MIDI in Sampled Orchestration

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May 2024

Thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Fine Arts in Sound Design
In the Graduate College of Fine Arts
Of Carnegie Mellon University
Pittsburgh, PA 15213

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Introduction

Upon entering a theatre, there is the sound of a cello emitting from the stage. The warm, lyrical sound of the cello's strings reverberates through the space, but there is no sightline toward where the sound is emitting. The cellist could be center stage, in the orchestra pit, in the wings, or anywhere their sound could be amplified. How can the audience know whether what they're hearing is a live cellist or merely a sounding replication of a cello? Technological advancements have made it possible for the cellist's performance not to be performed by a live musician. What is heard could be a recording of a cellist, a keyboardist on a cello patch, or a reconstructed sampled cello. Can an audience hear the difference between these different variations of a cello or an entire orchestra? Are the notes' inflections or the instrument's overall timbre[1] informing them? Does coming from an entertainment or musical background aid in hearing the difference? This thesis will explore whether audiences can hear the difference between a virtual orchestra and a real one and the process of creating a realistic-sounding virtual orchestra through the use of MIDI.

Musical Instrument Digital Interface, MIDI, is a result of technological advancements that have altered the entertainment industry's creative practices. MIDI has dramatically impacted how sound designers, composers, and orchestrators can do their jobs efficiently by revolutionizing a standard communication protocol and providing them with an entire orchestra at their fingertips. While MIDI has musical instrument in its name, it cannot create sound by itself as it is a control protocol (Huber, "Modern Music" 1). MIDI tells a device what to do when replicating an instrument, and is done through the use of MIDI messages. These messages are often triggered through the use of controllers like a keyboard.

[1] Timbre: The quality of tone distinctive of a particular singing voice or musical instrument ("timbre").

In music composition for film, MIDI is used to create mock-ups of scores for directors to listen to, giving a realistic representation of how a score will sound with musicians. A significant component of creating these realistic mock-ups comes from the use of sample libraries. In this regard, sample libraries are audio resources that contain samples from various instrument families like strings and woodwinds. The samples are made by recording musicians playing their instruments in different styles and techniques. Those recordings are assembled for easy programming and playback with software that utilizes MIDI. Sample libraries have their own unique sound due to the musicians that played for them, how they were recorded, where they were recorded, and how the samples were programmed. All libraries have one thing in common, and that is it takes a fair amount of work to have the samples sound realistic and not feel computerized. To combat a computerized sound, MIDI has numerous control change messages that give more variation in the recorded MIDI data. [When discussing the MIDI control parameters, all the examples given for explanation will be for a scenario where a keyboard is the primary MIDI controller.]

Commonly Used MIDI Messages

MIDI messages are crucial to MIDI, as they are the backbone of its communication. One type of MIDI message is the note-on message, which communicates three different aspects of information: the corresponding MIDI channel, note number, and attack velocity (Huber, “Modern Music” 21.). The message occurs when a key is depressed and will signify the start of a MIDI note. Once the key is released, a note-off message is triggered, which communicates the same information as the note-on message. This will also mark the end of the MIDI note, which results in the note appearing in the piano roll[2] when working with a digital audio workstation, DAW[3]. If the sample library used has any effect added to the sound, such as reverb, once note-off is triggered, this will start the reverb tail. Note-on and note-off messages are the two most common MIDI messages.

The MIDI note number, sometimes referred to as the pitch number, states which of the potential 128 notes are being activated. A common practice is that MIDI note 60 represents C4, also known as middle C, on a keyboard (Huber, “Modern Music” 21). All notes can be traced back to the piano, with notes 21-108 representing the full range of a piano. Notes 0-20 are around two octaves below a piano’s lowest note, with 109-127 being two octaves higher. This is all around the tuning of A4 = 440hz, the modern Western standard in music (“MIDI Note…”). While this is customary, it is by no means what a user is required to keep. MIDI note numbers can be reprogrammed, but it is essential to keep track of any changes made and how numbering functions work within MIDI. When counting with MIDI, MIDI begins with 0 instead of 1, which is the standard for computer programming. This means that MIDI note ranges are represented by

[2] A Piano Roll resides inside a DAW and is a place to input and edit MIDI note data and is represented graphically. Figure 6 shows a piano roll.

[3] A digital software used to record, edit, and produce audio.

0-127. If re-programming MIDI notes, such as making note 0 represent C0 instead of C-1, remember that this changes the layout of the keyboard. While middle C used to be represented by C4, it would now be C5.

Velocity is a huge component of MIDI that aids in producing a realistic sound because one way an instrument's timbre changes depends on how intensely it’s being played. Similar to MIDI notes, velocity is measured on a scale of 0-127 (see Figure 1) and recorded by measuring the force and speed used to depress a key (Rumsey, Chapter 4). As more intense musical passages tend to have a louder dynamic, velocity can also impact the volume or be programmed to affect different parameters. Not all MIDI devices have the ability to understand velocity in its entirety or simply the range of velocity. These devices often default to a velocity of 64, which lands in the middle of the velocity scale (Huber, “Modern Music” 21). This is not ideal for realistic music scoring, but if the device is connected and recorded in a DAW, the velocity can be edited later.

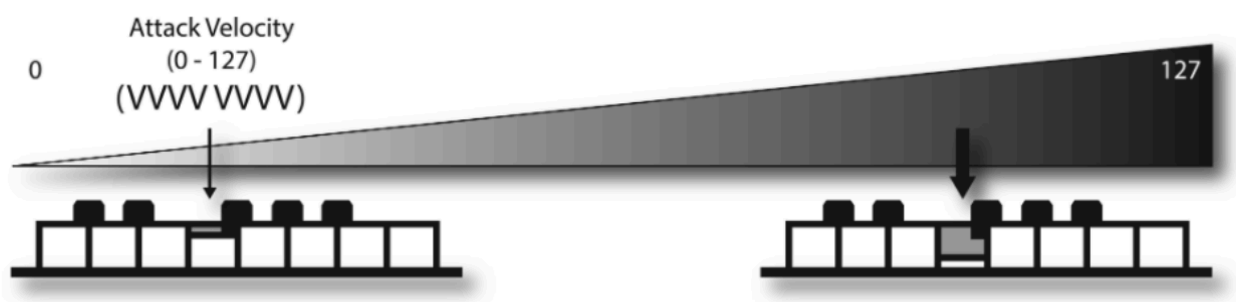

Figure 1. Velocity diagram with key depression example. (Huber, “Modern Music” 21).

