

## The Transformation Engine & MIDIForth Tutorial

**Bruno Degazio**

**Professor, Animation Sound Design**

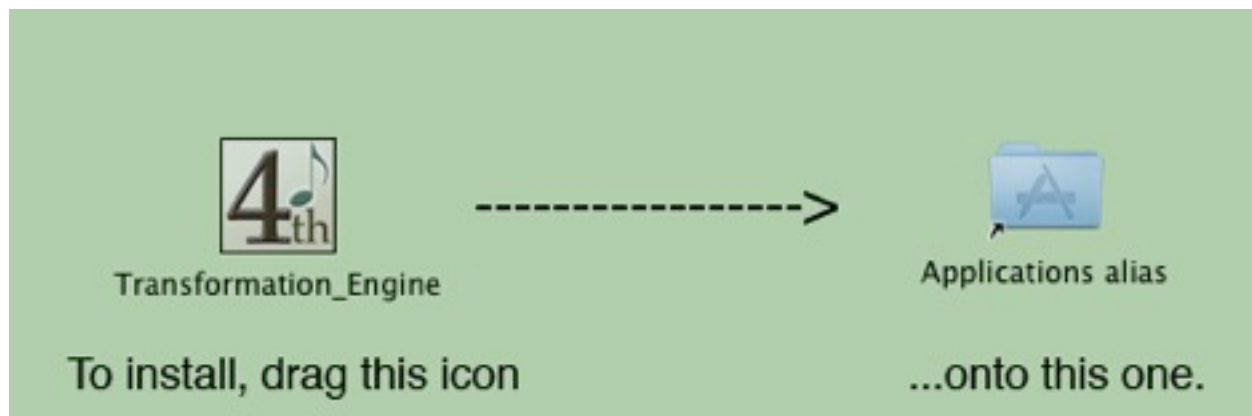
**Sheridan College, Oakville, ON, CA**

**email: [degazio@sheridanc.on.ca](mailto:degazio@sheridanc.on.ca)**

**website: <http://www-acad.sheridanc.on.ca/~degazio/>**

### INSTALLATION:

Mount the disk image and drag the Transformation Engine icon into the Applications Folder icon.



Do not rename the folder or put it inside another folder. It **MUST** be named "Transformation\_Engine" and be within the Applications folder on the Root drive (i.e. not within your user home directory or on another drive.) This limitation may be removed in a later version.

Throughout this tutorial I will refer to the software interchangeably as "MIDIForth" and as the "Transformation Engine". Technically and historically MIDIForth comes first. The Transformation Engine is built upon MIDIForth. They are now combined for convenience into a single application.

**MIDIForth** is a MIDI Recorder & Sequencer with functions optimized for the heavy data streams produced by an Electronic Wind Instrument (EWI.) In many ways it is a typical MIDI sequencer like Logic Pro or Cubase. What distinguishes it from these commercial programs are the following:

1. Support for Akai EWI and Yamaha WX5 Electronic Wind Instruments
  - automatic controller cleanup
  - easy note and controller data management during editing
  - monophonic quantization that respects controller data and legato
2. Multi-track graphic editing in a Common Music Notation (CMN)-like format.
3. Support for MusicXML for true CMN in Sibelius and Finale

**The Transformation Engine** is an interactive algorithmic composing engine that is built upon the structures of Midiforth. You can use MIDIForth without ever touching the Transformation Engine, but the reverse is not true. You must understand MIDIForth's data hierarchy thoroughly before using the Transformation Engine.

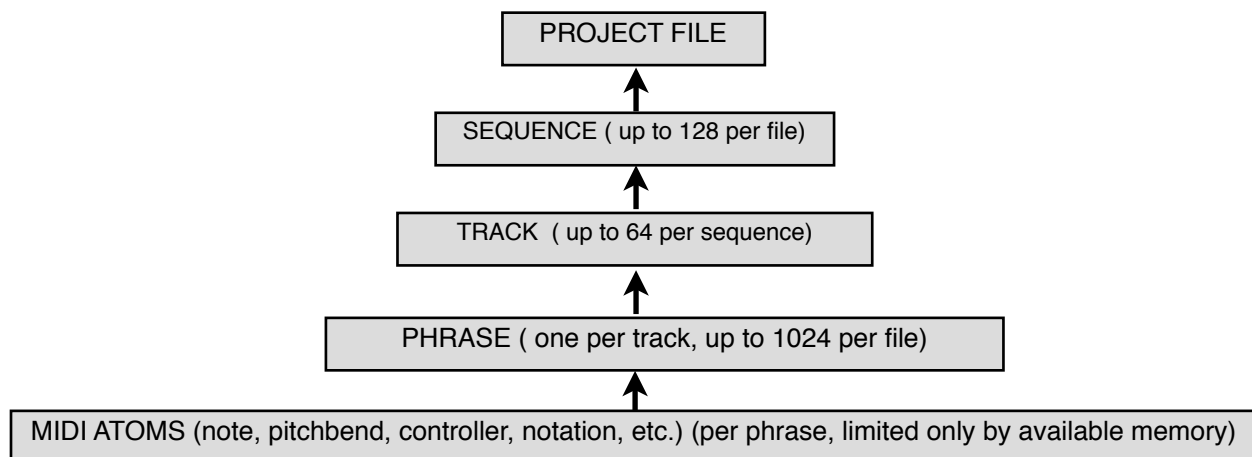
MIDIForth itself is built with a commercially available Forth compiler named iforth. Despite its name, MIDIForth does not give you access to this underlying Forth compiler. If you are interested in developing your own Forth applications, you can purchase iforth from :

<http://home.iae.nl/users/mhx/i4faq.html>

### The MIDIForth Data Hierarchy

The data hierarchy used in MIDIForth is much like that in most other MIDI sequencers with the exception of the "*Phrase*", which does not exist in a typical commercial sequencer. A PHRASE is simply a named collection of MIDI data. It might seem redundant because, when using MIDIForth purely as a sequencer, there is a one-to-one correspondence between Tracks and Phrases. However, phrases are used in several other ways in MIDIForth and The Transformation Engine including:

- a) as Themes (in the Transformation Engine)
- d) as Harmonic Structure specifiers (Transformation Engine)
- e) as Automation channels (Transformation Engine)
- a) as source patterns in the Golden Motive fractal generator
- b) as "groove" templates for quantization

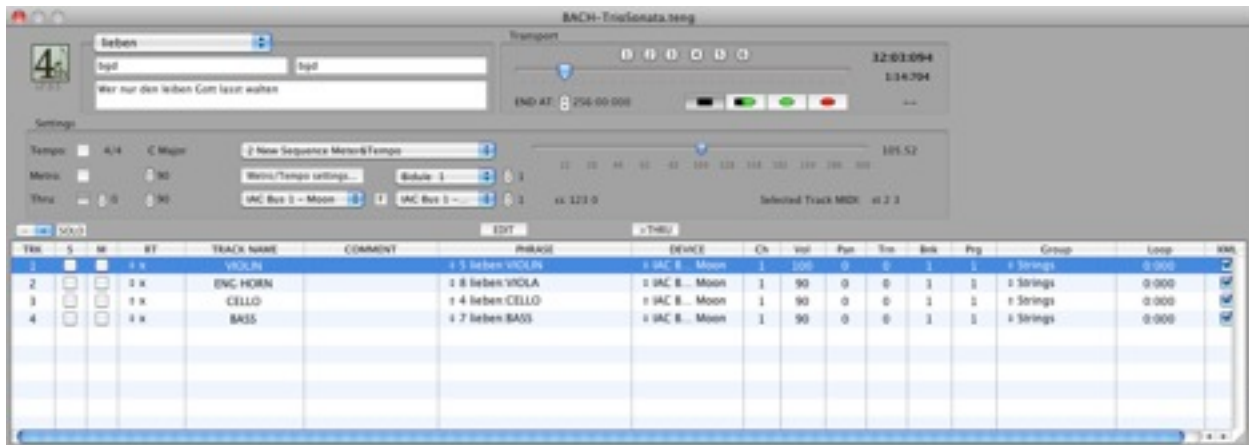


## TUTORIAL DEMO PART 1 - SEQUENCER PLAYBACK:

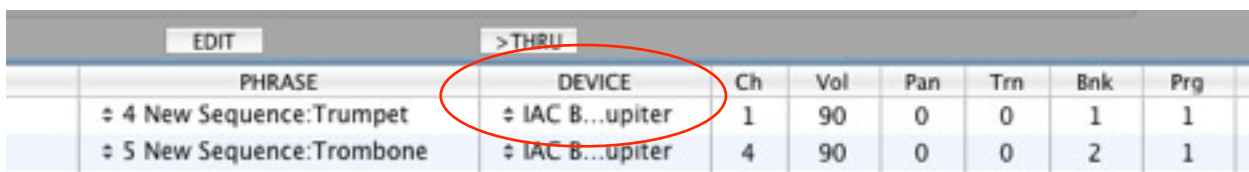
This section demonstrates MIDIForth as a MIDI Sequencer. To test out the MIDI playback capabilities try the following:

(1) Double-click the application file TransformationEngineSC-795 to launch it. The principal windows are accessed via the "MIDIFORTH" menu on the right of the menubar. The most important ones for using the Transformation Engine as a sequencer are the Eventlist Editor (cmd-1), the Multi-Phrase Graphic Editor (cmd-2) and the Sequence Window (cmd-3.)

