maintain.

Digital Audio Workstations (DAWs) are personal computer-based “desktop” studios that are capable of performing most of the above tasks within a software environment. Since internal computer programs are utilized to replace external hardware equipment, DAW studios can comfortably fit within the confines of a small office, basement, or bedroom.

Even with its reduced size, there are still certain pieces of external gear that will be required in order to record and playback music on a DAW. To properly connect all of these necessary items, you must become familiar with the three basic signal paths utilized within the digital studio environment:

🎶 **The MIDI Network** – consists of cables and hardware that allows MIDI data to flow between MIDI devices and the computer

🎧 **The Audio Network** – consists of cables and hardware that allows digital and analog sound signals to travel between audio devices and the computer

🌐 **The Computer Network** – consists of cables and hardware that provide access to the Internet or other computers on the network for file sharing and software upkeep

Regardless of network, **Signal Flow** refers to the direction path a source signal takes (either MIDI, audio, or computer) on its way to a specific destination. When signal flow stops, the DAW ceases to function properly.
The diagram below represents data signal flow between all three networks within the computer-based DAW studio. For instance, all MIDI devices can exchange MIDI data with each other (when properly configured) and with the computer. Likewise, audio signals can pass through the desired audio devices, and the computer as well. Note that the audio signals generated from the MIDI sound modules will have to travel over the audio network since the MIDI network cannot handle audio. Finally, the computer, and related devices, can freely access other PCs on the network, and the Internet, since this communication is contained within its own signal path.
The personal computer is the centerpiece of every DAW studio. Through this wonderful marriage of hardware and software, musicians are able to “virtually” create, notate, and record musical performances that could never have existed in the physical world. Traditional music recording techniques have also been dramatically enhanced through computer-based DAW systems.

Although many PCs are currently designed with multimedia usage in mind, the large majority of them still need to be carefully configured for electronic music production. For this reason, it is important for contemporary musicians to understand the basic components of a PC, as well as their function “under the hood.”

**PLATFORM & OPERATING SYSTEM (OS):** There are many companies today that manufacture personal computers but in order to purchase one, you must first select a platform. This refers to the specific framework (combination of computer hardware design and operating system architecture) needed to run software applications. Although there are several options available, the two most popular platforms are PCs that utilize Microsoft’s Windows and Apple computers that run Macintosh OS X (Roman numeral ten).

Basically, a computer is just a highly sophisticated combination of electronic hardware components within a plastic or metal container. By itself, it is totally inoperable without the use of software. The fundamental software utilized to make these components function is called an operating system, and is frequently referred to as the “OS.” The operating system serves as a foundation for all other software applications to utilize the computer’s hardware components. For this reason, any program installed on a personal computer must be compatible with both its hardware and operating system software.

**DESKTOPS & LAPTOPS:** Software performance is dependant upon hardware configuration and capabilities. In order to have a stable-running DAW that meets your musical needs, you must determine the basic computer system and design for your studio. Desktop computers are usually the fastest running, least expensive, and most expandable option available today. Tower-based models often include internal space for additional memory, storage, processing cards, and media drives. These can be beneficial in expanding the functionality of your studio.

Laptop computers may not be as fast, but they offer portability for the mobile musician. Although they don’t provide internal expansion possibilities, external options exist through USB and FireWire connectivity. Due to their small, sleek design, they can also be helpful in dramatically decreasing studio size. Laptop-based DAWs can easily fit on a small table or desk, making almost any area into a potential electronic music studio.
Regardless of which computer platform, model, or design you choose, they will all utilize the following items:

**CPU:** The central processing unit (CPU) is the main computer chip responsible for calculating most of the data running through the machine. The rate at which the CPU can calculate data is referred to as its “clock” speed and, for all music-related tasks, “faster is better.” Many computers today are shipping with dual CPUs which dramatically increase system performance.

**HARD DRIVE (HARD DISK):** Hard drives are utilized to permanently store data on a computer system. The OS, software applications, and user files are all saved to this location. Hard drives vary in storage capacity and speed. Electronic musicians will need the largest and fastest models available for multitrack audio recording and software synthesis. For most professional music situations, multiple hard drives are desired with one specifically dedicated just to recording audio.