Similar to how the force of a depressed key measures velocity, MIDI can also measure the pressure currently applied to a key. This is different from the force measurement, as it only records the initial force applied to a key and not any changes of pressure that happen once a key has been depressed. There are a couple of different types of pressure measurements, also known as aftertouch, and they each record pressure data in various ways. The first type of pressure message is the channel pressure. Channel pressure takes a change of pressure and assigns that new pressure value to all currently depressed keys. This means that if two keys are currently depressed, and less pressure is added to one of the keys, a new pressure value will also be applied to the key that didn't change pressure (Huber, "Project Studio" Chapter 2). The second type of pressure message is a polyphonic key pressure message. Rather than a pressure change of a single key affecting every other key, polyphonic key pressure will only change the pressure value of a key whose pressure has changed (Huber, "Project Studio" Chapter 2). Both of these pressure messages can be assigned to affect different parameters such as timbre, vibrato, loudness, and pitch.

All of these are examples of different MIDI messages. MIDI messages are transmitted through MIDI channels. A MIDI channel is a communication route for connected MIDI devices with a maximum of sixteen channels. Multiple devices can be on the same channel, but they can only communicate with one another if they share the same channel. If a synthesizer module is on channel 3 but receives a message from another device, a synthesizer on channel 10, the module will ignore the synthesizer's message. Devices have three port options: in, out, and through. Signal flow is pivotal; if the synthesizer and module are on channel 3 but connected by their out ports, they will not be able to communicate. The out port should connect the device that is sending the message to the receiving devices in port, meaning the synthesizer's out port is connected to the module's in port. Now, if that synthesizer wants to communicate with a second device, a drum pad, the synthesizer does not have a second out port. The drum pad would need to be connected to the module's through port to allow the synthesizer to communicate with the drum pad (see Figure 2). By doing this, the module is simply passing on the message from the synthesizer to the drum pad (“What are…”).

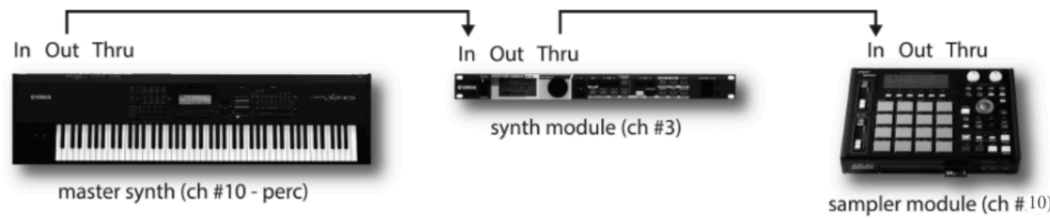

Figure 2. MIDI channels, assignments, and connections diagram with MIDI 1.0 spec (Huber “Modern Music” 17). The sampler module channel number was modified from the original material.

Commonly used control changes (CC) for MIDI are breath control, expression, hold pedal, and the modulation wheel. Breath control adds a sense of realism to sampled wind players by reproducing the air stream and articulation used to produce sound from wind instruments. Expression alters the level of an instrument and is helpful in creating realistic crescendos and decrescendos. The hold pedal acts similarly to the sustain pedal on a piano, and when depressed, it continues playing the MIDI note after the key has been released. Lastly, the modulation wheel that is attached to modulation has a similar effect as expression (Huber, “Modern Music” 28-39). All of these parameters, and ones not mentioned, can be connected to a MIDI controller for easier functionality and implementation.

MIDI Controllers and MIDI 2.0 Specification

MIDI controllers, which are used to control MIDI, come in various shapes and sizes. The most common controller is a keyboard controller with key numbers ranging from two octaves to the full seven-octave range of a piano. There are also weighted and semi-weighted key options to aid in a realistic feel while playing. An important factor in keyboard controllers is not to confuse them with a keyboard that has built-in presets for different sounds; if these controllers are not connected to sample libraries, they will not produce sound. MIDI acoustic pianos exist and behave like standard acoustic pianos, with the ability to send and receive MIDI messages (Huber, “Modern Music” 89). When keyboard controllers are connected to different samples, the keyboard will only produce sound when played in that specific instrument’s range. If a keyboard controller is used to perform a flute part, no sound will be produced if the G3 key is pressed, but if it is performed for a cello, will produce sound. Lastly, their ability to incorporate other types of controllers into their design, like faders and drum pads, makes keyboard controllers diverse.

Drum pads are touch-sensitive pads that the user can tap to produce a sound. These can be programmed to play specific notes on an instrument but are more practically used for percussion. This allows the user to have a full drum kit or percussion set up literally at their fingertips. Similar to the acoustic MIDI piano, MIDI drum kits exist, allowing a percussionist to record a MIDI drum track by playing a kit without their neighbors filing a noise complaint. Wind controllers can help capture wind players' breath and key articulation, which is challenging to produce on other controllers like keyboards (see Figure 3). Breath controllers do the same thing but cannot capture key articulation as there are no keys to press. The only thing breath controllers are measuring is the intensity of a person’s breath output. Electric guitars and basses have MIDI models similar to keyboards and drum kits for easy capture and playback of MIDI.

Small fader banks with knobs that can be programmed to any CC are also commonly used MIDI controllers.