(2) Using the File Menu "Open Transformation Engine File...", load the included file "BACH-Trio\_Sonata.teng." Open the Sequence Window (cmd-3.)



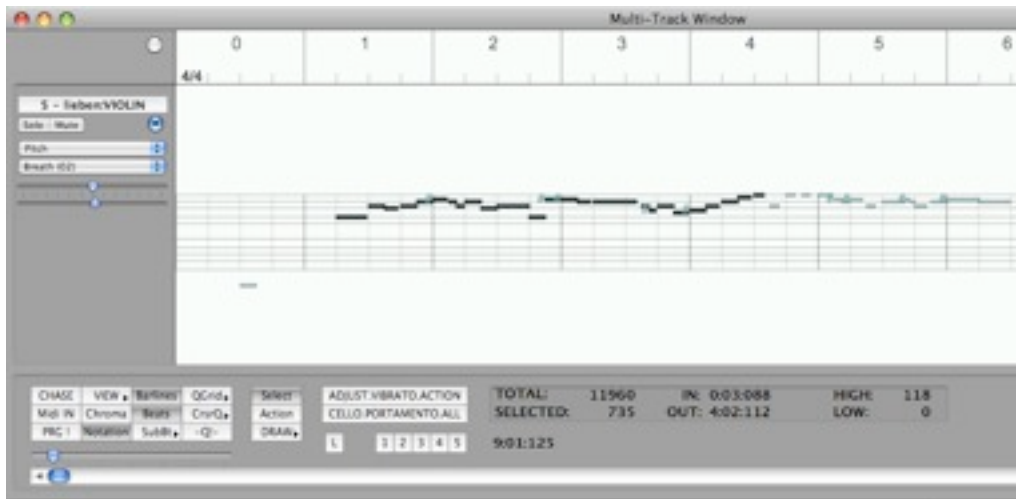
This file includes two versions of the sequence, which you can choose with the popup menu at the upper left of the window. For this tutorial, however, choose the first version, which contains the tracks exactly as recorded with an EWI4000 Electronic Wind Instrument. There are four tracks in this sequence, named Violin, English Horn, Cello and Bass. You will need to assign the four tracks to the appropriate MIDI Devices in your studio. Do this via the "DEVICE" popup menu for each track listed in the Sequence Window:



These can be hardware synthesizers, as declared in "Audio MIDI Setup" or software synthesizers in a Host application. MIDIForth and The Transform Engine do not provide plugin hosting. If you don't have any MIDI Hardware or software synths, use the easy "SimpleSynth" application included in this download. This free software (courtesy "Not A Hat Software") provides access to Quicktime's built-in sample-playback synthesizer. To use SimpleSynth, make sure its "MIDI Source" is "SimpleSynth virtual input". In the MIDIForth Sequence Window, assign this device to the track.

(3) Click the “Play from Beginning” button (in the transport area of the Sequence window) or type the "0" key to play the sequence. After a one measure silence you should be able to hear the four instruments of the trio sonata playing on your synthesizer(s). You can follow the recorded MIDI playback in quasi-notation in the Multi-Phrase Graphic Editor (cmd-2).

(4) With the Multi-Phrase Graphic Editor frontmost, select any phrase by clicking within the music-notation area. Click and drag to select some notes.



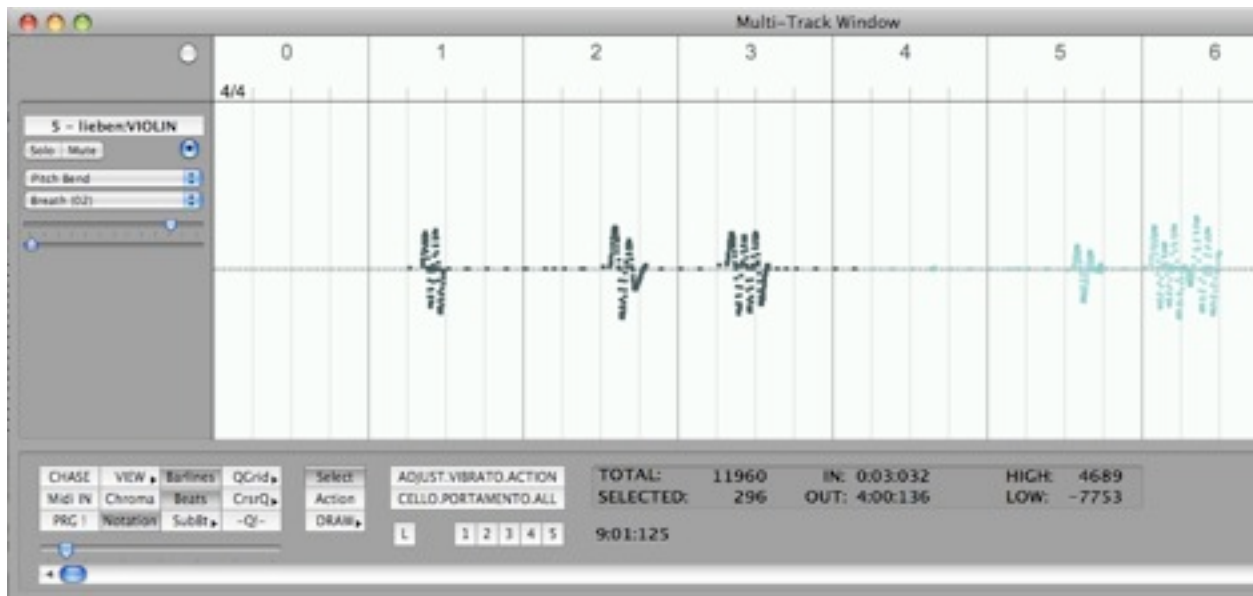
Type 'b' to view only breath controller information:



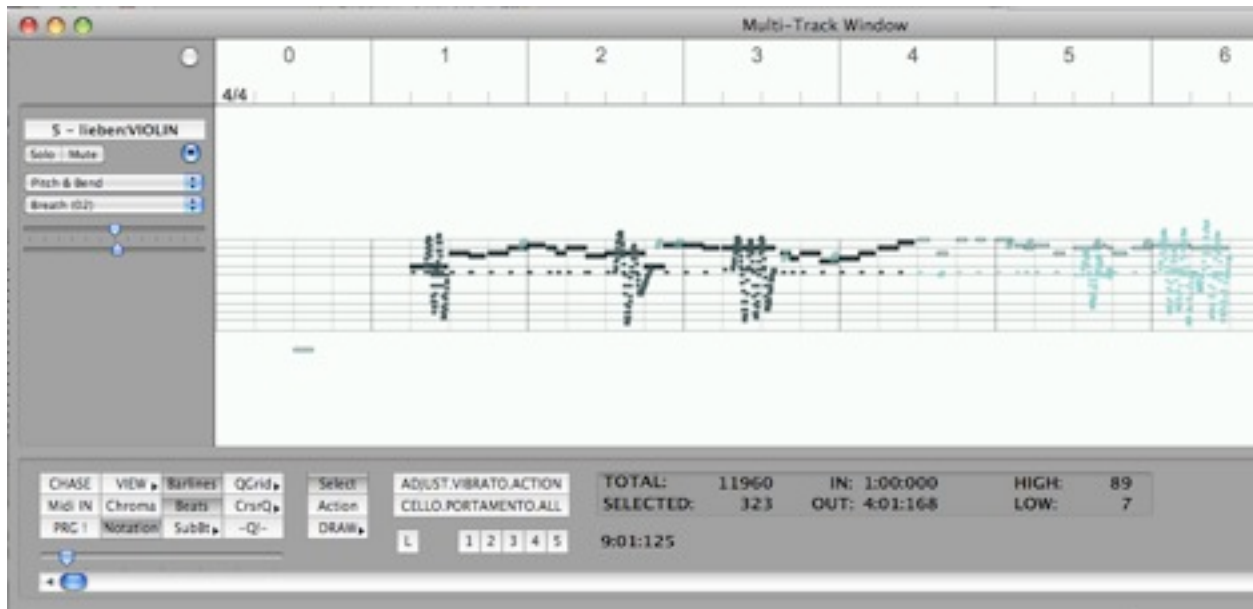
Type "f" to view notes and breath controller simultaneously within a single pane:



