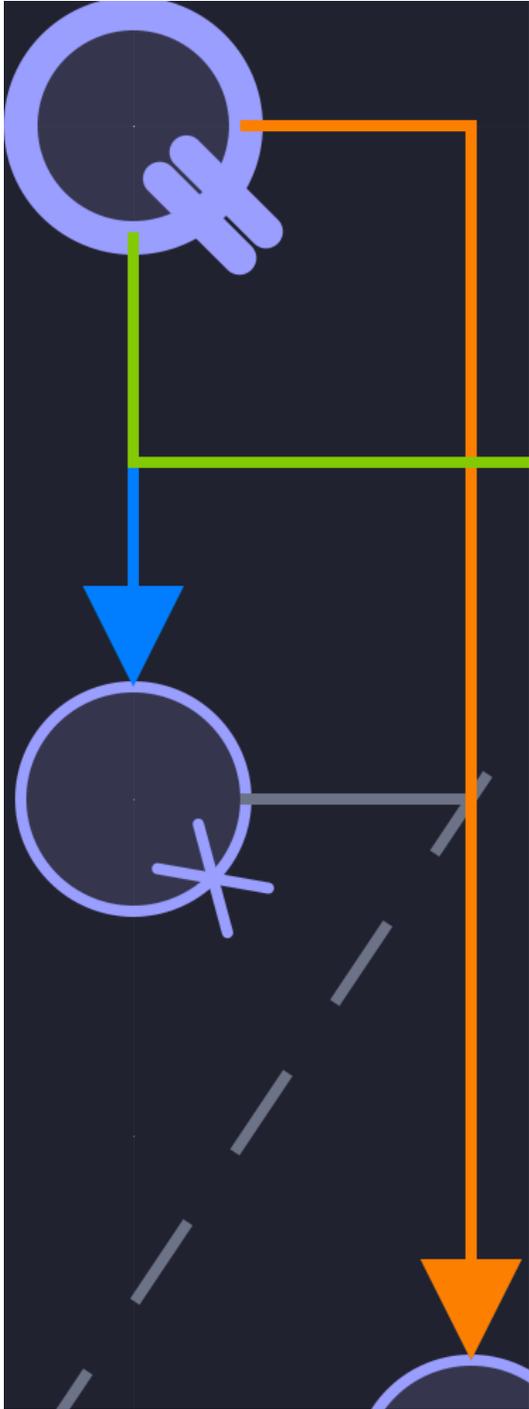




Nodal
GENERATIVE MUSIC SOFTWARE
Nodal 2.0 Manual



nodalmusic.com

Introduction

Nodal is software for composing music, interactive real-time improvisation, and a musical tool for experimentation and fun. Nodal uses a new method for creating and exploring musical patterns, probably unlike anything you've used before. Using circles and lines with arrows, Nodal represents a view of music that emphasizes musical elements (such as notes, pitches, rhythms, dynamics) and the interconnection between them. Making music in Nodal involves designing processes that generate musical sequences. It is a generative method in that it creates music from these elements and processes. Instead of describing music as a fixed progression or path from one musical element to the next, Nodal allows for the possibility of multiple pathways between musical elements. Creative musicians know that music is not made up of a fixed series of ideas: any given piece of music is merely one representation of many that can be drawn from the musical material at hand. By representing and generating music differently, Nodal offers users the chance to work in an intuitive and direct way with the processes of music creation.

In Nodal users create networks of nodes that are connected by edges (in graph terminology nodes are points in space and edges are connections between them). Nodes and edges can be given various musical parameters in the form of MIDI information that can be read by software agents called voices. Voices move around a network reading MIDI information such as note or continuous controller messages as they go. Voices are associated with a MIDI channel and output port so that they can send the MIDI messages they read to any MIDI instrument that you choose. Also the voice's MIDI stream can be recorded into a DAW so it can be edited or combined with other materials.

The path that a voice takes through a network is determined by the structure of

the network and by a number of signaling rules that are built into Nodal. These rules provide for a kind of "traffic management" that guides where a voice will go next. The time that it takes for a voice to move from one node to the next is proportional to the length of the edge between nodes. In this way, edges represent the duration in time between note events.

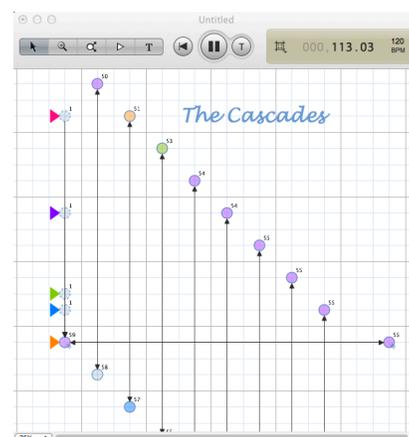
While care has been taken to make Nodal intuitive to use it is based on a number of abstract principles that may be new to many people. You might find that you will "get" Nodal much more easily by working through the tutorial. Technical explanations of the software are given in the Reference section of this manual.

You will also find a number of examples included with Nodal. To access these examples, go to the menu *File > Open Example* and select one of the example files. Once the file is open press the play button to start playing.

If you'd prefer to watch rather than read, we have developed on-line tutorial videos that guide you through using Nodal, starting with the basics and building up to advanced topics. These tutorials are available at:

<http://nodalmusic.com/tutorials/>

We hope you enjoy using Nodal to compose and perform your music.



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This version last modified: December 19, 2019

The *Nodal Manual* was written by
Jon McCormack and Peter McIlwain.

What's New in 2.0

Nodal 2.0 is a major internal update to the software, bringing it up to date with many modern MacOS and Windows features. These include:

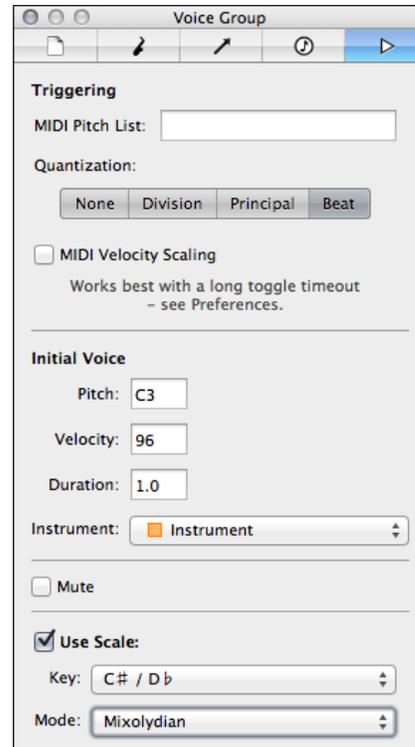
- Nodal is now a 64 bit application and runs on the most recent versions of MacOS (10.15 "Catalina") and Windows 10.
- New, updated retina graphics in the interface.
- A new, more flexible licensing system.
- Many other internal updates and bug fixes.