**RAM:** Random Access Memory (RAM) is one of the most important factors in overall computer performance and stability. These memory chips are used to store temporary information while the CPU is computing data. In most situations, adding more RAM to a computer increases its speed, stability, and functionality. For music-specific applications, more RAM provides for additional software sound possibilities, increased track counts, and larger amounts of simultaneous DSP effects.

**PORTABLE MEDIA DRIVES:** This refers to the various computer storage devices that save information in a portable format. CD-R(W), DVD-R(W), Zip, and floppy drives all belong to this category.

**EXPANSION CARDS:** These electronic circuit boards can be placed inside a computer to offer additional connections and/or computing capabilities. Most desktop towers can accommodate full-size PCI cards while some laptops can only accept the smaller PCMCIA format. Many manufacturers offer expansion card MIDI and audio interfaces.

**COMMUNICATION PORTS:** These allow computers to easily interface with external devices such as hubs, scanners, and printers, as well as audio and MIDI gear. The following cable connections are commonly utilized on most desktop and laptop computers:

- **1/8” miniplug** – used to connect analog microphones, stereo headphones, & speakers
- **USB** – (Universal Serial Bus) the standard for connecting keyboards, mice, printers, digital cameras, and scanners
- **FireWire** – commonly used high-speed connection for video and audio devices
- **Ethernet** – utilized to connect computers to a network or high-speed modem
Acoustic musicians utilize music notation to record and communicate performance-related instructions. The performer reads and interprets the notation and then plays the desired part according to the composer’s specifications. On its own, printed music notation makes no sound at all. It’s musicians that are needed to produce the audio performances dictated by the written information. Although this method works well for humans, computers are completely incapable of reading traditional music notation.

**MIDI (Musical Instrument Digital Interface)** is the music technology industry standard for electronic musical data communication. The MIDI protocol is a digital language that allows devices made by various manufacturers to “interface” with each other and share performance-specific information.

The MIDI specification describes every detail of a musical performance as a series of events (what pitches were played when, for how long, at what dynamic, using which sound, etc.). In its most basic form, MIDI data is like music notation for computers. Like printed notes on a page, MIDI is just information that tells the sound source (sound module, synthesizer, or software instrument) what to play and how to play it. Since it is just descriptive data, no audio is contained within the MIDI signal. The actual performance sound is only generated after the MIDI information “triggers” the sound source to play.

For this reason, MIDI instruments and sound sources form the digital “musicians” within the DAW environment. MIDI instrument controllers are utilized to enter performance data while sound modules, synthesizers, and/or software instruments are used to hear the performance data.

Traditionally, MIDI devices have used multiple 5-pin DIN connection ports to interact with each other. Each port is unidirectional, only allowing information to flow one way. The OUT port is used to send MIDI data to other devices in the network while the IN port receives MIDI information from external sources. When multiple MIDI devices are connected in sequence, the THRU port (if it has one) can be used to pass incoming MIDI data along to the next MIDI device in the signal chain.

Presently, most professional electronic synthesizers, sound modules, and MIDI controllers contain internal MIDI interface ports. Modern computers, however, utilize bidirectional USB and FireWire ports to connect with external devices. For this reason, DAWs often have to utilize external hardware USB or FireWire MIDI interfaces.
General MIDI

Although the MIDI protocol specifies patch number (1-128) in its code, it does not identify the actual instrument’s name (piano, guitar, saxophone, etc.) This caused musical chaos for users since manufacturers didn’t organize their instrument patches in a uniformed order. One company’s piano could have been sound patch #001, while another’s might be #003. This inconsistency made it difficult to share MIDI performances since all the channel instrument assignments would have to be reprogrammed for each MIDI device.

The General MIDI (GM) specification was an attempt to rectify this problem and bring MIDI to the consumer market. In order for MIDI files to be popular among average users, they had to be easily portable and require no instrument remapping in order to play back correctly. The MIDI Manufacturer’s Association (MMA) addressed this issue by standardizing a program number map of instrument sounds that were to be consistent among all MIDI devices. This bank of sounds came to be identified as General MIDI or GM for short.