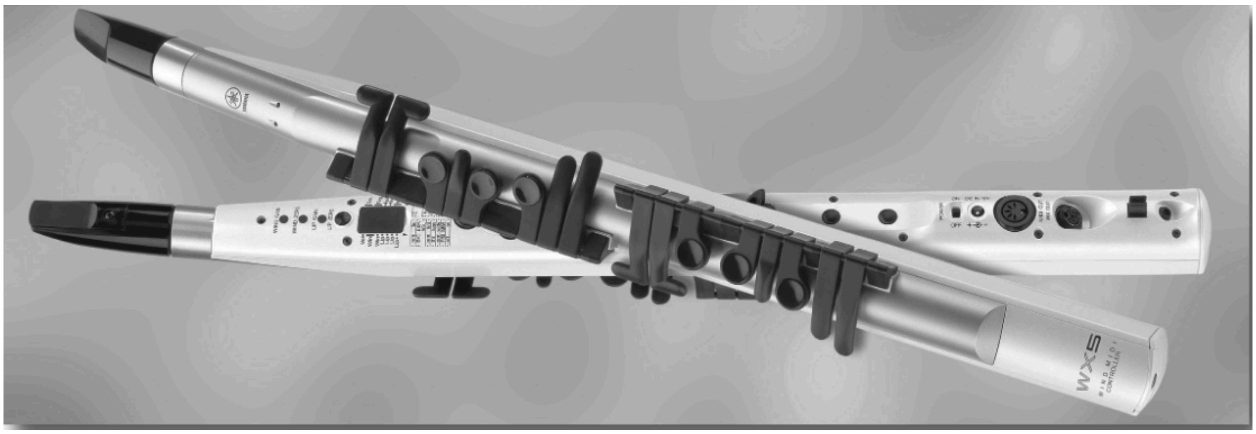

Figure 3. Yamaha WX5 MIDI wind controller. (Huber "Modern Music" 99).

Since the original release of MIDI 1.0 in 1983, MIDI has a new specification. This latest release has been in development for over a decade, and MIDI 2.0 was officially released in 2020. With the original 1.0 specification, MIDI runs off five-pin MIDI cables or DIN connectors that can only transmit data unidirectionally[4]. Devices that need the ability to send and receive messages from one another must be connected by two cables. MIDI 2.0 has added the ability to allow devices to communicate bi-directionally if the devices are running off the 2.0 specification (Hasegawa). This is possible partially because 2.0 devices are able to use different cables, such as Ethernet, FireWire, Bluetooth, and serial ports, along with the new MIDI Capability Inquiry or MIDI-CI.

MIDI-CI has allowed two significant improvements to occur outside of bidirectional communication: backward compatibility and auto-configuration. Backward compatibility allows 2.0 and 1.0 devices to communicate with each other. This is achieved by 2.0 devices sending a

[4] Unidirectional: Involving, functioning, moving, or responsive in a single direction ("unidirectional").

message to all connected devices asking whether they're running off the 2.0 specification. If the device receives a reply, the two devices are able to continue communicating through the 2.0 specification. When a device does not answer this message, this means that the device is running off of the 1.0 specification, and all further communication will be done with 1.0 (Anderton, "MIDI 2.0: What Actually Matters for Musicians"). With the auto-configuration feature, users no longer have to spend time mapping their MIDI controls. With the 1.0 specification, devices could not recognize one another. Devices did not know who was being controlled, and the controller would not know what it was controlling. Now, devices are able to recognize themselves and other devices and map controls accordingly. If a user has a preference for MIDI mapping or a project requires a unique map, devices can still be mapped manually.

The last major change with the 2.0 specification is improved expressiveness. MIDI controllers have upgraded from a 7-bit resolution to a 32-bit resolution. Bit resolution is how many bits of information can be stored in a digital bit of two according to the power of the bit number. The 7-bit resolution would be 2^7 or 128 values of information, similar to the number of MIDI notes and velocity. Velocity has also been upgraded from 7-bit to 16-bit (Anderton). On top of this, there are now per-note controllers that allow users to get specific with their sound, such as how a string player adjusts their bow for different playing techniques. All these improvements have made jobs easier for all MIDI users, musical and non-musical.

MIDI in the Professional World

To better understand how industry professionals use MIDI in their work, interviews were conducted with three separate industry professionals: theatrical sound designer Joshua Reid, orchestrator for theatre, film, and television August Eriksmoen, and composer and pianist Alex Marthaler. All three use MIDI differently in their profession, ranging from primarily system communication to MIDI mock-ups and integration in live performance.

Reid's primary use of MIDI is linking system components together for his sound designs of plays and musicals. He prefers MIDI as opposed to other control protocols like Open Sound Control (OSC) because he's observed that MIDI is more reliable. Since MIDI has been around since 1983, it is a universal communication language for gear, works with legacy devices[5], and has less network dropping. Equipment Reid commonly links for show control includes the console to Qlab, sound and lighting consoles, the DSP (digital signal processing[6]), and processing engines. The main challenge faced by having multiple components linked through MIDI is maintaining the directionality of everything. This makes tracking everything that is linked together and what device controls another vital.

On a production Reid worked on, he had the opportunity to construct a wireless MIDI rig. Part of the set was a piano that sat in the middle of a turntable, which a lead actor played throughout the show. Since the actor played the piano, this was not an issue in having sound emit from the piano, as the actor simply played it. The issue arose when it was discovered that the actor's understudy does not play the piano, presenting the problem of how to have sound originate from the piano if the understudy had to step into the role. As the piano sat on an active turntable, the option to run cables to a speaker hidden around the piano was eliminated, making a

[5] A device that is no longer manufactured.
[6] Digital Signal Processing is taking a digital signal and then processing it in various ways such as adding delay to speakers.

wireless rig the best solution. Reid hid a wireless MIDI rig on the turntable that triggered the hidden speaker, maintaining the belief that the understudy was playing the piano live.

A MIDI system needs to expand and incorporate the orchestra pit for musicals, especially when keyboards are required. These keyboard rigs often consist of a computer that stores MIDI patches connected to a MIDI-compatible keyboard. Alex Mathaler, having played piano in nearly twenty pits, has experience programming MIDI for these rigs. His experience comes from programming Mainstage, a software commonly used in theatrical productions that contains different samples that can be played back on MIDI controllers. The work of programming Mainstage, which Mathaler describes as tedious, was partially due to him being the one who was using the Mainstage patches. He often found himself going back through his programming to make adjustments, such as not having enough time to trigger the next sample, the key switch being in a difficult position, or the wrong sample being programmed in the sequence. The majority of the rehearsal time during holds, Mathaler would adjust his Mainstage patches for easier use and had all the kinks resolved by opening night.