The new licensing system means that older (Version 1.X) licenses will no longer work. If you own a valid 1.X license please contact Nodal Support (support@nodalmusic.com) for details and pricing on how to upgrade to a 2.0 license.

What's New in 1.9

Welcome to Nodal version 1.9. This release incorporates a number of new features, which are summarized here.

Scales



Voice groups can now recognize scales. This is particularly useful when you are using relative notes and offsets in a Nodal composition.

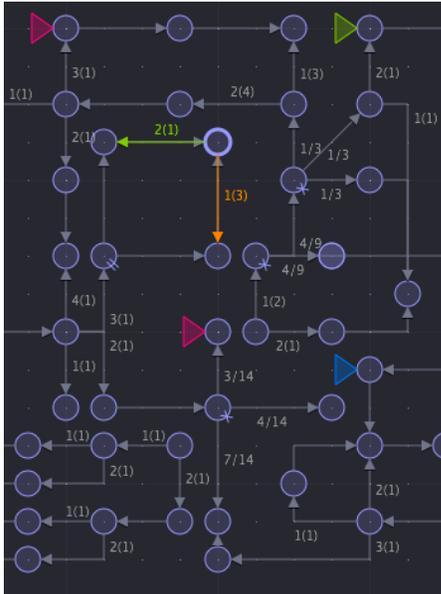
To activate this feature, select one or more voice group players (triangle symbols in your composition) and check the "Use Scale" box in the Voice Group editor as shown above.

You can then select a *Key* and a *Mode* from the drop-down menus. Key sets the key signature for the player and Mode selects the set of possible notes within that key the voice group will play. You can choose from a variety of common modes, including Chromatic, Major, Minor, Whole tone, Lydian, Dorian, and Phygian. For background information on musical modes, see this [Wikipedia article](#).

Different voice groups can use different Keys/Modes, allowing the generation of harmonies or key changes within a composition.

For a quick overview of this feature, load the file "Keys and Modes" from the *File > Open Example* menu.

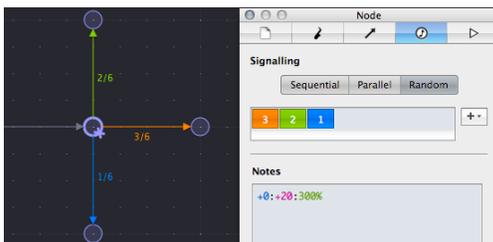
Edge Signalling



To assist in understanding a Nodal network structure, you can now display edge signalling information within the main document window.

The display of this information can be turned on and off from the *View > Show/Hide Edge Signalling* menu.

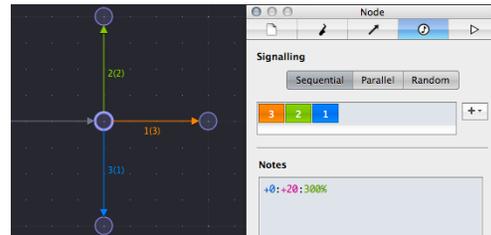
The display is active only for sequential or random nodes with 2 or more exiting edges. The information displayed depends on the node type. Here's a simple example:



In this example the selected node is set to Random signalling, with the probabilities set as shown in the colour chips. Each

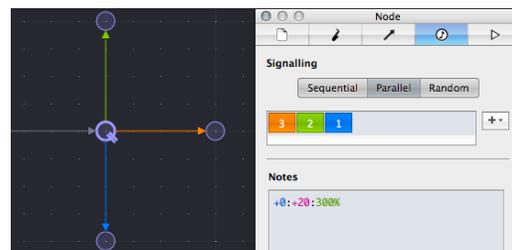
edge displays the probability of a signal traversing that particular edge when it exits the selected node. The output probabilities will always sum to 1.

The image below shows the same network but with the Node signalling changed to Sequential:



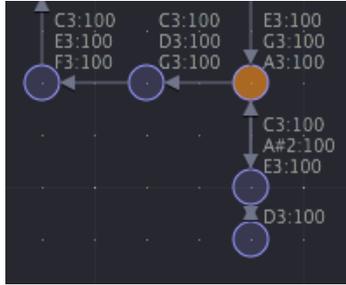
In this case the edge labels are in the following format X(Y), where X is the order the edge will be traversed, and Y is the number of times in succession the edge will be traversed. So for the green edge – labeled 2(2) – will be the second edge traversed and it will be traversed twice.

Finally, for a parallel Node, no information is displayed as all edges are traversed simultaneously, regardless of the signaling order or number shown in the Node editor.



Show Last Note Sent

A new option to show the last note or notes sent by a node has been added. The display shows both the note sent and its velocity.



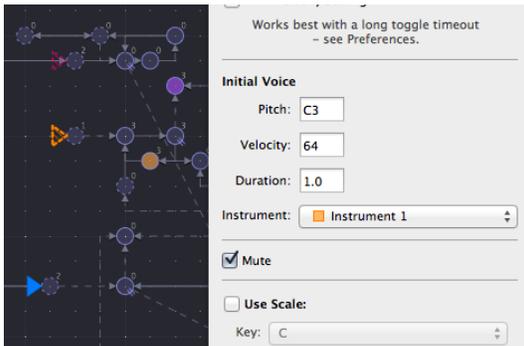
You can enable or disable this option via the View menu or using the keyboard shortcut Shift-⌘-L.

Voice Group Muting

Individual voice groups' MIDI output can now be muted at any time. The voice group will continue to play, but it will not output any MIDI information.

To toggle voice group muting select the voice group(s) you want to toggle and then Right-click (or Control-Click on Mac) and select "Mute" from the menu.

Alternatively you can click the "Mute" check box in the voice group editor.



Note that muted voice group triangles are displayed as dashed, and likewise a node being played by a muted voice group highlights with a striped pattern to distinguish it from unmuted signals.

Other New Features

You can now start and stop individual voice groups from context menu. To do this, select the voice group(s) you want to

start or stop and then hold down the right mouse button (or Control-Click on Mac) and select start or stop.

New example files have been added for this release.

The selection behavior has been modified for multiple selections.

Relative offsets have been changed when using Scales. Offsets of +0 and -0 can be used to snap to the closest legal note in a scale.