Type 'r' to view pitchbend information:



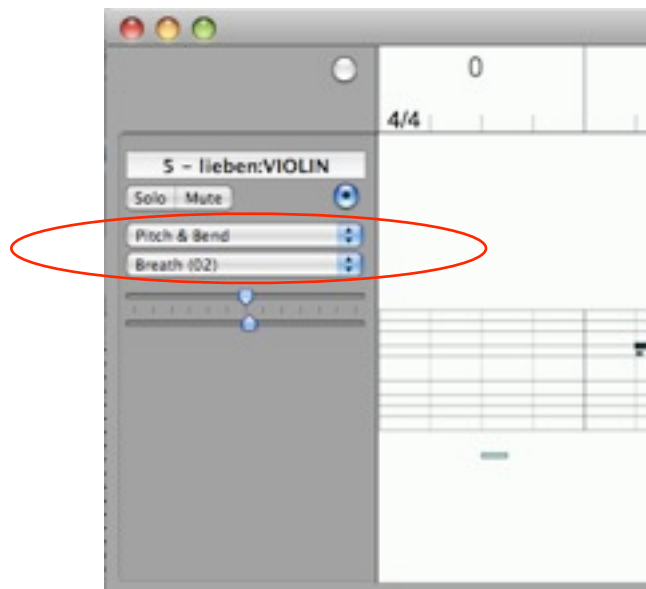
Type "g" to view notes and pitchbend data simultaneously



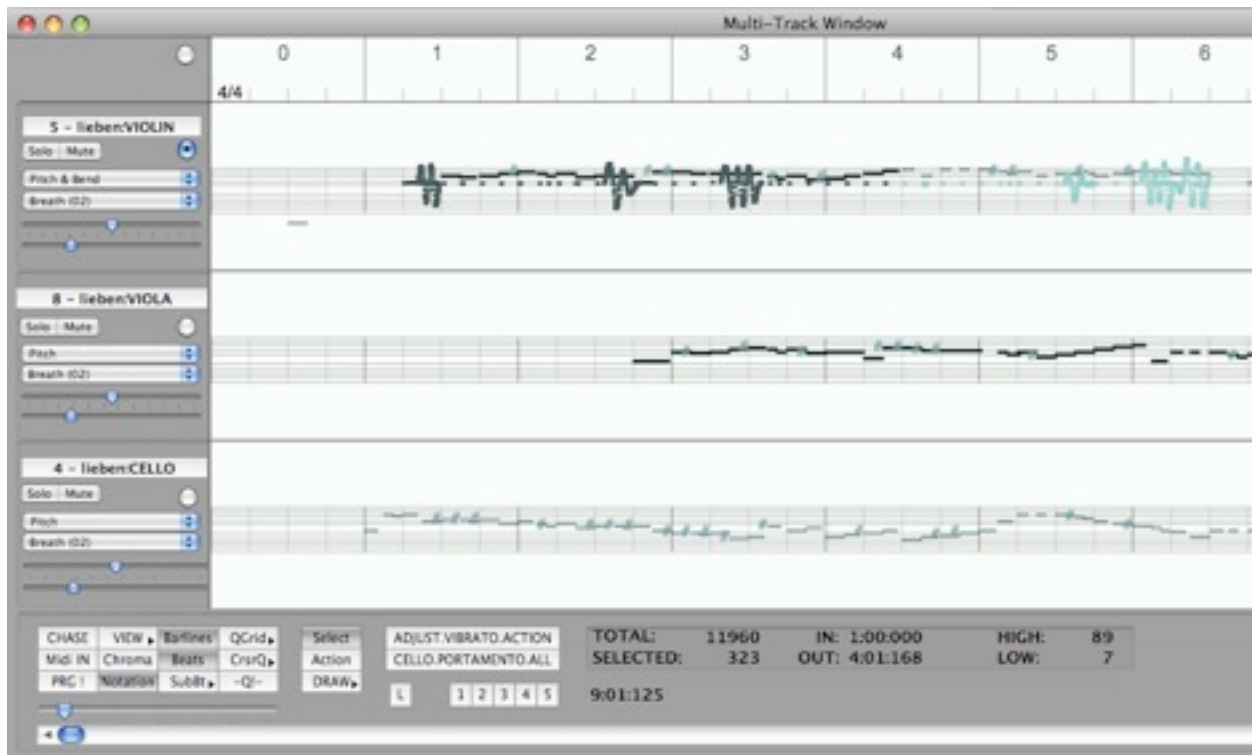
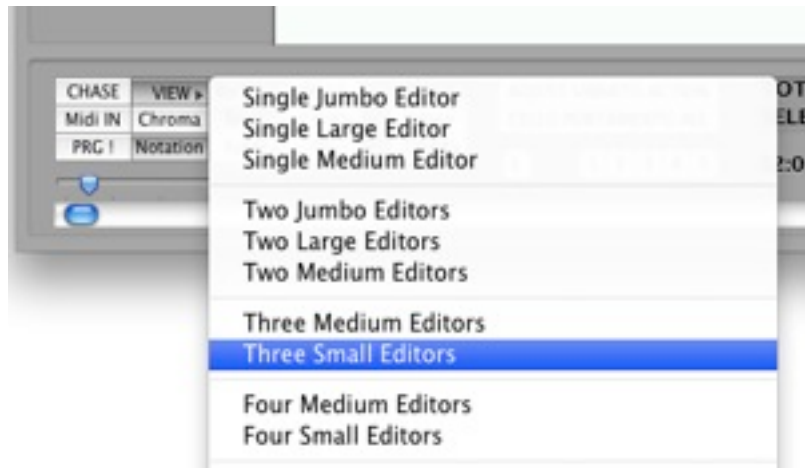
To return to viewing Notes without breath or pitchbend data, type "p".

The ability to view and edit notes, breath controller and pitchbend data simultaneously is one of MIDIForth's main strengths as a sequencer for Electronic Wind Instruments.

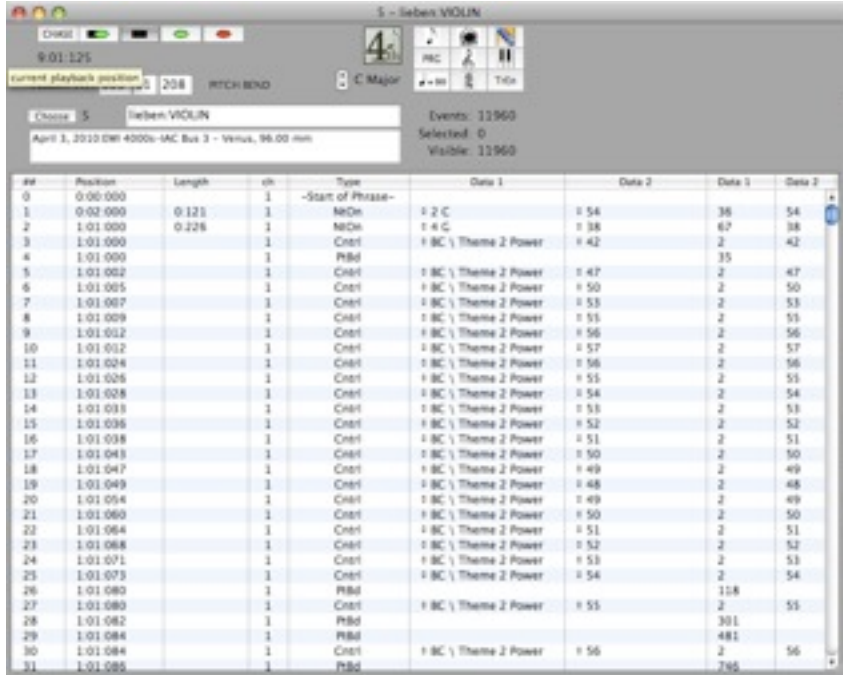
There are many other types of MIDI data that can be viewed and edited in this window. The complete list is in the popup menu at the left of the graphic pane:



You can configure the Multi-Phrase Graphic Editor to show up to six phrases simultaneously via the "VIEW" button in the lower left of the window. (NB - The larger settings require a monitor at least 1200 pixels high.)