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Although the GM standard has proven itself to be durable, there have been attempts to improve upon its design. Yamaha developed what they called XG while Roland introduced their GS instruments and both did well. These advancements led to the creation of General MIDI Level 2 (GM2), which provided for more instrument sounds, additional MIDI message definitions, effects implementation, and enhanced expressive capabilities.

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MIDI Hardware

MIDI devices are pieces of electronic equipment that generate MIDI data when operated. They usually fall under the following categories:

**MIDI INTERFACES:** Since most computers do not contain built-in MIDI ports, these are used to connect one (or more) MIDI devices to a computer. Basically, all of the MIDI data that travels through the MIDI interface can be routed to any MIDI device connected, as well as to the computer. Numerous MIDI devices greatly expand the amount of sound possibilities available and are preferred for professional-sounding results. Although it is totally possible to create decent sounding music with only one MIDI device, having many available can dramatically increase sound quality.

**SYNTESIZERS:** Up until recently, these have been the default MIDI instrument utilized with a DAW. Synthesizers are really two MIDI devices in one package (a **controller** and a **sound module**). The controller is the actual part of the device that looks, feels, and responds like a traditional musical instrument. In most cases, this is in the form of a piano keyboard but can also be a drum, guitar, saxophone, or other commonly recognized instrument design.

The purpose of the **controller** is to provide the musician as close to the traditional performing experience as possible when working in the electronic domain. For instance, a classically trained pianist would probably be able to adapt better to a keyboard-like electronic instrument as opposed to having to mouse-click in an entire performance one note at a time. Likewise, a percussionist would most likely be able to enter a drum groove faster, and with the right “feel” if he/she could just “play” it into the computer using a drum set-like MIDI controller. Additionally, most controllers offer sliding faders, wheels, and/or joysticks that allow for such things as pitch bend, vibrato, and other expressions to be entered while performing. For this reason, the quality of the controller part of a synthesizer is very important to musicians.

The controller, however, does not make any sound. It just transmits MIDI data about how it is being performed. In order to hear the performance, a **sound module** is needed. This is the part of the synthesizer that actually contains all of the instrument presets and sound editing capabilities. The sound module is usually accessed through a small display screen on the device. Buttons on the instrument allow the user to navigate through the various “virtual” pages and windows of the instrument’s operating system and choose the desired feature or task.

A feature known as **Local Control** insures that a synthesizer’s controller will always trigger the internal sound module’s currently selected instrument sound. When working with a DAW, it is often necessary to deactivate this feature since the MIDI performance data must first go to the software and be recorded. Once this is done, the DAW can instantly pass the signal on to the sound module and trigger the appropriate sound. In this scenario, leaving local control on can accidentally produce simultaneous triggering of multiple sounds from both the controller and the DAW.

In addition to controller and sound module, many high-end synthesizers offer built-in sequencers, processing effects (like reverb, chorus, delay, compression, etc.), hard drives or CD burners, and
sound expansion. These types of instruments are often referred to as MIDI Workstations due to their all-in-one packaging. Yamaha’s Motif, Roland’s Fantom, and Korg’s Triton series are all examples of this instrument category.

As beneficial as these instruments might appear, they are not ideal for all situations. First, they are usually large and bulky which means they take up a lot of space in your small home studio. Secondly, many of the advanced built-in features are already available within most computer music software applications making them redundant and unnecessary. Lastly, digital display screens are expensive and require the instrument to utilize a software operating system to function. This is why synthesizers usually have small displays that are often cumbersome to navigate. Nevertheless, these instruments represent the “Stradavarius” of electronic instrument design.

**MIDI CONTROLLERS:** These are basically synthesizers without the built-in sound module. By just providing the instrument-like input part of the device, musicians are able to choose the best available controller to their liking. As mentioned above, MIDI instrument controllers usually offer additional buttons and/or features that can greatly expand its expressive abilities. It is usually these items that determine cost and quality.

Since these are relatively new to the DAW environment, most of them come with built-in USB or FireWire ports in addition to the traditional MIDI interface connections. These computer-friendly additions allow users to connect directly to a computer, bypassing the need for an external hardware MIDI interface altogether. By eliminating the internal sound module, MIDI controllers are capable of being very light weight and portable. Due to this, they are often very popular with laptop-based mobile recording musicians.