Compatibility

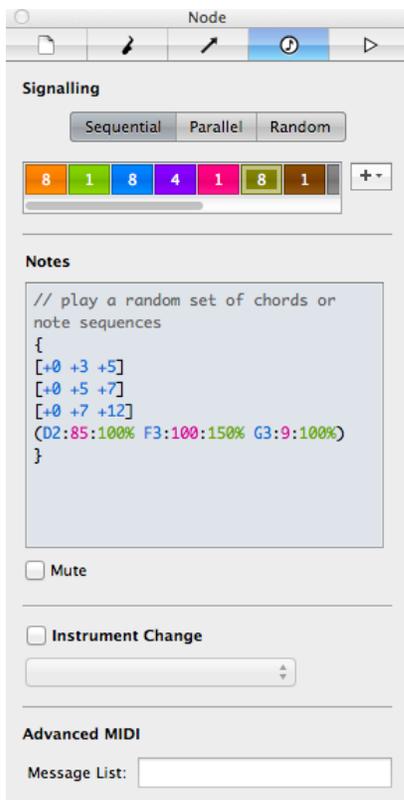
Nodal is compatible with MacOS 10.6 and higher. As of this release we no longer support OS releases prior to 10.6.

The Windows version will run under Windows Vista, 7 and 8.

What's New in 1.8

Note Lists

Nodal 1.8 incorporates a number of improvements and new features from 1.7. The most important change is the new note list editor that consolidates separate pitch, velocity and duration lists from previous versions of *Nodal*.



The new note list allows specification of *note events*, which can optionally include velocity and duration. Additionally, notes can be grouped in hierarchical sets and played sequentially, randomly or in parallel. This allows, for example, a single node to play a chord (or set of chords).

Nodal 1.8 will read files created with previous versions of Nodal and convert them automatically to this new format. Note that because of the new functionality

in 1.8, files created or saved in 1.8 will not work correctly when read into previous versions of Nodal.

The format for specifying a note is simple:

NOTE : VELOCITY : DURATION

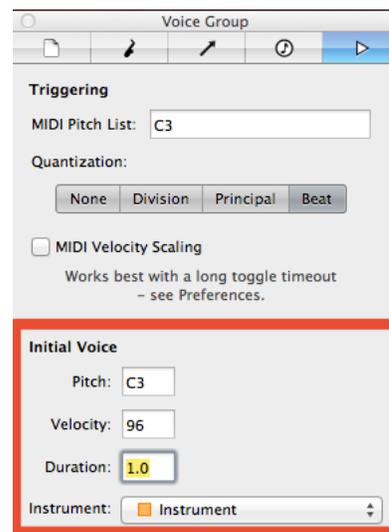
The VELOCITY and DURATION components are optional. As with prior versions, specification may be absolute or relative, so the following are all valid note specifications:

C3 C3:55 C3:75:150%

+5 -12:96:*2 +0:-10:50%

Relative and absolute values can be mixed in a single note specification. For pitch and velocity, relative values are added or subtracted (+ or -). For durations, relative values may also be multiplied or divided.

If you don't specify a velocity or duration, the current value of the playing voice is used. For starting nodes, the default value is specified in the *Initial Voice* settings in the *Voice Group* editor.



You can also group notes together by placing brackets around them. Different brackets allow notes to be played sequentially (round brackets '(' ')'), in parallel (square brackets '[' ']') or randomly (curly brackets '{' '}'). Brackets

may be nested to as many levels as you need. Some examples:

```
[C3 E3 G3] // play a C major chord
```

```
{+0:30 +0:60 +0:90 +0:120} // play the
previous pitch with velocity randomly
selected from the values shown
```

```
(+3:100:100% +5:100:200%
+7:100:400%) // play the three notes
sequentially with relative pitch increases
of +3, +5 and +7 semitones and increasing
durations
```

```
{
  [+0 +3 +5] [+0 +5 +7] [+0 +7 + 12]
} // randomly play from the 3 specified
relative chords.
```

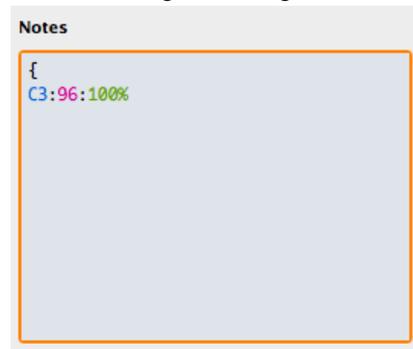
For relative chord sequences the first pitch in the list becomes the new pitch for the voice traversing the node, so in the example above it remains unchanged (since the first element of each chord is always +0).

Notes listed without brackets are played sequentially.

You can enter comments for a line in the Note entry by prefixing them with // (like comments in Java or C++). This can be useful for documenting specific sequences, or in a live performance when you want to turn different sequences on or off quickly.

While you enter note sequences, your list is continuously parsed and checked if it is valid. Notes will be automatically changed to upper case, but you can enter them in upper or lower case. An invalid sequence will cause the Notes list border to flash

with an orange rectangle.



In the example above the closing '}' bracket is missing (notice the orange rectangle indicating the error). As soon as a correct note list is entered, it is activated for that node and will be used when playing (there's no need to hit RETURN or any other key).

The Note editor also has syntax colouring and auto-completion (hit the TAB key to add default velocity and duration fields).

You may be interested to know that internally Nodal takes your note sequences and turns them into a self-contained Nodal network, with the entire network represented by a single node.

You can also enter notes using a MIDI keyboard. To enter notes sequentially, play them one at a time. To enter chords hold down the chord as you would normally play it.

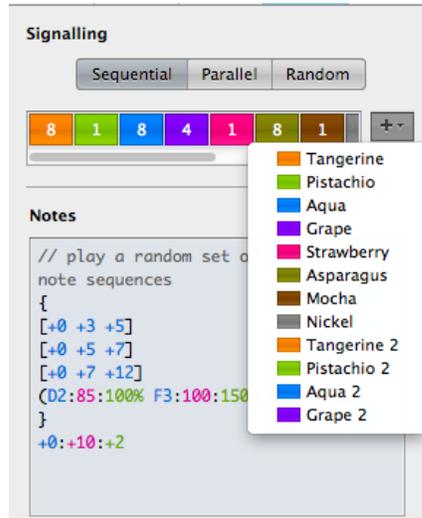
Other New Features

The default velocity for new notes has been increased to 96 (from 64).

User interface and usability improvements have been made to the edge editor.

New "tooltip" information has been added for nodes and edges (to see the tooltip, hover your mouse over the element of interest for a few moments).