While programming MIDI may be tedious, having a keyboardist play multiple instruments in a pit is common. Reid, Mathaler, and Eriksmoen all agree that this frees up space in the pit and saves production money. Eriksmoen mentions that when orchestrating for theatre, he looks at his instrumentation and budget to see what musicians he can afford and what would be possible to play with a MIDI keyboard. He also needs to take the physical size of the pit into consideration to see if all the instruments will be able to fit. Another important factor is how often an instrument is played throughout a show. A marimba has a large footprint in a pit, and if it is used for one song in a production, then the chances increase that it will be assigned to a keyboardist. Another way Eriksmoen looks at parts for keyboardists is by having them play an instrument that already exists in the pit. MIDI would be used to play a different concept on the instrument, adding to the sound's fullness or augmenting the existing part.

As a composer, Marthaler primarily uses MIDI through his notation software when actively composing. He predominantly uses it for playback to assist in figuring out the pacing of a song and as a way to check for any wrong or unintentional clashing of notes, creating unwanted dissonance. Unlike other composers who may spend hours adjusting MIDI playback settings in their notion software and connecting their sample libraries to it, Marthaler spends very little time altering these MIDI settings. Mathaler states his reasoning is that he does not want to grow accustomed to his pieces sounding like samples. Some composers and music enthusiasts believe MIDI mock-ups sound better than live recordings or have become accustomed to hearing their music with artificial quality. When this acclimation happens, they have a hard time recognizing their pieces when they are played by musicians. MIDI also has the capability to play something that would be impossible for a musician. If a musician receives an unplayable part, it can lead them to believe that the composer doesn't understand their instrument or how to write for it, which can result in a loss of trust in the composer. The trust between a musician and a composer is vital for good sessions and getting the best sounds possible in a composition. While Marthaler does not utilize MIDI often in his compositional practice, he does have experience creating mock-ups.

Based on Mathaler's experience creating MIDI mock-ups, his main advice is to use quality samples and spend time on the mix. It does not matter if the samples being used are the most expensive in the world or how many hours are spent trying to make them sound realistic; if the samples are bad, the mock-up will sound bad. Many sampled libraries have different microphone positions that can change at a user's discretion and should be used to alter the sample's sound to best suit project needs. This applies to the overall mix, and the user needs to mix and master their mock-up to maintain the sound quality of the final recording.

Eriksmoen has also created MIDI mock-ups, where the goal is getting samples to sound like they're coming from a live player. He cautions against using the instrument family that provides the most grief in sounding realistic: the strings. When combined with live strings, sampled strings can often help a string section when used as a background or middle voice. If strings are needed as a foreground voice, Eriksmoen has paid out of his own pocket on mock-ups to hire and record string players to avoid dealing with unrealistic sampled strings. This is due to directors having unforgiving ears. Directors want to be moved when listening to a mock-up and not have an orchestrator or composer explain to them that the sampled cello will sound better once it's replaced by a live player.

Reid, Mathaler, and Eriksmoen disagree on whether audience members can tell the difference between a live instrument and a sampled one. Reid and Mathaler believe that audience members can tell the difference between the two and have even begun to assume that an orchestra pit is artificial when located remotely. Reid mentions that vocals can help hide the indiscretion of virtual instruments, especially ones that are difficult to manipulate into sounding realistic, like strings. Eriksmoen, on the other hand, believes that people who work in the entertainment or music industry may be able to hear the difference between live versus sampled instruments, but he does not believe that a typical audience member can hear a difference. In live settings, he argues that people's ears are more forgiving to the sound of samples, and having live musicians blended alongside helps. When losing the ability to have live musicians alongside samples, that changes.

The MIDI Orchestra and Musicians

David B. Smith is currently a professor at City Tech in Brooklyn, New York, and is known for being a leader in computer instrument systems for live performance. In his work on computer instrument systems, Smith has done two operas with the Opera Company of Brooklyn (OCB) back in the early 2000s. Both of these productions featured either an entirely virtual orchestra or an orchestra that was primarily virtual with several live musicians. Both of these shows used the software Sinfonia and received serious backlash from the musician's union.

Sinfonia is an orchestral enhancer and musical instrument that can fill in the gaps for an incomplete orchestra. It works by connecting a MIDI keyboard to the software, selecting the desired song from the Sinfonia library, and playing the rhythm shown by the correlating key on the keyboard ("Sinfonia"). This will begin the song's playback and allow the keyboardist to control the tempo by how fast they play the depicted rhythm. By allowing the keyboardist to control the tempo, if the live musicians play a song at a different tempo for a performance, the keyboardist can ensure Sinfonia stays in time with them. Sinfonia is also compatible with outboard gear and can be mixed outside a standard stereo mix, which is a feature Smith takes advantage of.

Smith's first production, which was done entirely with a virtual orchestra running through MIDI and Sinfonia, was Mozart's *Magic Flute,* performed on August 9, 2003. In order to aid in the realism of not having any live players, Smith positioned speakers in the orchestra pit in a similar fashion to a typical orchestral set-up. Every speaker represented what would have been a musician and was mixed to represent a specific instrument (Smith). This instrumental system playback was manipulated by assistant conductor Stephan Jarvi. Jarvi was able to change the pacing of the virtual orchestra through the use of their keyboard and Sinfonia (Eichler). This design allowed adjustments to be made if singers began to rush or slow down during the performance to help keep everyone together. While there were comments on the virtual orchestra's realistic qualities, the local Musicians Union was not pleased with the performance.

Local Musician Union 802, which works on Broadway, went on strike on March 7th, 2003, when their concerns about being replaced with virtual instruments nearly became a reality. The strike began after failed attempts to negotiate between Local 802 and the League of American Theatres and Producers, which resulted in the League threatening to replace the musicians in the local on all their shows with virtual orchestras (Simonson). After four days, the two parties managed to end the strike and come to an agreement. Five months after the strike, Smith's *Magic Flute* opened, and local 802 made their concerns vocal. The opera only had one performance and was part of a research project regarding virtual orchestras, and the producer, OCB, could not afford to hire all the required musicians (Pogrebin). After several discussions with Local 802, the consensus was that OCB would try to gather funds to produce two operas a year with a live orchestra. While the OCB did budget to hire musicians for their next opera, they also planned to incorporate a virtual orchestra alongside the musicians.