**SOUND MODULES:** Just like controllers are synthesizers without the built-in sounds, sound modules are synthesizers without the controller. By separating the controller and sound module, musicians are able to utilize one input device (controller) to trigger sounds from any sound module connected. Since sound modules take up very little space, and can be mounted on shelves or within racks, multiple units can easily be incorporated within a home studio. Whereas the all-in-one design of traditional digital synthesizer workstations offers the user a somewhat portable MIDI production instrument, the separate MIDI controller / sound module combination provides more sonic and expressive possibilities while better conforming to space limitations within the non-mobile studio.

**CONTROL SURFACES:** Once computer software allowed electronic musicians to jettison much of their external gear, they started to actually miss the feel of tweaking knobs and sliding faders in the studio. To fill this void, manufacturers offer MIDI control surfaces that allow musicians to control software operations by once again pressing buttons, turning knobs, and sliding faders. Instead of having to use the computer keyboard or mouse, these MIDI control surfaces can interact with software programs and accomplish the desired tasks in a way similar to how it was done with traditional external equipment.
The DAW

MIDI plays a very important role in the DAW studio but, as we have discussed, it is just an information protocol. Just like music notation, MIDI cannot be played back on a car stereo, CD player, or MP3 device. For this reason, the sound generated from a MIDI data performance must eventually be recorded as audio in order to be distributed for personal or commercial use. This is why digital audio workstations are so popular. In fact, most MIDI-based studios have now merged and become one with the DAW. Let’s take a look at the two most commonly used DAW systems.

PORTABLE STUDIOS: These are similar to the synthesizer in that they try to be an all-in-one solution. Looking similar to a traditional mixer, and operating like one, these mobile “studio-in-a-box” designs offer multitrack digital recording on the go. In order to compete with computer-based systems, some high-end models also offer external monitor support and computer mouse input to ease interface navigation.

For the mobile musician, these units can be ideal. Costing roughly the same as a “loaded” computer, they offer most of the features you would need for multitrack digital recording. Like the synthesizer workstation example, however, they also have significant drawbacks. For instance, computer-based studios can easily add new features by installing new or updated software. Hardware-based portable studios are not as flexible. In order to gain more features, you usually have to add more pieces of external hardware, which ends up making everything less mobile-friendly. Additionally, many musicians record performances individually (one take at a time), thus not needing all of the simultaneous multitrack input features of the portable studio. Although there is a professional market for these devices, the computer-based studio is much more popular.

THE DESKTOP STUDIO: This is what most electronic musicians refer to as a DAW. They are highly flexible and can be configured in numerous ways. Due to this, there is no one traditional computer-based DAW setup. The only similarities between desktop studios are that they all utilize computer hardware and software to do the majority of recording and editing tasks. Although MIDI and audio equipment are necessary for professional sounding results, computers that feature built-in microphones and speakers make it possible to do everything with just the software inside the machine.

Since most current musicians feel somewhat comfortable using a personal computer, and more than likely already own one, the desktop studio is fast becoming the default music creation device. In fact, some computer software applications make it possible to compose songs without even having to understand music theory or notation. For these reasons and more, computer-based DAWs have become attractive for both professional and amateur musicians alike.
Audio Hardware

**AUDIO INTERFACE:** For a DAW to record, edit, manipulate, mix, and master audio, the sounds must first get into the machine. Although most computers have a miniplug analog input to accommodate consumer-grade microphones and audio equipment, this connection does not allow for multiple, simultaneous signals and is usually too noisy for professional sounding results.

For this reason, many computer-based studios utilize an external audio interface. Since this device converts all incoming analog sound waves into digital algorithms, the computer receives a noise-free, digitized signal. Likewise, once the computer has finished processing audio, this same interface converts the resulting digital signals into analog currents needed to make speakers vibrate and reproduce sound.

Before computers, large mixing consoles were utilized to route multiple audio signals to numerous destinations. Even within small home studios, personal mixing boards often served as the “central nervous system” for the recording process. Since many audio interfaces now feature multiple input and output ports (often referred to as I/O), mixers are becoming less important in the digital studio. Additionally, manufacturers are now offering units with built-in MIDI interfaces and control surfaces that can offer the look and feel of traditional mixers.