(5) Select "Eventlist Editor" or type cmd-1 to open an Eventlist window. This window shows all the Midi events in a single phrase in time sequence. Events can be individually edited in this window:



The screenshot shows a software window titled "5 - Seben VIOLIN". The interface includes a transport control bar at the top with a play button, a time display showing "9:01:125", and a "current playback position" indicator at "208". Below this, there are controls for "Pitch Bend" and "C Major". A dropdown menu shows "Seben VIOLIN" and "Events: 11960". A table below displays a list of MIDI events in a time sequence.

#	Position	Length	ch	Type	Data 1	Data 2	Data 3	Data 4
0	0:00:000		1	-Start of Phrase-				
1	0:00:000	0:121	1	MIDI	1 2 C	1 54	36	54
2	1:01:000	0:126	1	MIDI	1 4 C	1 38	67	38
3	1:01:000		1	Cntrl	1 BC \ Theme 2 Power	1 42	2	42
4	1:01:000		1	Rbd			15	
5	1:01:002		1	Cntrl	1 BC \ Theme 2 Power	1 47	2	47
6	1:01:005		1	Cntrl	1 BC \ Theme 2 Power	1 50	2	50
7	1:01:007		1	Cntrl	1 BC \ Theme 2 Power	1 53	2	53
8	1:01:009		1	Cntrl	1 BC \ Theme 2 Power	1 55	2	55
9	1:01:012		1	Cntrl	1 BC \ Theme 2 Power	1 56	2	56
10	1:01:012		1	Cntrl	1 BC \ Theme 2 Power	1 57	2	57
11	1:01:024		1	Cntrl	1 BC \ Theme 2 Power	1 56	2	56
12	1:01:026		1	Cntrl	1 BC \ Theme 2 Power	1 55	2	55
13	1:01:028		1	Cntrl	1 BC \ Theme 2 Power	1 54	2	54
14	1:01:033		1	Cntrl	1 BC \ Theme 2 Power	1 53	2	53
15	1:01:036		1	Cntrl	1 BC \ Theme 2 Power	1 52	2	52
16	1:01:038		1	Cntrl	1 BC \ Theme 2 Power	1 51	2	51
17	1:01:043		1	Cntrl	1 BC \ Theme 2 Power	1 50	2	50
18	1:01:047		1	Cntrl	1 BC \ Theme 2 Power	1 49	2	49
19	1:01:049		1	Cntrl	1 BC \ Theme 2 Power	1 48	2	48
20	1:01:054		1	Cntrl	1 BC \ Theme 2 Power	1 49	2	49
21	1:01:060		1	Cntrl	1 BC \ Theme 2 Power	1 50	2	50
22	1:01:064		1	Cntrl	1 BC \ Theme 2 Power	1 51	2	51
23	1:01:068		1	Cntrl	1 BC \ Theme 2 Power	1 52	2	52
24	1:01:071		1	Cntrl	1 BC \ Theme 2 Power	1 53	2	53
25	1:01:073		1	Cntrl	1 BC \ Theme 2 Power	1 54	2	54
26	1:01:080		1	Rbd			118	
27	1:01:080		1	Cntrl	1 BC \ Theme 2 Power	1 55	2	55
28	1:01:082		1	Rbd			301	
29	1:01:084		1	Rbd			481	
30	1:01:084		1	Cntrl	1 BC \ Theme 2 Power	1 56	2	56
31	1:01:085		1	Rbd			765	

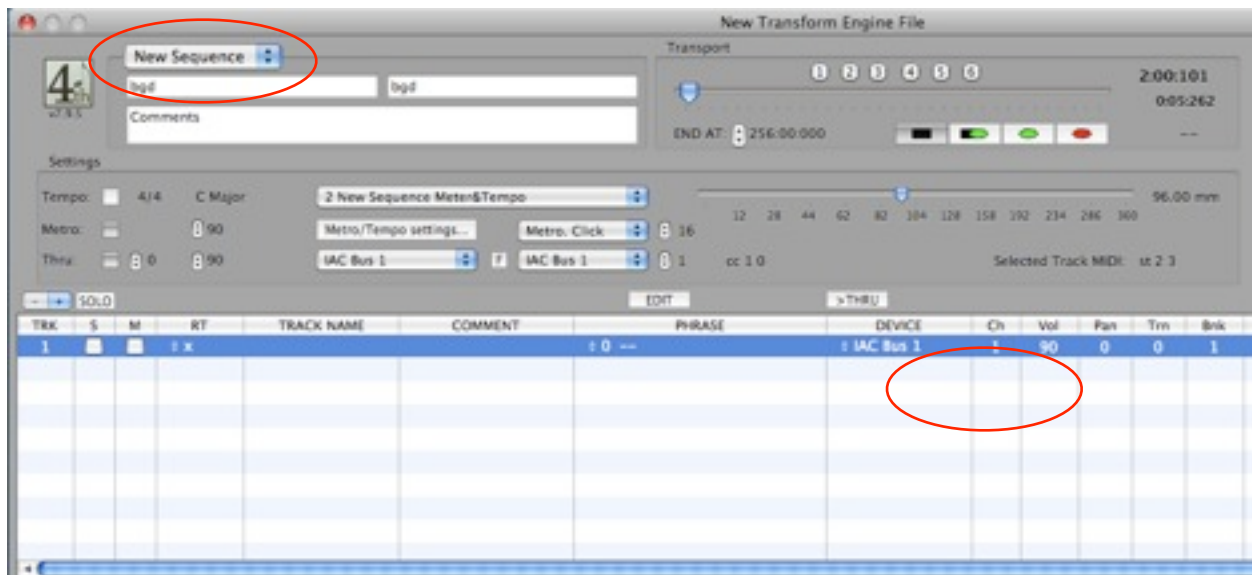


## TUTORIAL DEMO PART 2 - MIDI RECORDING

Once you get MIDI playback, you'll probably want to record some music, so here's a tutorial on how to set it up:

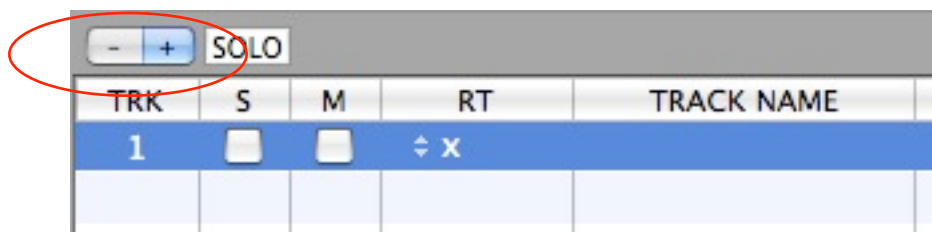
### RECORDING SETUP:

First, create a new project with "New transformation Engine File..." from the file menu. Then set up the Sequence Window for recording:



The default name will be "New Sequence" but you can rename it to anything you like with the "Rename" item in the Sequence menu.

To begin with, there will be only one track listed. You can add more tracks with the "- +" button on the left side of the window, just above the track list:



The maximum number of tracks in a sequence is 64.

Create a few tracks. Name them by clicking in the "Track Name" column. This name will be used later, after you record a MIDI performance. You can also add a short text note in the "Comment" column.