The OCB produced the opera *The Marriage of Figaro* in 2004 as a part of another research project on virtual orchestras. As part of the agreement with Local 802 regarding *The Magic Flute*, the virtual orchestra would be comprised of 25 instruments, with an additional 10 being live musicians (Smith). Smith was ecstatic, as the ideal combination for Sinfonia is to be played alongside live musicians rather than by itself. Local 802, however, felt the OCB ignored their previous agreement by not hiring a full orchestra. Members of Local 802 spoke with all the musicians who were hired for opera before the performance, and every hired musician dropped the opera at the last minute. Smith states that one of the musicians approached him before the performance. She said she had been threatened with being blacklisted by union leadership if she decided to play for the opera. The OCB claims that union representatives pressured the board of OCB to sign a document permanently banning “The Virtual Orchestra Machine” (Smith). This marked the end of Smith’s collaboration with OCB, and budget constraints prevented the OCB from providing orchestras. Later in the year, the union agreed to allow Sinfonia and virtual instruments as long as they could be approved beforehand (Hernandez).

Preparation for the Mock-Up

As industry professionals were not able to agree on whether audience members would be able to hear the difference between a MIDI track and musicians playing, people's ears will need to be tested. The idea is to create a MIDI mock-up of a song and have people listen to excerpts from both a recording of the song that is played by musicians and the mock-up before deciding if what they're hearing is MIDI or not. Based on the previous interviews, the hypothesis is that people who work in entertainment will be more accurate in distinguishing the MIDI than those who do not.

There are several different factors to consider when creating a mock-up that sounds realistic. The first and most important part, as Mathaler has mentioned, is selecting the samples that are being used. If the samples for a virtual instrument do not sound good, then the mock-up won't sound good. No amount of programming or audio manipulation can make horrible sounds pleasant. Next is to make sure all the MIDI programming is accurate and humanized. Musicians can not hold a consistent tempo; there will be slight variations throughout the song, and the same is true about musical phrasing. Each musician breathes life into their instrument differently, which is one reason why different orchestras playing the same piece of music sound different. Expression and other MIDI CCs need to be utilized to create this sense of realism; without them, there is no life in the virtual instruments, and they will sound computerized. If possible, listen to a reference track or have a song with a similar desired sound to it to listen back to when mixing. Knowing how the instrumentation sounds with musicians is vital to creating a realistic-sounding mock-up.

The first task of creating the mock-up was to figure out which song to replicate that had an accurate score and recording of the piece. Omni Music Publishing is a company with full scores of movies available for purchase; one is Dreamwork's 2010 animated film *How to Train Your Dragon,* composed by John Powell. After acquiring the score, the next step was to study it with special attention to the instrumentation of every song, as any instrument outside of a traditional orchestra, like bagpipes, would require another sample library. Last was to ensure that the soundtrack from the film had a recording of the song, as some of the songs in the score provided were not in the movie. This is how Powell's song *Romantic Flight* was chosen as the mock-up song.

After choosing the song, the score was investigated further, paying particular attention to notated articulations, extended techniques, and whether players were sharing a part or playing separate material. In this piece, Powell frequently has the strings shown on two separate staves playing divisi or split. The wind players often play together, especially when the full orchestra is playing, which with woodwinds is helpful as other instruments can easily overpower them. When the orchestration thins, the wind players begin harmonizing with each other but play the same rhythm and phrase. These are all important factors to look into, as they directly affect how MIDI tracks will be programmed inside a DAW, which will be Logic Pro for this mock-up.

After completing this further score analysis, it was time to decide which sample libraries to use. This decision was rather easy, as Spitfire Audio had recently released an updated version of a previous library, Spitfire Symphony Orchestra. The legato-style mock-ups created with this library, shown as proof of the library's improved quality, were a major factor in the decision, and another updated feature was total performance control. Typically, when using MIDI in this regard, there are two common programming practices to use a library fully. This is having individual tracks for every articulation of an instrument or utilizing key switches. When using a keyboard as the MIDI controller, key switches are often pre-programmed to the keys at the bottom range of the keyboard. Each key is assigned to a patch that correlates to different articulations or playing techniques. Depressing a key will trigger a new patch inside a sample for that new articulation or technique. With total performance, MIDI automatically switches these patches based on how the keyboard is being played. These are a couple of reasons why Spitfire's Symphony Orchestra was chosen, outside of the wide range of techniques it provides. This library is paired with Spitfire's Solo Strings, as *Romantic Flight* begins with a violin solo.