The "Add Edge Tile" menu is now sorted by creation order and new colours have been added:



A colour-blind friendly palette can now be configured via the application's preference file (Mac) or registry (Win) by settings "AlternateColorPalette" as true. The default is false (implied by the setting's non-existence). It may be set on the Mac from the terminal: "defaults write edu.monash.cema.Nodal AlternateColorPalette true"

Numerous bug and compatibility issues have been fixed.

Nodal 1.8 is fully compatible with Mac OS X 10.7 (Lion), but also works under 10.6 (Snow Leopard) and 10.5 (Leopard).

Tutorial

Working with Nodal

Nodal can make sound by addressing your operating systems' built in synthesizer. For more professional sound sources Nodal can send MIDI information to software synths or to external hardware synths by assigning the appropriate MIDI ports. Software synths are typically found in many DAW packages such as Ableton Live, Cubase, Logic, and Digital Performer. Nodal can also accept MIDI input for node parameter entry. In the tutorial below we will assume that you *do not* have a software synth or a MIDI keyboard.

Making a simple network

1. Open Nodal.



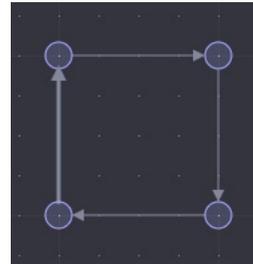
2. Click on the *Node & Edge* tool (\mathbb{N} -3**) as shown above.



3. Click on the grid to make a node.

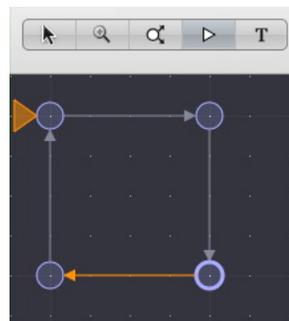


4. Click on the first node, hold and drag to make an edge connecting to another node.



5. Add two more nodes. To form a closed circuit, make an edge from the 4th node (just as you have been doing) and drag it up to the 1st node that you made.

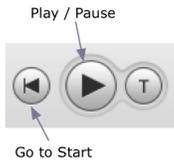
This node will respond with a green ring informing you that you have made a connection.



6. Click on the *Voice Group* tool (\mathbb{N} -4) then add a *Voice Group Triangle* by clicking

* \mathbb{N} -3 is the keyboard shortcut for this function: hold down the command and 3 keys (Mac) or Ctrl and 3 (Windows) simultaneously.

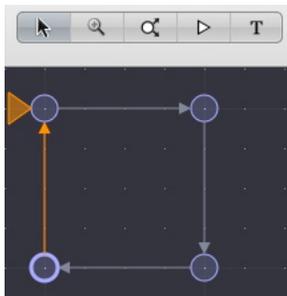
in the middle of the first node as shown.



7. Press the *Play / Pause* button (or press the space bar on the keyboard)

You should hear middle C (C3 in MIDI) being played continuously. As each note is played, a node will flash. You can see what pitches are entered into a node by hovering over them with your mouse cursor.

Editing Pitch Information

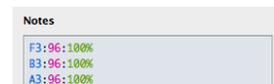


8. Keep the program playing and click on the *Selection* tool (⌘-1). Then select one of the nodes.



9. In the *Node* inspector window change the pitch in the note in the *Notes List* to D3.

You should now hear 3 nodes sounding the pitch C3 and 1 node sounding D3.



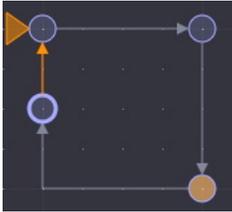
10. Select another node and change the Notes to a list: F3,B3,A3 (enter these by typing the notes and hitting TAB to add velocity and duration information).

Note that you can see the note list for a particular node by hovering over it with the mouse.

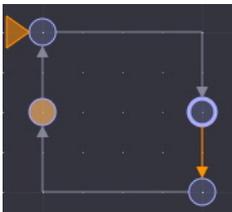
You will now hear a more complex sequence of pitches: 2 nodes sounding C3, 1 sounding D3 and 1 that cycles through the pitches F3, B3, and A3. Note that each node also has a list for MIDI velocity that can be specified as a list in the same way as pitch.

Editing Rhythm

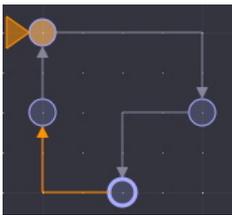
The circuit, or network, that you have just made consists of 4 nodes arranged in a square. The square represents a cycle of 4 beats so we could say that the music is currently in 4/4 time.



a.



b.



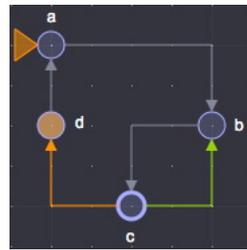
c.

- Using the *Selection* tool ($\#-1$), drag the nodes around to change their positions in the 4 beat square as shown above.

You have now produced four rhythms that occur in 4/4 time. You can however, place the nodes anywhere on the grid.

Try out different node placements to hear a wide range of rhythmic patterns. Before continuing with the tutorial, edit the network to return to the pattern shown above in figure c of step 11.

Changing Output Edges



- Add another edge by clicking on the *Node & Edge* tool ($\#-3$) then click, hold and drag from the middle of node c in the figure, to the middle of node b.

This produces a more complex series of node firings:

a, b, c, d, a, b, c, b, c, d ... etc

Node c has two output edges (or connections), which can be highlighted by clicking on the node with the *Selection* tool. These are designated with the colours orange and green. Each time node c fires the output edges are selected in sequence, orange, green, orange, green, ... etc.



- Click on the *Selection* tool and select node c. Then in the *Node* inspector double click on the orange square and click on the up arrow to change the value in the box to 2.

This will produce:

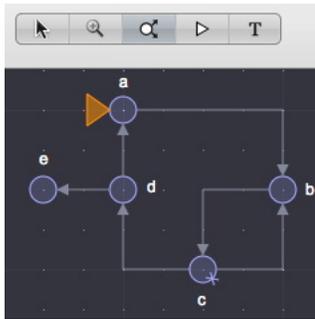
a, b, c, d, a, b, c, d, a, b, c, b, c, d ...

This is the result of node c outputting to orange twice then to green once.



- With node *c* still selected, change the signalling mode to *Random* as shown, in the *Node* inspector.

You will now hear a constantly changing pattern because the output from node *c* is selected randomly. Node *c* is now marked with an "x", indicating random signalling.



- Click on the *Node & Edge* tool and make a new node as shown above.

Notice that as soon as node *e* fires the sequence stops at a dead end. This is because there are no outputs from *e* to connect it to other nodes.



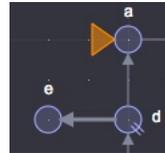
- Select node *d*, and in the *Node* inspector change the signalling method to *Parallel* as shown.