		EDIT	>THRU
TRACK NAME	COMMENT	PHRASE	DEVICE
VIOLIN		÷ 5 lieben:VIOLIN	÷ IAC Bus 1
ENG HORN		÷ 8 lieben:VIOLA	÷ IAC Bus 1
CELLO		÷ 4 lieben:CELLO	÷ IAC Bus 1
BASS		÷ 7 lieben:BASS	÷ IAC Bus 1

The Sequencer's track columns from left to right have the following meaning:

SEQUENCE WINDOW TRACK COLUMNS	
<b>TRK</b>	- Track Number
<b>S</b>	- solo
<b>M</b>	- mute
<b>RT</b>	- install the Transformation Engine on this track (not needed for normal sequencing - leave set to 'x')
<b>TRACK NAME</b>	- short descriptive name, usually the instrument name i.e. bassoon
<b>COMMENT</b>	- you can use this for additional brief text
<b>PHRASE</b>	- the actual MIDI data is contained in a "phrase", of which 1024 exist in every project file. With this menu you can choose which phrase will play back from this track.
<b>DEVICE:</b>	- Very important! Here is where you choose which MIDI device (i.e. synthesizer) will be played by this track. This popup will list all the devices you have defined for your studio in the Audio Midi Setup application.
<b>Ch</b>	- the MIDI Channel of the device specified in the previous column.
<b>Vol</b>	- the starting MIDI volume for this track
<b>Pan</b>	- the starting MIDI Pan for this track
<b>Trn</b>	- the pitch transposition for this track
<b>Bnk</b>	- the MIDI bank number for this track
<b>Prog</b>	- the starting MIDI Program change for this track
<b>Group</b>	- Tracks can be grouped together for quick muting and soling of several tracks. "Option-clicking" on the Solo or Mute buttons will affect all the tracks in the same group as the track clicked on.
<b>Loop</b>	- a value set here, in bars, beats and ticks, will cause the track to loop only the specified length of the phrase. "0:00:000" means play straight through without looping.
<b>XML</b>	- choose whether this track will be exported to MusicXML for notation in Sibelius or Finale.

**Set up the THRU Input and Output instruments:**

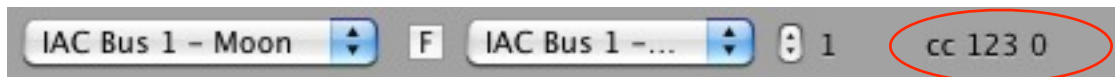
To record MIDI, you must first specify the instrument used for input and the synth used for output. You do this through the two popups in the Sequence Window on the line labeled "Thru".



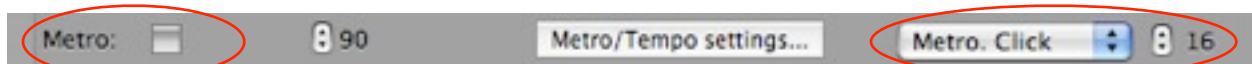
With the first popup choose your instrument, e.g. "EWI4000". With the 2nd popup, choose the synthesizer you want to play. Also set the appropriate MIDI channel with the arrows to the right of the popup.

**IMPORTANT!:** Do not set the THRU input and output popups to the same device! This will create a MIDI feedback loop which will cause erratic behavior and may crash the application.

Click the Thru button to turn on MIDI Thru. Play your instrument. You should be able to hear a sound from the selected synthesizer and also see MIDI data changing in the text to the right of the MIDI channel arrows.

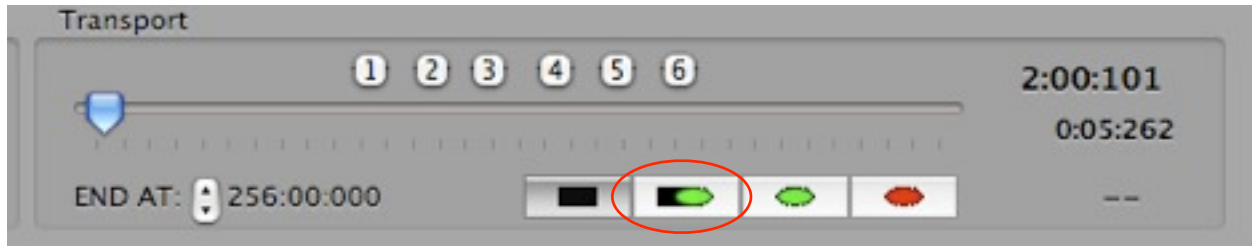


Next, turn on the metronome by clicking the "Metro" button:



Select a MIDI device for the metronome using the popup to the right of the "Metro/Tempo Settings.." button. For convenience there is a pre-defined Metronome Click instrument available in this menu, but you can use a synth or drum machine in your studio if you prefer.

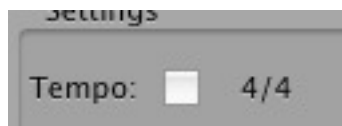
Now click the "Play from beginning" button (the 2nd from the left) in the Transport area of sequence window:



You should hear the metronome click and see the bars&beats counter changing. Adjust the tempo with the Tempo Slider:



Make sure the Tempo Button is OFF, or the tempo slider value will be over-ridden by the the tempo automation track whenever you restart the sequence.

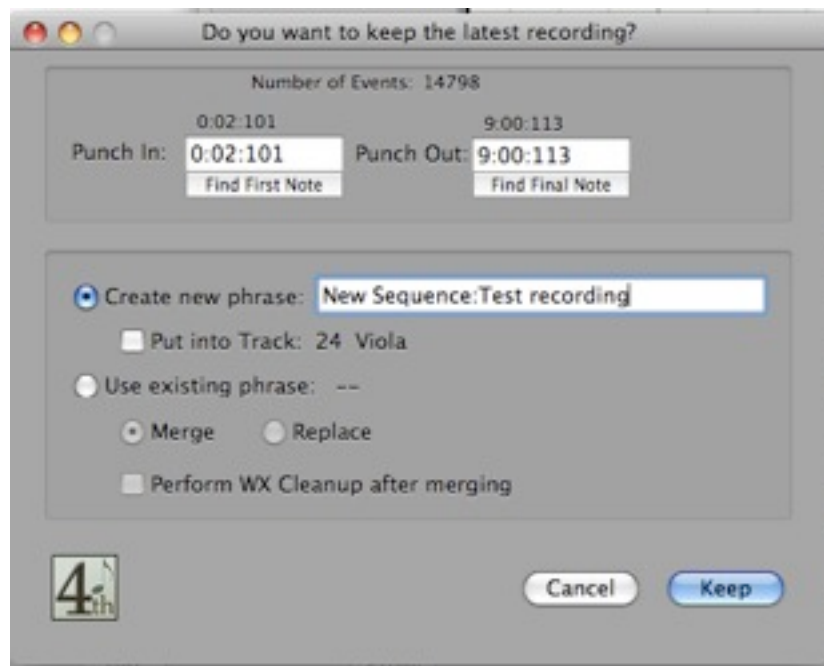


**RECORDING:**

MIDIForth has no specific "Record Mode". The recording function is operating whenever the sequencer is playing, which allows you to capture those moments when you were just "playing along" with the music without any specific intention to record. (This was one of my favorite features in the old Logic Audio, which seems to have gotten lost in the move to Apple). There is a record buffer which is continually being filled with incoming MIDI data. IMPORTANT: The buffer is emptied whenever the "Play from Beginning" button (or its keyboard equivalent, the '0' key) is clicked.

So to record, just play along with the click. Perform a few bars of music, then click the "Stop" button in the transport area (or type its equivalent, the Return key).