Naturally, size and features play a large role in determining the cost of an audio interface. All-in-one models that included audio, MIDI, and control surface options are growing in popularity but take up more space. Mobile laptop musicians often prefer the smaller palm-sized devices but these can’t offer all the features of their larger counterparts due to the size restrictions.

When designing a studio, it’s important to select the interface that is best suited to your recording needs. The following options are often included on many interfaces:

- **XLR Inputs** – needed to connect professional microphones and high-end equipment
- **Pre Amps** – needed to boost incoming microphone signals to audible levels
- **Phantom Power** – needed to power professional condenser microphones
- **TRS & TS (Balanced & Unbalanced) ¼” Inputs & Outputs** – needed to connect guitars, keyboards, and miscellaneous audio gear
- **RCA Inputs & Outputs** – often used to connect consumer CD players or tape recorders
- **SPDIF, AES/EBU, TDIF, ADAT Lightpipe (Optical)** – various professional quality proprietary digital connections that are only needed if you use external devices incorporating these standards
MICROPHONES: If you want to include any acoustic instrument or sound in your recordings, you are going to need a microphone or two. Since microphones produce such a low signal, they need to be connected to a preamp. This device boosts the signal to an audible level. Basically, without a preamp, most professional microphones won’t work. This is the reason why many audio interfaces include preamps on one (or more) input.

Microphones usually fall into three main categories: dynamic, condenser, or ribbon. Dynamic microphones are relatively inexpensive and are good at capturing close, loud sounds. This makes them ideal for recording drums, guitar amplifiers, and “screaming” vocals. On the other hand, due to inherent limitations, they can “color” the signal, producing a slightly “gritty” or “dirty” sound.

Condenser microphones are the alternative. Since they are much more sensitive and accurate with capturing sound, they produce a noticeably clearer signal than their dynamic counterparts. In order to operate, however, they need a small amount of voltage usually supplied either from an internal battery or external device. Phantom power is the term used to identify this condenser-powering voltage and is often included on audio interfaces specifically for this reason.

Ribbon microphones are roughly similar to dynamic mics and get their name from the thin aluminum ribbon they utilized to capture sound vibrations. This delicate element produces a “silky smooth” sound that is slowly regaining popularity within the studio.

MIXERS: Although no longer mandatory, these devices are still very handy to have in the studio. Once all of the audio gear has been successfully connected to the appropriate ins and outs of the mixer, sound from these devices can be routed to multiple destinations within the studio. Along the way, additional devices can be added to the signal chain to manipulate or enhance the sound. Traditionally, mixers are utilized to raise or lower volume levels, determine the placement of audio (through panning) in the stereo or surround-sound field, and shape the over-all quality of sound by sending the signal to various EQ and effects processors.

Since all DAW audio must travel through the computer, many software applications offer “virtual” mixers that allow you to do most of the above actions within the program. When necessary, these “virtual” mixers can also interact with, and utilize, other software-based sound sources and effects processors without having to add or change a physical cable!

This is the reason manufacturers are starting to implement “dummy” mixer-like control surfaces within audio interfaces or as stand-alone devices. In essence, they provide the best of both worlds by allowing users to make software-setting changes through traditional mixing style techniques.
**MONITOR SPEAKERS & HEADPHONES:** Acoustic musicians constantly make adjustments to their sound while performing. In fact, this on-the-spot decision making skill is essential to creating a professional-sounding performance. In order to make the best musical choices, musicians must be able to clearly hear all aspects of the live performance as it happens.

Professionals in the audio and video industry often use the term “monitor” to describe a standard or reference by which something can be judged. For this reason, high-quality amplified studio speakers are often referred to as monitors since electronic musicians base all of their musical decisions by what they hear through these devices. Unlike consumer-oriented speakers that are often designed to exaggerate certain frequencies and enhance sound color, studio monitors and headphones are intentionally manufactured to provide a clear and unbiased representation of the audio signal. This allows the listener to hear the truest representation of the recorded sound quality. Since speakers need electrical power to operate, they need to be connected to either external or internal amplifiers.