Node *d* is now marked by the parallel icon (circle with 2 parallel lines on the bottom right).

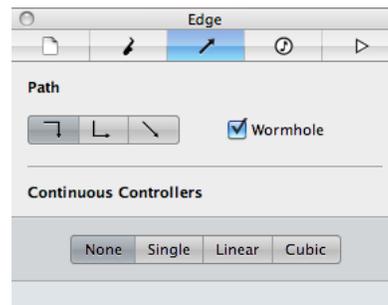


- Select node *e* and enter +12 into the *Note* list area. It is not necessary to enter velocity or duration values.

The parallel connection at node *d* results in both node *e* and *a* firing simultaneously. The loop is continuous again because the connections between *a*, *b*, *c*, & *d* are continuous.



- With the *Selection* tool, select the edge between *d* and *e*.



- Then in the *Edge* inspector select the *Wormhole* option.

- Press *Play / Pause* to run the program.

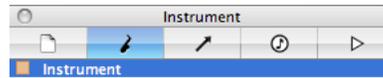
You should hear the network looping continuously again. Nodes *d* and *e* fire simultaneously, with node *e* sounding an octave above (+12 semitones) node *d*.

Normally the distance between nodes determines the time between notes. *Wormhole* edges however ignore distance and the connection across them is instantaneous. So the wormhole connection between *d* and *e* results in both nodes sounding at once with the pitch of node *e* sounding an octave above node *d*.

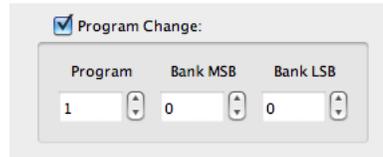
By setting the *Note* list for node *e* in 17 to +12 you specified a relative value in Nodal. A node with a relative pitch value will play with a pitch transposed up or down from the

pitch of the neighboring node that precedes it in the sequence. For MIDI pitch and velocity, relative values can be + or - any number of semitones within the MIDI range. You can mix absolute note values (e.g. C3, D#2) with relative values (+12, -5). Relative duration will be explained in section 6 Changing Duration pg 7.

Instruments and Voices



21. In the *Inspector* window, click on the *Instrument* icon, as shown above, and select the orange instrument.

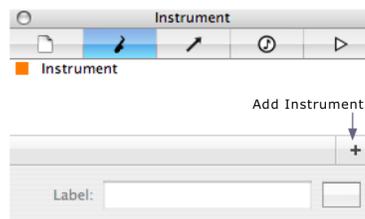


22. Select the *Program Change* option (towards the bottom of the inspector window) and highlight the *Program* number. Set this to your desired General MIDI instrument.

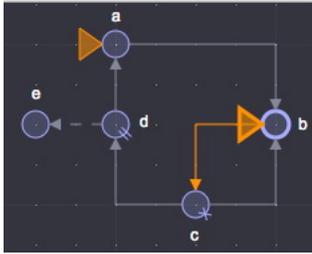
To see the interface for the Nodal synthesiser choose from the menu:

View > Show Synthesiser

This gives a menu of instruments and displays the current instrument for each MIDI channel.

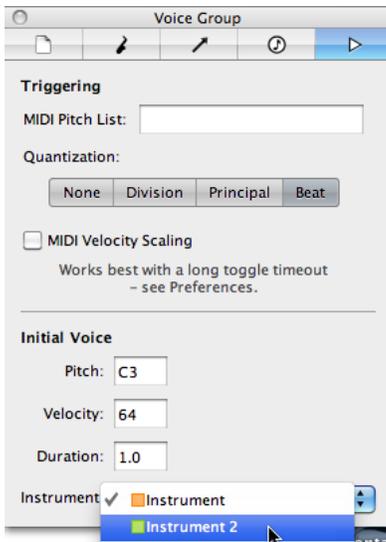


23. In the inspector window add a second instrument by clicking on the + button.
24. Select the new instrument (it should be called "instrument 2" by default). Then activate the *Program Change* checkbox and enter a program number that is different to the orange instrument.



25. Using the *Voice Group* tool, make another starting *Voice Group Triangle* as shown.
26. If the program is running, stop it by pressing the *Play / Pause* button. Then press the *Go to Start* button (to the left of the *Play / Pause* button).
27. Start the program again.

You should now hear a polyphonic texture with two parts playing simultaneously. In Nodal these parts are called voices. One voice starts at node *a*, and the other at node *b*.



28. With the *Selection* tool, click on the starting triangle for node *b*. Then in

the *Voice Group* inspector select instrument 2 as shown.

29. Stop, go to start, and restart the program.

You should now hear the two starting voices with two different instrument sounds.

Changing Velocity and Duration



30. Select node *d* and change the *Note* list in the inspector to the values shown above.

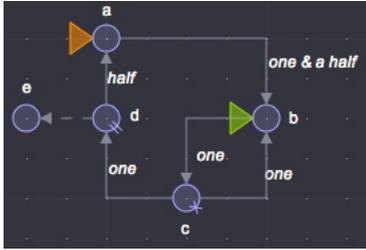
As the program plays, the notes that are generated by node *e* have a longer duration than other notes. Their loudness (note-on velocity) switches between being softer (-20) and louder (+20).

Notes are specified by a pitch value, followed optionally by velocity and duration values, separated by a ':'.

Note duration is, by default, set to 100%. This is a relative value that relates to the output edge length. For example, the duration of notes made by node *a*, are 100% of the distance/time between *a* and *b*. Beats are represented by lines in the background grid, so we can see that the distance between nodes *a* and *b* is one and a half beats.

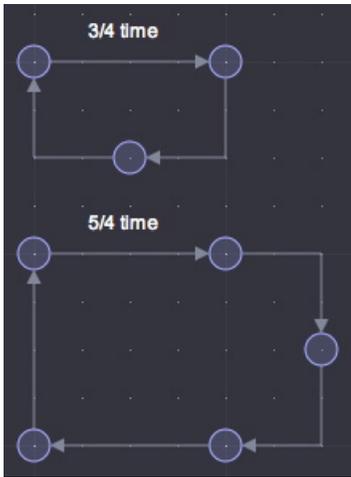
The duration for notes made by node *e* however, is now set to 4. This is a fixed value and designates 4 beats. Changing output edge length does not change the duration time with such a fixed value.

You may have noticed that the edges can only snap to vertical or horizontal orientation. This limitation automatically quantises distance/time to units of full beats.