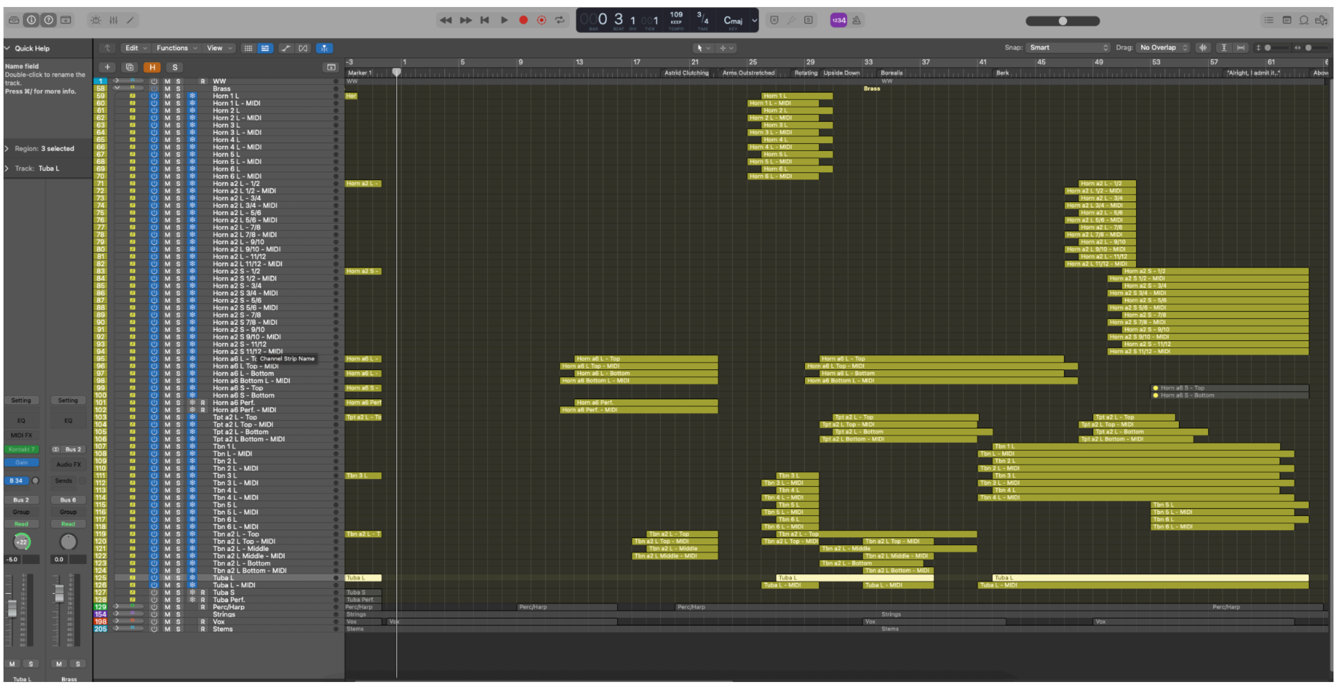

Figure 4. Brass family in the final version of the *Romantic Flight* mock-up.

To accurately and efficiently create a mock-up, a well-constructed and balanced template that makes the creator's life easier is needed. The template made for *Romantic Flight* is based on one by composer and educator Guy Michelmore, who discusses different template formats in his course, Sampled Orchestration. Rather than using key switches, this template is constructed by having every instrument have a separate track per articulation, playing technique, and number of musicians playing on a sample. Each track then has a corresponding MIDI track for easy recording of MIDI CC, and this way, the CC can be copied to other tracks without copying the

MIDI notes. There are twelve French Horns in *Romantic Flight,* spit on two staves played as a2 or a6, simply meaning two horns or six horns are playing the same line. Inside sample libraries, there are often patches for a2, and depending on the instrument, they will expand upward towards a6. With the number of players on a line and the different articulations, the *Romantic Flight* mock-up had twenty-four tracks for the horns, not including their MIDI track (see Figure 4).

Once all the tracks have been created with their proper sample patch and MIDI track, it is time to *gain structure* all of the samples. This is done so that when transitioning between articulations for the same instrument, there isn't a sudden drop or boost in gain, and the creator can simply keep working on the mock-up without having to stop and fuss with the abrupt change. It will also be helpful during the mixing process. To create a gain structure, a gain plug-in is added to all tracks, while a sound level meter plug-in is added to the master track. When playing each track, the goal was to have each track meter around negative twenty decibels with a median velocity number. Upon completing this, five separate summing stacks, one per instrument family, including vocals, are created. Afterward, the last step in the template creation is to add the tempo, time signature, and hit points. A hit point is a notation marked in film scores that describes something that is occurring in the film like "Billy laughs". Film composers use hit points to line up specific points of their music to the film. In addition to the tempos notated in the score, additional tempo changes of two to three beats per minute, bpm, will assist in the slight fluctuations of tempo heard when musicians play.

Creating the Mock-Up

When creating the content for the *Romantic Flight* mock-up, the first twelve measures were completed to their fullest at the start of the process. As the rest of the mock-up was made, it went instrument family by instrument family through the entire song. The first twelve measures were completed with every family to ensure that all the samples behaved properly and sounded well together, even though all but one came from the same sample library. It was also nice to have a completed section to refer back to when feeling discouraged or frustrated during the process to remember that the end product would sound fantastic. These measures also contained the most difficult instrument to replicate, the solo violin.

Recreating a realistic sound for the solo violin was difficult not only because it was a string instrument but also because of the number of legato grace notes. MIDI is not well known for being able to produce smooth, short, connected notes like grace notes or hammer-ons. For each grace note to speak properly, the placement and duration of the surrounding notes had to be altered. To keep Powell's vision in mind, the start of these grace notes never came before they were notated. However, they often get played longer than what was notated, which, again, is a result of having to allow a short legato patch time to speak. This would have been less of an issue if these grace notes had been short and staccato.

The first instrument family to be finished in its entirety was the strings (see Figure 5), which are the base for an orchestra and the most difficult to make sound realistic. Each instrument, starting with the lowest voice, was recorded in twelve-measure spurts, as that was the average number of measures that spanned the open score. The MIDI notes were implemented into Logic through the use of a MIDI keyboard, with the exception of a few moments for the harp, piccolo, and flute. Their parts were too fast or complex for a non-keyboardist to play accurately. Instead, these parts were written in notion software and exported as MIDI files. This was quicker and more reliable than manually inputting all the notes in Logic's piano reel.