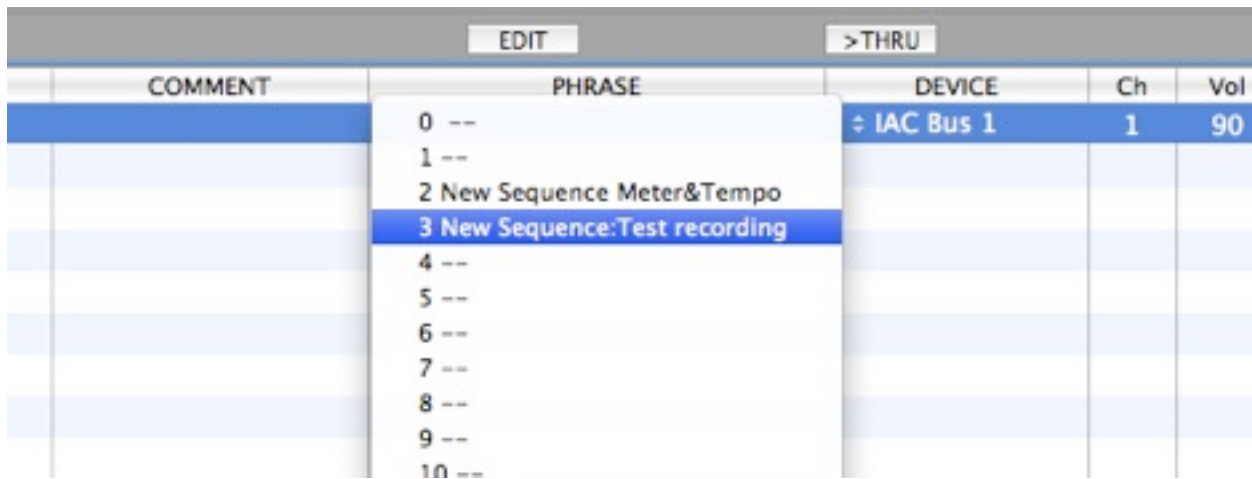
Your MIDI performance is now in the buffer, but it will be lost the next time you "Play from Beginning" unless you save it to a phrase. To do this, click the red "Record" button in the Transport area of the Sequence window. You will be presented with the Record Dialog:



Here you can choose to create a new phrase with this performance, or merge it into an existing phrase. If you choose to create a new phrase, you can specify a name for the phrase in the text field, and optionally automatically assign the phrase to a specific track in your sequence. The track presented here will be the first one that matches the MIDI Device and Channel settings for the THRU track. You can disregard this and manually assign this phrase to any track you like later.

For now, create a new phrase and click the "KEEP" button.

In your sequence window, set the PHRASE popup for the first track to the phrase you just recorded:



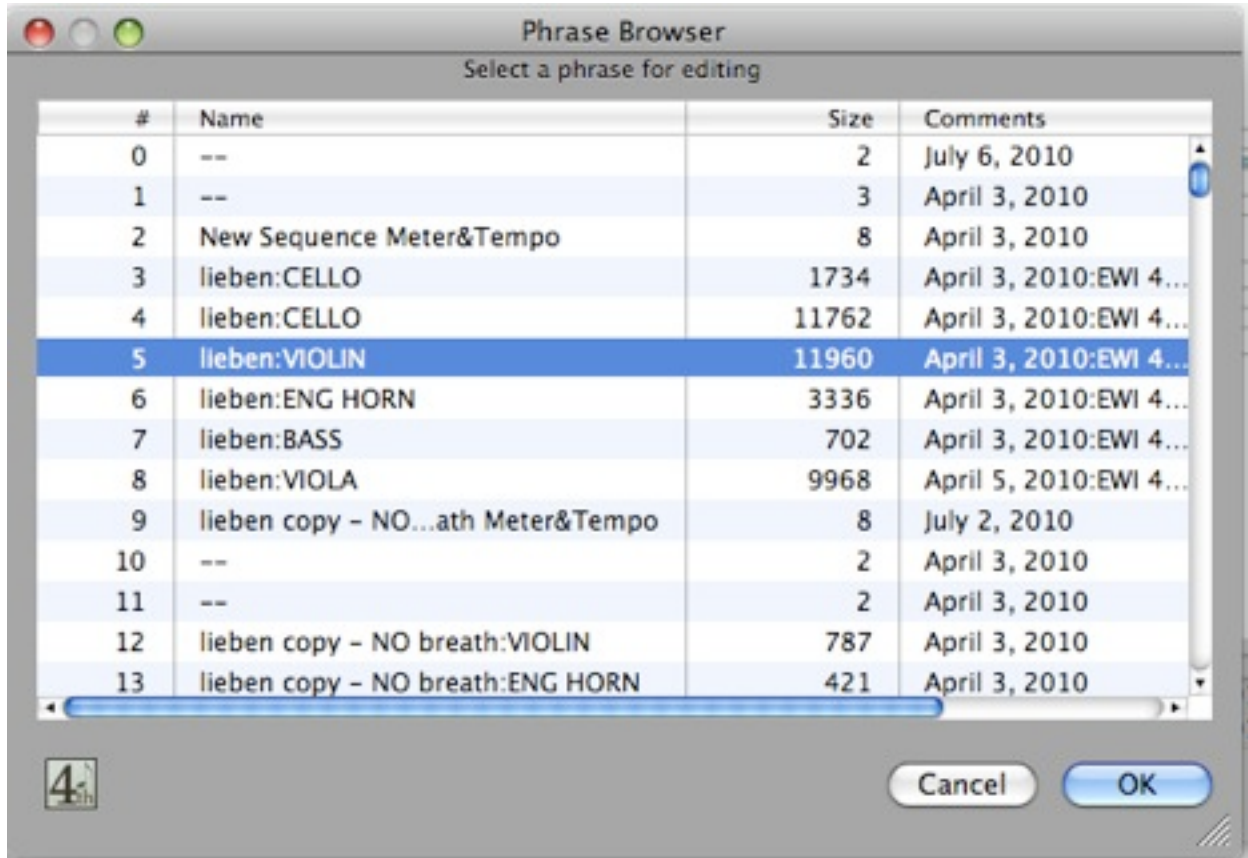
The screenshot shows a MIDI software interface with a track list. At the top, there are two buttons: "EDIT" and ">THRU". The track list has five columns: "COMMENT", "PHRASE", "DEVICE", "Ch", and "Vol". Track 3 is selected, and a context menu is open over it, listing options from 0 to 10. The option "3 New Sequence:Test recording" is highlighted in blue.

COMMENT	PHRASE	DEVICE	Ch	Vol
	0 --	÷ IAC Bus 1	1	90
	1 --			
	2 New Sequence Meter&Tempo			
	3 New Sequence:Test recording			
	4 --			
	5 --			
	6 --			
	7 --			
	8 --			
	9 --			
	10 --			

Now click "Play from Beginning" again. You should be able to hear your recorded performance playing on the MIDI Device for track 1.

**EDITING:**

Open the MultiPhrase Graphic Editor window. From the VIEW Button in the lower left corner, choose "Single Jumbo Editor" (or a smaller size if your monitor is small). If your newly recorded phrase is not visible, click the Phrase Selector Button at the left of the graphic pane (the one displaying the name of the current phrase). You will get the Phrase Browser dialog which should look something like this:



Select your new phrase from the list and click OK. You can now edit your MIDI performance in the Graphic Editor pane, as you did the Bach track in the earlier tutorial.

## TUTORIAL 3 - WIND CONTROLLER EDITING

### THE PROBLEM WITH CONVENTIONAL SEQUENCERS

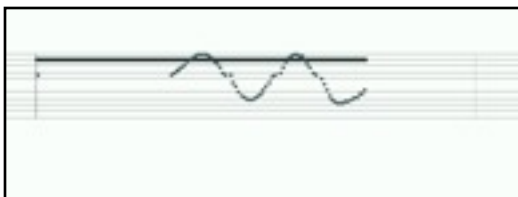
Midi editing of Electronic Wind Instruments (EWI) such as the Akai EWI 4000 or the Yamaha WX5 presents a challenge to the software designer. These devices generally emit great quantities of MIDI data which are difficult to handle in an editor.

The basic problem is that MIDI was designed with keyboard performance in mind, where a player strikes a key and thereafter has no control over the sound of the note. This means that the protocol expects very little information for each note - in fact only two pieces of data are required to play a note - key number (=pitch) & velocity (=initial loudness). However, as any wind player will tell you, there's a lot more to a note than these two numbers can specify. For example a note's loudness may change after it begins - it can get louder (crescendo) or softer (diminuendo). A note's pitch may also change after it begins - it can go sharper (scoop) or flatter, or alternate between these (vibrato).

These musical gestures are not beyond the capacity of MIDI in itself. For example, MIDI defines *continuous controllers*, such as controller #2, *Breath Control*, which can affect the loudness of a note at any time. It also defines *pitchbend*, which can affect the pitch of a note at any time. It is these additional data that an EWI uses to give the player some musical control of the loudness and pitch of a note after it begins.



A note, with its EWI-generated breath controller data superimposed.



And with its EWI-generated pitchbend data superimposed.

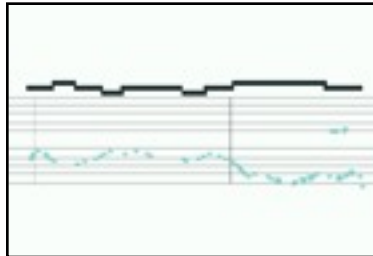
A problem arises in conventional sequencers however, because they have been designed with the keyboard performance paradigm in mind. When editing a note, these sequencers assume that the only relevant data are the key number and velocity, which are contained, so to speak, in the note itself. They do not consider that there may be a great quantity of breath controller and pitchbend data that are important to the correct sounding of this note. Therefore after a small amount of editing, the notes and the relevant breath control and pitchbend data become hopelessly unsynchronized.