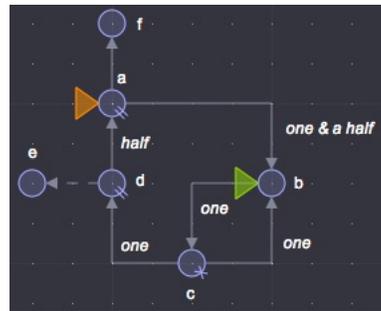
The smaller grid units represent subdivisions of the principal grid. Therefore in this tutorial, a beat can be sub-divided into 4 grid units. To calculate the duration of an edge, count the total number of grid units it traverses. For example the distance from node *a* to node *b* is 4 horizontal grid units and 2 vertical units. This gives a total of 6 units or 1 and a half beats. If you hover the cursor over an edge its length will be given in both principals (beats) and divisions (divisions of beats).

With a little thought, it is possible to create networks for all time signatures. For example, 3/4 and 5/4 time signatures are shown below.

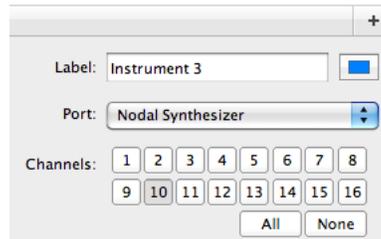


You can also hide the grid display (\mathbb{N} -') and even turn off the grid-snapping feature (Shift \mathbb{N} -'). Both these options are in the View menu.

Instrument Change



31. Create a new node connected to node *a* as shown. Set the signalling for node *a* to *Parallel*.



32. Create a new instrument (click on the + button in the *Instrument* inspector).
33. Set the MIDI channel for this instrument to 10.

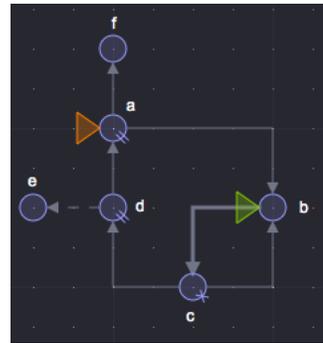
It is possible to assign more than one MIDI channel to a single instrument, so in this case make sure that only 10 is selected.



34. Select node *f* and, in the *Node* inspector, set the *Note* list to: F1 G1 A1 B1 (there is no need to enter velocities or durations).
35. Then activate the *Instrument Change* checkbox and select Instrument 3 from the menu, as shown above.
36. Stop, go to start and play the program.

You will now hear a tom-tom percussion part that is triggered by node *a*. This is caused by the use of the *Instrument Change* feature that was set for node *f*. You may remember that a voice is an aspect of a *Voice Group* that traverses a network producing notes with an assigned instrument. *Instrument Change* swaps the instrument associated with a voice to a new instrument. This means that once a voice has encountered an *Instrument Change* command it will retain that new instrument when it continues on to other nodes. This instrument remains until another instrument change command is received.

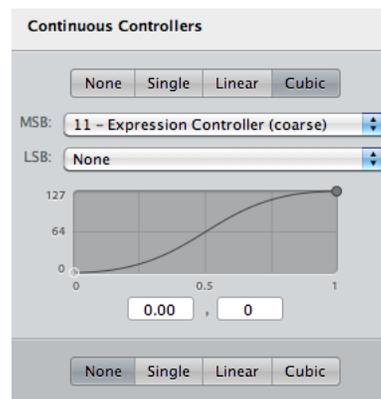
Continuous Controllers



37. Select the edge from *b* to *c* as shown above.

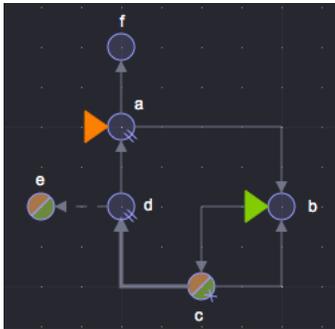


38. In the *Edge Inspector*, click on the *Cubic* tab in the *Continuous Controllers* section.

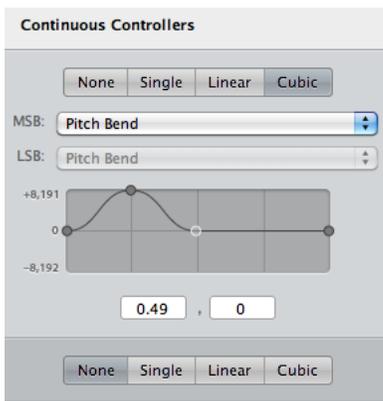


An editing interface for continuous control will appear as shown above.

39. Select controller no. 11, Expression Controller in the MSB menu.
40. Change the controller value curve as shown above by dragging the handle on the right of the editor up to the top of the edit space.



41. Select the edge from node c to d.



42. Create a new control editor and select Pitch Bend as shown above.

43. Edit the control curve as shown.

To do this you will need to create new handles. This can be done by clicking in the edit space. Handles can be deleted by selecting them and pressing the delete key.

44. go to start and play the program.

You should be hearing a note that fades in every so often (this is the result of the expression controller) and other notes that have pitch bend. The duration of the control curves matches the length, in time, of the edge to which they are associated.

Nodal allows you to add as many additional controllers to each edge as you want. Two-byte and single byte controllers are supported. Control messages are sent in the order specified.

Voice Triggering

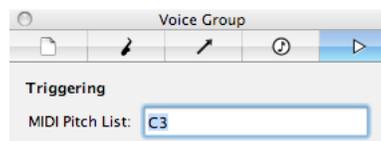
Voices can be turned on and off independently of the play button. This functionality is similar to that of *clips* in Ableton Live which can be triggered in real-time. There are two ways that voices can be triggered; 1) using the mouse and 2) using a MIDI note message. MIDI note messages will not be covered in this tutorial however information about triggering using MIDI note messages is given in the Reference section, see pg 20.

45. Start Nodal running (using either the start button in the transport section or the space bar).

46. Check that the Selection tool (#-1) is selected (this is the arrow cursor).

47. Option-click (Mac) or Alt-click (Windows) on a *Voice Group Triangle*.

You will notice it is possible to turn off voice groups and then turn them back on using step 47. This method is designed assuming that voices should be active when Nodal is started however it may be the case that it is preferable to start voices only by triggering them. In order to do this *Voice Group Triangles* must be designated as triggering. Triggering *Voice Group Triangles* will only start or stop in response to mouse clicks or to MIDI note messages.



48. Select a starting triangle and in the *Voice Group Inspector*, enter a MIDI pitch value (C3 for example) in the MIDI Pitch List field as shown above.