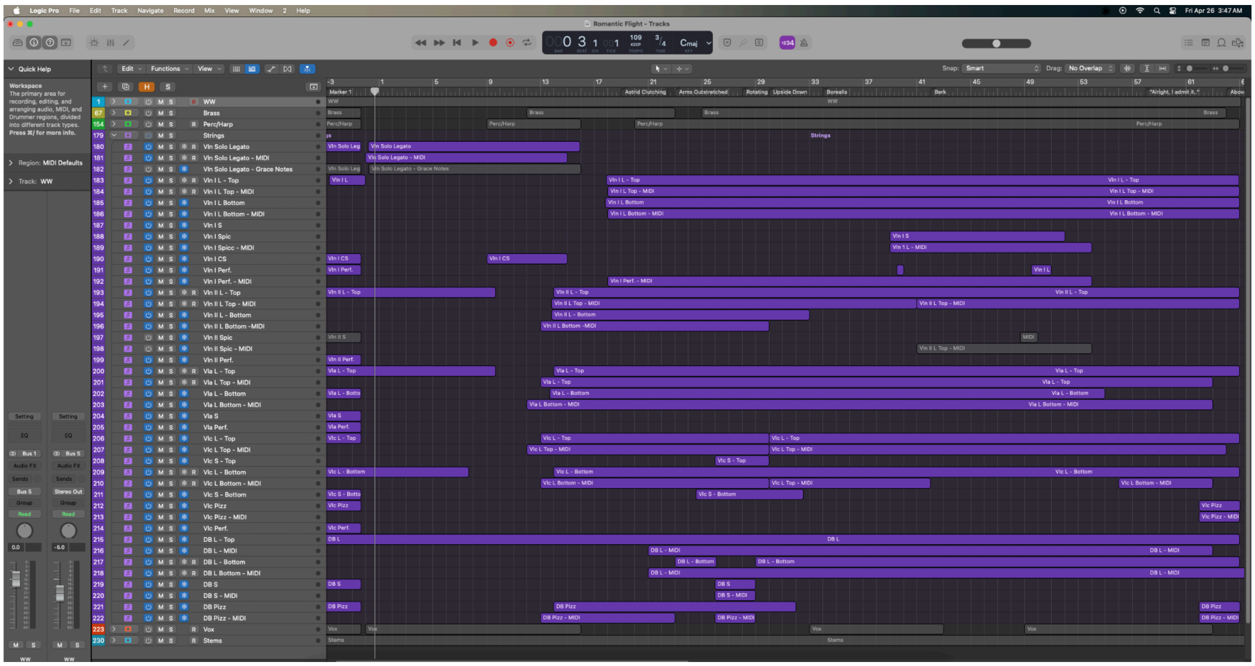

Figure 5. String family in the final version of the *Romantic Flight* mock-up.

A common issue that arose was around instruments that transpose at the octave, such as the bass, contrabassoon, and piccolo. Logic has a score section that was helpful in checking the right notes, especially in clefs that people have a harder time with, like the alto and tenor clefs. However, Logic would sometimes switch a clef on one of the octave-transposing instruments from the bass clef 8va bassa to a normal bass clef. This resulted in the bass samples not producing sound when believed to be playing a producible pitch on the instrument.

Once all the notes were implemented properly, and velocity was adjusted to better represent the dynamics notated, the original modulation data recorded from the initial MIDI implementation was adjusted. The modulation data was re-recorded on the MIDI track using a modulation wheel. Expression is a viable option to use instead of modulation to get similar, if not identical, results. On sustained notes, the modulation would still be moving, as producing a non-quivering pitch on many instruments is almost unheard of. Modulation also aids in dynamics like crescendos and decrescendos to help build the suspension toward the song's climatic moments.

After a section of the orchestra was complete and before mixing the section, the next step was to go into the sample library pack and take a closer look at the microphone settings for each sample. The three different microphone settings used were a close microphone, which records the sample up close and is more likely to have breath sounds, fingers on strings, and key clicks. A tree microphone consists of three omnidirectional microphones in a "T" pattern that records in stereo, with the third microphone filling in the middle of the sound. Lastly is an ambient microphone, which is helpful in capturing an instrument's sound inside a room. These microphone levels were adjusted while playing the MIDI keyboard so that the instrument could be heard while these changes were happening. Once that was complete, it was time to mix that section of the orchestra.

When mixing the different orchestral sections, the idea is to get each section to sound well on its own. By doing this, all the MIDI tracks for that family can be bounced down to a single track. This way, when mixing all the different families together, there are a handful of tracks to work with instead of hundreds, as *Romantic Flight* had two hundred and twenty tracks. During the mixing process for *Romantic Flight,* these stems had to be re-bounced several times. This was due to multiple factors, such as discovering when the cellos carry the melody, which can be heard beautifully when it is just the strings but was lost when combined with the full orchestra. Another mixing factor was incorporating slight tempo changes, which were done more towards the end of the piece. In the reference track, there seemed to be a small ritardando [7] that

[7] Ritardando: With a gradual slackening in tempo → used as a direction in music ("ritardando").

was not notated in the score. This ritardando was added to the mock-up during the mixing process.