**Software**

Software programs are basically digital instructions that tell the hardware components what to do. What usually makes these applications easy to use is their graphic user interface (GUI). The various menus, buttons, and windows utilized to navigate the program need to be logically assembled on the screen in order for the user to quickly and easily utilize the available features. Software applications that offer numerous user features can often have high learning curves, due to the many toolbars, menu options, and editing features within the program.

Music software usually falls under the following categories:

**NOTATION:** These programs are utilized to create professional looking notation manuscripts. Musicians will find these helpful with producing lead sheets, transcriptions, and ensemble scores. Although you can playback notation files using MIDI sound sources, these programs often do not provide the professional audio capabilities found within sequencing software. MakeMusic’s **Finale** and **Sibelius** are two popular examples of programs in this category.

**SEQUENCING / MULTITRACK RECORDING:** Arguably the most popular type of music software available, these applications turn a computer into a digital multitrack recording studio. Originally, sequencers were hardware devices utilized to record and playback multitrack MIDI files. By recording each MIDI event in sequence, entire performances could be carefully edited and mastered.

It wasn’t long before MIDI sequencing software appeared for PCs. As computer hardware developed, software companies began to add audio recording capabilities to their sequencing programs. Currently, most sequencers offer multitrack recording of both MIDI and audio performances. For this reason, the term DAW is often utilized to identify the sequencing software specifically, as well as the desktop studio as a whole.
DAW sequencer applications fall into two main categories: native (or host-based) and DSP. **Native** applications utilize the “host” computer’s “native” processing hardware to function. This often requires a computer with a very fast CPU, extra-large storage space, and the maximum amount of RAM possible. Since native-based programs are usually the most flexible and least expensive, they are very popular among both amateur and professional musicians alike. MOTU’s Digital Performer, Apple’s Logic, Steinberg’s Cubase, and Cakewalk’s Sonar are all examples of popular native-based DAW applications.

**DSP** (Digital Signal Processing) applications require dedicated hardware (usually provided by the DAW manufacturer) in order to function. These are the standard for professional recording studios and the entertainment industry. Although the dedicated hardware significantly raises the over-all cost of the studio, it dramatically increases track count, sound possibilities, and effects processing. At present, Digidesign’s Pro Tools is the industry-standard in this category.

**SOFTWARE INSTRUMENTS & PLUG-INS:** In addition to replacing analog recording equipment, computers have also made it possible to convert synthesizers and effects processors into software applications. Racks of audio processing equipment and electronic keyboards are no longer needed in the DAW studio since a single MIDI controller can access all sounds and effects from within the PC.

Although many of these applications can function individually (often referred to as “stand-alone mode”), they are also capable of working within a DAW sequencer. When accessed this way, they are referred to as a “plug-in.” This reference comes from the analog equivalent of physically “plugging in” external devices to the recording console. Although no cables are required with software plug-ins, these applications serve the same purpose by providing additional “virtual” devices and sonic solutions within the DAW studio.

**EDITOR / LIBRARIANS:** This category of music software is quickly becoming obsolete as more and more software instruments are replacing traditional hardware synthesizers. These applications communicate with hardware synthesizers and allow the user to edit the instrument’s sounds through the software. The resulting patches can then be organized within libraries or project folders for instantaneous recall.

The obvious benefit is that the user no longer has to spend time adjusting knobs or changing settings on the physical instrument. In essence, the software Editor application replaces the synthesizer’s user interface while the Librarian provides easy storage and organization for the instrument’s sounds. Since these
features automatically come with software instruments, editor and librarian programs only apply to musicians who want to operate their physical instruments within a virtual environment.

**EDUCATIONAL / ACCOMPANIMENT:** These applications offer computer-assisted instruction with learning music-related content. Some of them can also quickly generate complete arrangements of songs just by entering the letters of a chord progression. Although not usually associated with a DAW, these programs are very popular in the consumer and educational markets. Ars Nova’s *Practica Musica* and Harmonic Vision’s *Music Ace* are popular examples of tutorial-based music education software while PG Music’s *Band In A Box* is probably the best known accompaniment program on the market today.