49. Press the play button (or spacebar).

Notice that the voice group you selected in step 48 is not active when Nodal is playing. By entering in the MIDI pitch value in the triggering section the voice group was designated as triggering. The voice group will be active when a MIDI note with the designated pitch value is sent to Nodal. This design assumes that triggering will mostly be done with MIDI note triggers, however mouse clicking also works in this scenario.

50. With Nodal still running, Opt-click or Alt-click on the designated *Voice Group Triangle*.

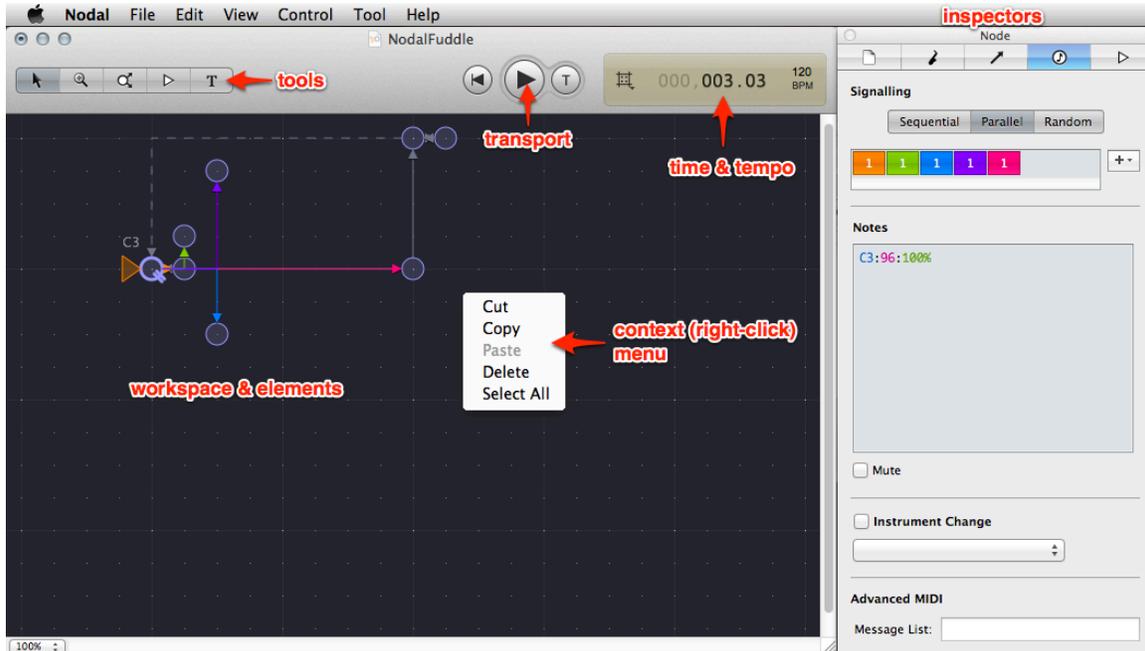
The actual time when a voice group is triggered defaults to being quantized to

the next beat. The quantization can be changed to different temporal resolutions in the *Voice Group Inspector*.



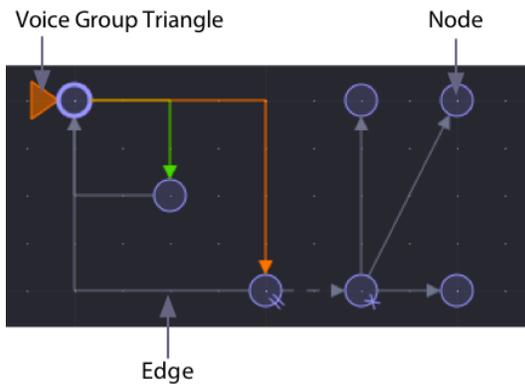
51. Try triggering voice groups with different quantization settings by selecting them in the *Voice Group Inspector* shown above.

Reference



Overview of the Nodal interface.

Basic Elements and Concepts



Voice and Voice Group

A voice is a singular entity within a *Voice Group*. A voice moves through a network that is created in Nodal. The path taken is determined by the connections, or *edges*, between *nodes* in the network. Nodes are indicated by circles, and edges are shown as lines with arrowheads which indicate direction of travel. The start of a journey

by a voice is indicated by a *Voice Group Triangle*.

Voice groups may have more than one voice if there is more than one starting point allocated to that particular group, or if a voice passes through a node with parallel connections, causing two or more voices to be spawned.

Voices trigger MIDI messages specified by the values stored in the nodes and edges of the network they are traversing. These messages are then passed to a designated *Instrument*, which is associated with the voice's *Voice Group*. When a voice visits a node, the node fires and lights up in the colour corresponding to its *Voice Group*.

By default all voices are activated when play is on. However their play state can also be turned on and off independently of Nodal's play state by various methods including external MIDI note triggers. In this way, voices function like clips in

Ableton Live. See pg 18 for details about voice triggering.

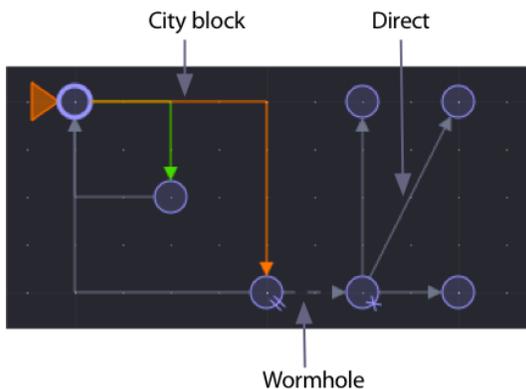
Node

A *node* is an object that generates MIDI events when it fires, typically a note on event. Parameters that determine the pitch, velocity and duration of the note are located in a node. The instrument that sounds a note is governed by the voice that visits the node. One exception to this is where a node is set to *Instrument Change* mode. This will force a voice passing through a node to associate with a particular instrument (which is essentially defined as the MIDI channel that note data is sent through).

It is possible to view the number of times a node has fired by choosing in the menu:

View > Show Node Counters

Edge



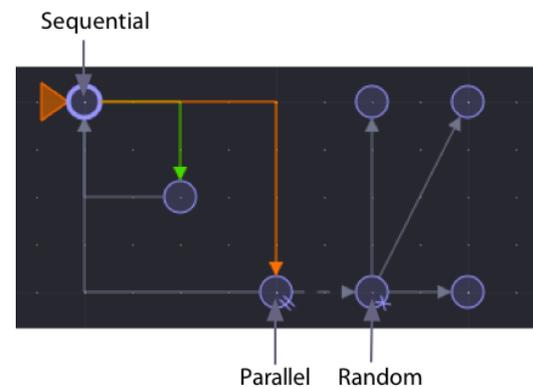
An *edge* signifies the duration in time between two note events. It also signifies the pathways by which voices traverse a network of nodes. In Nodal an edge is a one-way connection between two nodes (for bi-directional connections, two edges are required). The duration between note events is proportional to the length of the currently active edge. To identify them, edges are assigned a colour. Edge colour does not relate to voice colour. There are three types of edge:

- *City block*: here the edges are given corners so that their length quantizes with the grid divisions.