### MIDIForth's SOLUTION

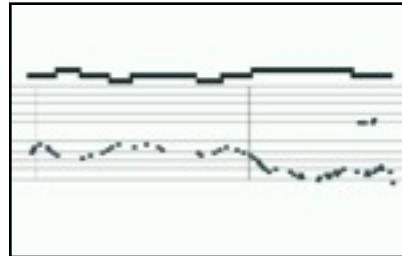
MIDIForth attempts to solve this problem by providing a number of tools that keep the additional performance data - breath controller and pitchbend - attached precisely to its note. A few of these tools are demonstrated in the following tutorial. The basic technique used is that, whenever possible, ALL Midi



data within the boundaries (beginning to end) of a given note are treated as a single entity. Several of the special-purpose editing functions do this automatically (more details on these below), but the most important one you should memorize is the Edit menu's *Select Within Note or Theme* (cmd-L). This function selects all data within the start and end boundaries of the selected notes, allowing you to copy, paste and move the entire data package as a single entity.



First select the notes...



*Select Within Note* (cmd-L) selects all contained performance data

There are three common problems when sequencing data derived from an EWI such as the Yamaha or Akai instruments.

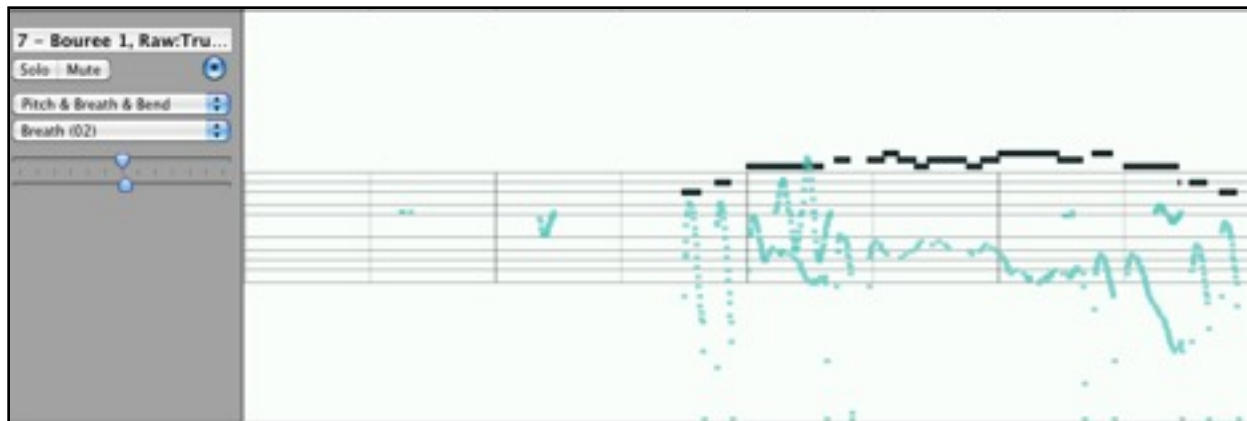
1. Extraneous performance data outside a notes boundaries, and incomplete performance data within a note's boundaries.
2. Spurious notes of very short duration due to key flutter or sloppy finger technique.
3. Erratic velocity response.

In addition, there is a fourth problem which is not unique to EWI performances alone - inaccurate or sloppy rhythmic performance, which requires quantization to correct. Although this problem is common for all types of instrumental performance, correcting it in a recorded EWI performance presents technical challenges which no sequencer besides MIDIForth, to my knowledge, has addressed.

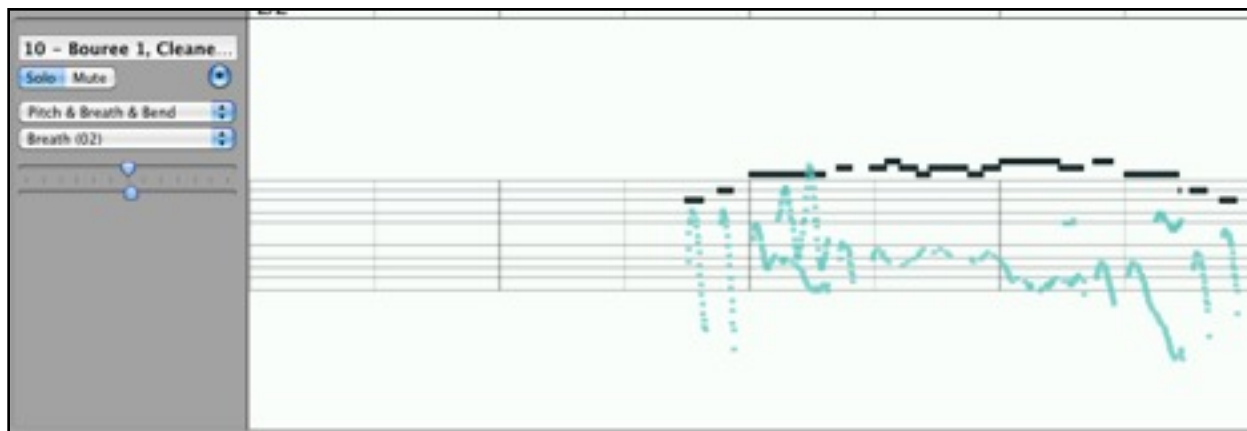
MIDIForth provides tools to deal with each of these problems individually.

### 1. Extraneous performance data.

The first step after recording a MIDI performance with the EWI or WX5 is to remove all breath controller and pitchbend data outside the boundaries of sounding notes. This extraneous data has no effect on the sound of the synthesizer, but can become a nuisance when you start to arround blocks of notes with their embedded breath and pitchbend data. The function *WX Cleanup* found in the *Goodies* menu performs this task:



Bach Bouree, Trumpet, EWI Performance as recorded. Note the extraneous pitchbend data before the first notes.



Bach Bouree, Trumpet, EWI Performance after *WX Cleanup*..

*WX\_Cleanup* also ensures that every note has a valid pitchbend and breath control datum precisely at its beginning. Note that this function acts upon the entire phrase, whether selected or not.

## 2. Spurious short notes.

This is a common problem due to poor performance technique or inappropriate controller set up. There is an example of this type of spurious note visible near the right hand side of the above example. Here's a closer view:

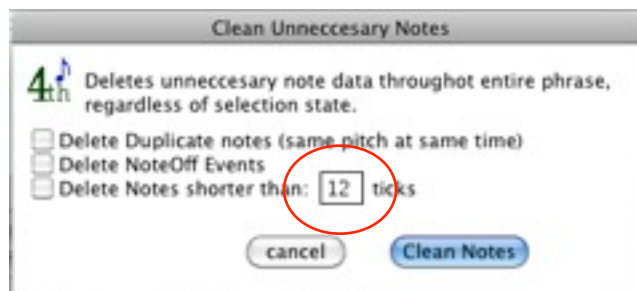


In this case it is obvious that the spurious note is an anticipation of the coming note 'D'.

In performance these notes are usually not a problem in themselves and are usually inaudible, but they become problematic when you attempt to edit the data, especially when quantizing or transcribing the performance into CMN. For this reason there is a function *Meld Selected Short Notes* in the *Goodies* Menu, which automatically joins any such short notes to the long note with which it should be connected:



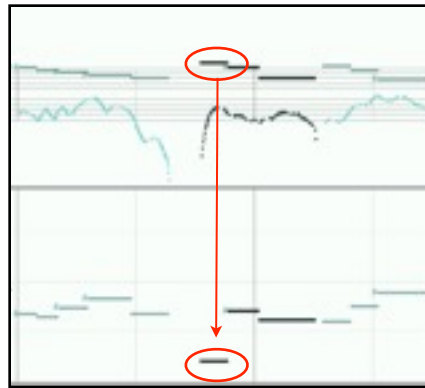
The length of short notes to which this function will be applied is by default 12 ticks or less ( NB MIDIForth's temporal resolution is 240 ticks per quarter note). If you would like to change this length, you can do so with the dialog brought up by *Cleanup Notes...* in the *Goodies* Menu:



### 3. Erratic Velocity Response.

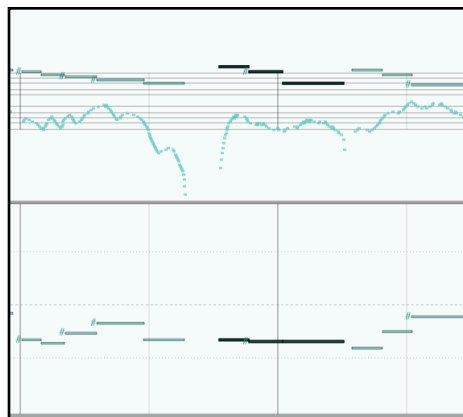
Another quirk of the EWI is the rather erratic nature of its velocity response. In practice this is usually not too much of a problem, since the attached synthesizer is usually programmed to ignore velocity, or at least minimize its effect. However the erratic velocities can become a problem later if this recording is used to drive a velocity controlled synth program such as piano or marimba, or when it is used as a Theme in the Transformation Engine.