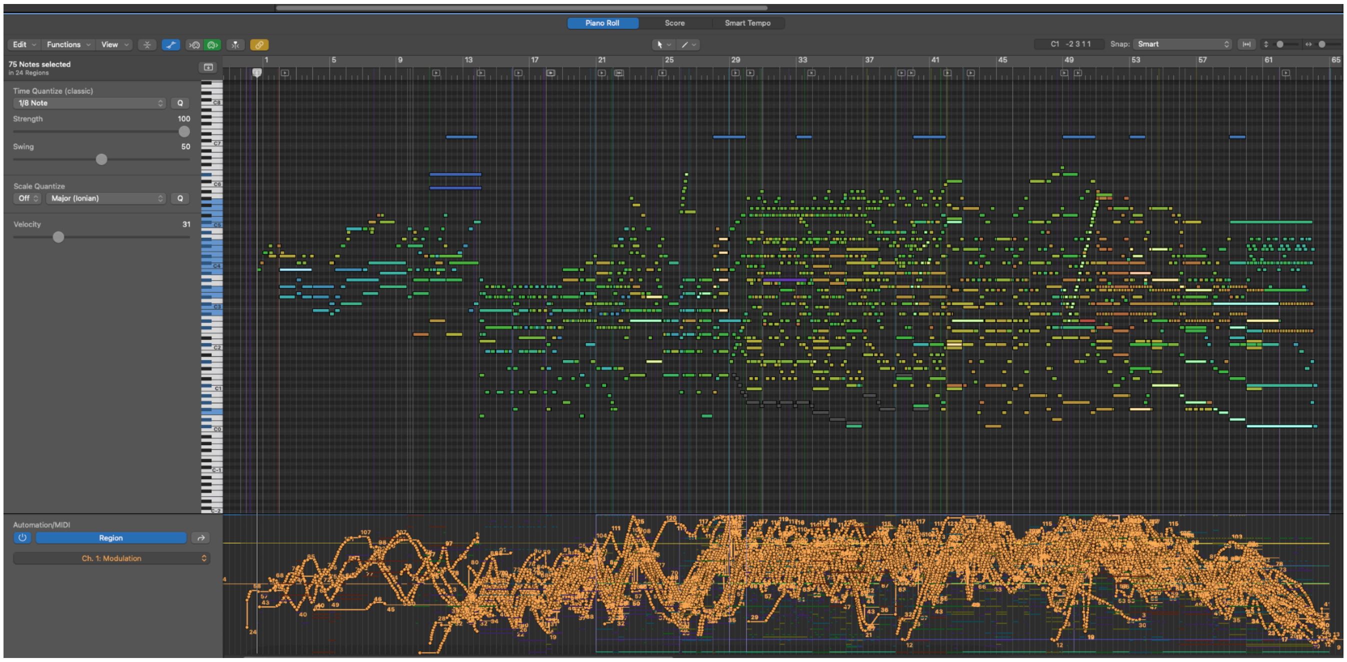

Figure 6. The piano roll shows MIDI notes, velocity, and modulation from the final version of the mock-up.

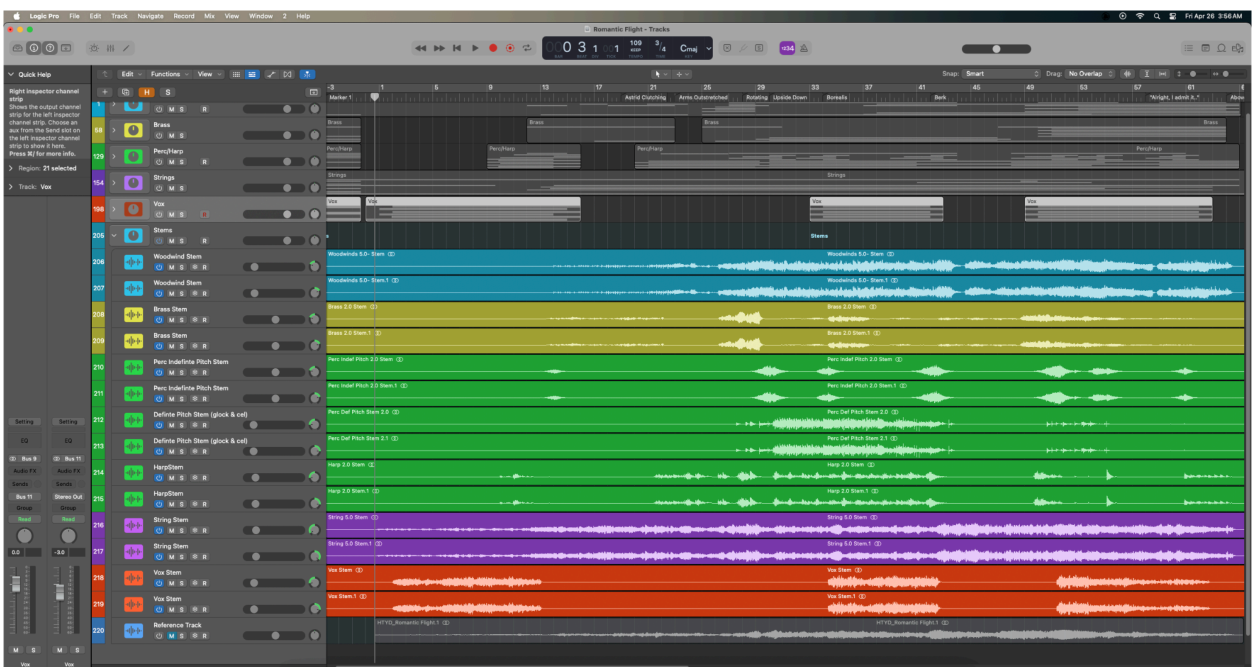

Figure 7. Shows the stems in stereo from the final version of the mock-up.

Poll and Closing Remarks

After the mock-up was completed, a three-day poll went live that had people listen to excerpts from both the mock-up and the official recording of *Romantic Flight*. The poll consisted of five excerpts from different sections of the song. Three were from the mock-up, while the others were from the recording. Both the mock-up and the recording had a section of the song that was tutti, all together and a section that was not. Each of the excerpts was roughly ten seconds long. Out of the thirty-two people who took the poll, 40.6% do not work in entertainment, while 59.4% do. Their occupations range from music production, composer, sound design, and musician to carpenters and fundraising. Overall, the hypothesis that people outside the entertainment industry would have a harder time distinguishing the mock-up from the recording is true.

The question that received the most diverse answers was the last excerpt of the mock-up at the end of the song. What made people guess it was the official recording was also a reason why people thought it was MIDI, and that was about the sound of the flute and piccolo. The mock-up at the end is mixed in a fashion that allows the listeners to hear the breath of the players and their tonguing. Ironically, what made many people believe this mock-up excerpt was the recording was also the reason people knew it was MIDI; the flute and piccolo sounded too artificial. Other comments from poll takers regarding the realistic quality of the mock-up have to do with the strings, brass, and mix of the mock-up. These are all factors that Reid, Eriksmoen, and Mathler spoke about when creating realistic-sounding MIDI.

A surprising part of the poll was that people did not talk about the MIDI vocals in the mock-up. This portion of the mock-up was the area of most concern of people hearing it, and immediately knowing it was MIDI. Instead, people thought that the vocals in the recording sounded fake, which led them to believe it was a MIDI excerpt. Overall, the comments received when asking the people to explain why they chose their answer have been extremely helpful. All the comments can be used to go back to the mock-up and make adjustments to help improve its realistic quality.

MIDI has a unique ability to be used in various ways, as shown by how Reid, Mathler, and Eriksmoen use it professionally. It can be used to link system components and help enrich the sound of an orchestra with musicians or by itself. Entire songs can be produced through the use of MIDI and sample libraries that can accurately depict how a recording with musicians will sound. Lastly, MIDI can fool an audience member who works outside entertainment and music into believing it is a real musician.

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