The player's performance style, especially the manner of tonguing, will have a great effect on the resulting velocities. Here's a typical example of erratic velocity. Note that this is a dual view in the MultiPhrase Graphic Editor - the upper pane shows pitch and breath controller superimposed, while the lower pane shows the same phrase's note velocities:



In this case the note's velocity is too low. You can see this both by comparing the velocity to the velocities around it, and intuitively by comparing it to the height of the breath controller data for the note, which is a truer measure of the note's loudness.

For this reason, MIDIForth provides a function that measures the average breath control value through the duration of given note, and applies that average as the note's velocities. In practice this has been found to provide a much more musical velocity performance that follows the breath control performance very well. This function is available as *Convert BC to Vel*, in the *Goodies* menu:



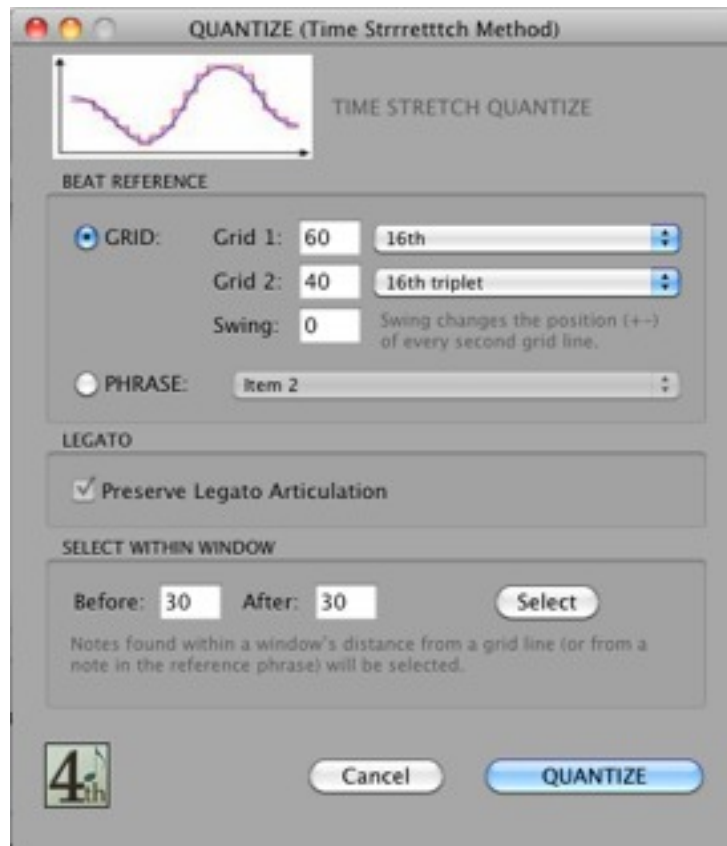
#### 4. Quantization

Using a conventional sequencer's quantization function on an EWI performance will invariably result in a great mess of misaligned data, because the quantization process moves the notes without shifting the embedded performance data. This makes quantization of EWI performances on such a sequencer virtually useless.

MIDIForth has a special purpose quantization routine that *does* respect the embedded data and furthermore implements the alignment process as a form of time-stretching rather than simply time shifting.

The inspiration for this came from my work as a sound editor in the film industry, where it is a frequent task to fit a piece of post-recorded dialog to an on-screen actor's lips. The most natural process for this involves a laborious process of time-stretching (or time-compressing) each syllable in the recording to fit the on-screen actor's lips. Done carefully this can give a near-perfect fit of dialog to image.

MIDIForth automates and applies this same process on a note-by-note basis to precisely fit a recorded performance to a beat grid. The function that implements this is called *Time Stretch Quantize*, available in the *Operations* menu:

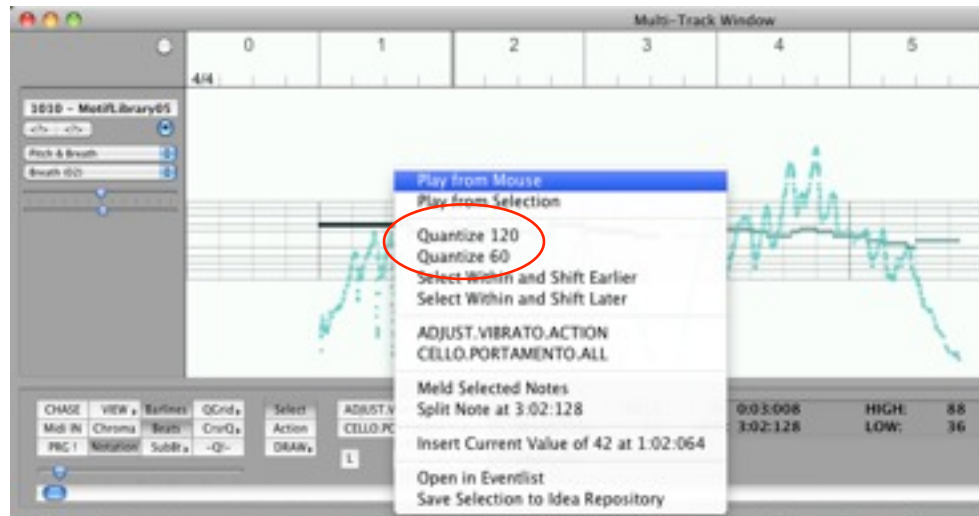


This dialog allows you to set two simultaneous grids for quantization, so that, for example, you can quantize both straight eighth-notes and eighth-note triplets in one pass. Select the desired quantization values from the popups at the right, or enter the ‘tick’ values directly into the text fields. This latter form of entry can be useful for uncommon quantizations, e.g. Quintuplet-sixteenths, which correspond to a tick-value of 48 (= 240 / 5).

Instead of a rigid grid, you can alternatively specify another phrase to be interpreted as a rhythm template or “groove”. Quantized notes will then be shifted to the nearest corresponding note in the “groove”-phrase. NB - this option has not been thoroughly tested.

This method of quantization always preserves the legato articulations of the recorded performance, so “Preserve Legato Articulation” is automatically checked.

For convenience, this form of quantization is also available from the contextual menu obtained by right-clicking (control-clicking) in the MultiPhrase Graphic Editor. Note that the quantization settings are displayed as ticks, e.g. 120 ticks equals 1/8th note, 60 ticks = 1/16th note, etc:



116

Bourrée I.

The first system of musical notation for 'Bourrée I.' consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#) and the time signature is 3/4. The music begins with a treble clef, a key signature of one sharp, and a 3/4 time signature. The first measure contains a quarter rest in the bass and a quarter note in the treble. The subsequent measures show a rhythmic pattern of eighth and sixteenth notes in both staves.

The second system of musical notation continues the piece with two staves. The notation follows the same clef and key signature as the first system, showing a continuation of the rhythmic patterns.

The third system of musical notation continues the piece with two staves, maintaining the 3/4 time signature and one sharp key signature.

The fourth system of musical notation continues the piece with two staves, showing a continuation of the rhythmic patterns.

The fifth system of musical notation continues the piece with two staves, showing a continuation of the rhythmic patterns.

The sixth system of musical notation continues the piece with two staves, showing a continuation of the rhythmic patterns.

117

The seventh system of musical notation concludes the piece with two staves. The notation follows the same clef and key signature as the previous systems, ending with a double bar line.