- *Direct*: the shortest path between two nodes.
- *Wormhole*: an instantaneous connection.

Like nodes, edges also generate MIDI information. This takes the form of continuous controller and pitchbend data, which are specified in the edge inspector. As the length of an edge defines the time between notes, it is also used to define the duration of continuous controller or pitchbend changes.

Signaling

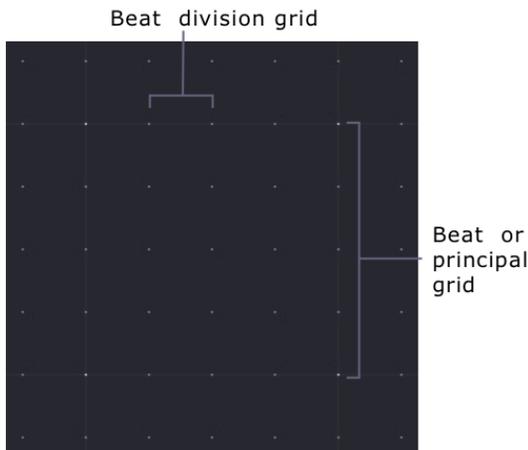


When a node fires the voice then passes to a new node that is connected by edges to the firing node. If a node has more than one output edge, one or more of them must be selected by rules within the node. This is called signaling. There are three possible signaling methods:

- *Sequential*: output edges are selected according to a fixed sequence.
- *Parallel*: all output edges are selected simultaneously. This spawns more voices.
- *Random*: one output edge is selected at random.

For more information see Inspectors / Node pg. 24.

Time and Space



Time in Nodal is equivalent to distance. The edit space can be divided according to a grid. The grid has *principal lines* and *divisions*. The distance between two principals is equivalent to one beat. The ratio between principals and divisions can be set in the *Document* inspector.

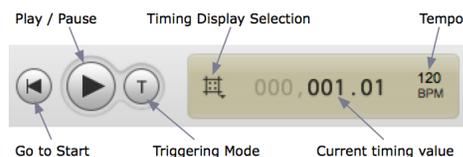
By default, nodes entered into the edit space automatically snap to the nearest grid point. Similarly, edges snap to grid points with city block edges. This ensures that note timings are quantised to the grid time.

It is possible to turn off the *Snap to Grid* function, choose:

View > Turn Snap to Grid Off.

This will lead to timings that are not referenced to a pulse or meter. The tempo value still holds however as it represents the time for a principal. But edge timings will not necessarily consist of whole number ratios of the beat or principal.

Transport and Timing



Go to start

Returns the network state to the initial state:

- Click the *Go to Start* button

Play / Pause

Toggles between play and pause modes:

- Click the *Play / Pause* button or press the *Space bar*

Play runs the network from the current state. Pause suspends playback but does not change the state of the network.

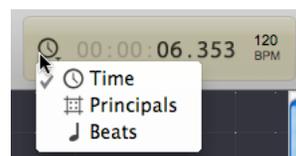
If Nodal is configured for MIDI synchronization in slave mode then playback will commence automatically when the master application starts. Conversely Nodal can act as a timing master which will cause slaved software to start playback. For more information on synchronisation see pg 34.

Triggering Mode

The *Triggering Mode* button turns triggering mode on and off. In *Triggering Mode* Nodal will receive MIDI note messages as triggering information. *Voice Group Triangles* can be assigned a MIDI pitch value, and if this pitch is received as an incoming MIDI note on message, the voice group associated with the starting triangle will start to play. If a note off message with the same pitch is received the voice group will stop.

In *Triggering Mode* node editing is switched off. This is to avoid confusion that may result from the fact that MIDI note input is also used for node editing. For more information about triggering see pg 18.

Timing Display Selection



This is a menu than provides for three different timing types:

- Time (clock time) in:

Hours : Minutes : Seconds .
Milliseconds

- Principles (elapsed principle durations):

Principles . Beats

- Beats (elapsed beat durations):

Beats elapsed since play began.

Current time

This value indicates the amount of time that the network has advanced since its beginning. Time is specified in minutes, seconds and milliseconds (not ticks). This reflects the fact that Nodal can operate outside of metrical time when the snap to grid function is disabled (see Time and Space below).

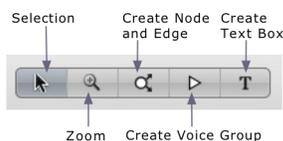
Tempo

To enter a tempo value:

1. double-click on the number specifying beats per minute
2. type in a new value.

Tempo values can also be entered into the *Document* inspector (see pg 24).

Tools



Selection

This tool is used to select objects in the edit space including: nodes, edges, *Voice Group Triangles* and text boxes.

To make a single selection:

- click

To make a multiple selection:

- click and drag

To make multiple discontinuous selections:

- Command-click (Mac) or,
- Control-click (Windows) or,
- Shift-click

Multiple selection enables the simultaneous entry of all node and edge parameters in the inspectors (except for continuous controllers). This is very useful for real-time improvisation.

Zoom

To zoom in:

- *Zoom* tool and click or,
- Command + (Mac) or,
- Control + (Windows)

To zoom out:

- *Zoom* tool and Option-click (Mac) or,
- *Zoom* tool and Alt-click (Windows) or,
- Command - (Mac) or,
- Control - (Windows)

To return to the default view, choose:

View > Actual size

Create Node and Edge

This tool has multiple functions.

To make a single node:

- click in the edit space.

To make a new node connected with an edge from an existing node:

- click and drag from the existing node.

The direction of the connection is from the old node to the new node.

To make an edge between two existing nodes:

- click and drag from one node to the next.

The connection will be confirmed by a green ring around the second node.

Note that when creating city block edges it is possible to flip them over by holding down the Shift key before the mouse is released.

Create Voice Group

The *Voice Group Triangle* indicates the starting node for a voice when the program is run.

To attach a *Voice Group Triangle* to a node:

- click on a node.

An instrument can then be associated with the *Voice Group Triangle* by selecting in the *Voice Group Inspector* (see pg 15).

Create Text Box

To create a text box:

- Click then enter text by typing.

To change the font attributes:

- select the text with the text tool,
- right click or ctrl-click (Mac), Alt-click (Windows) to call up a contextual menu

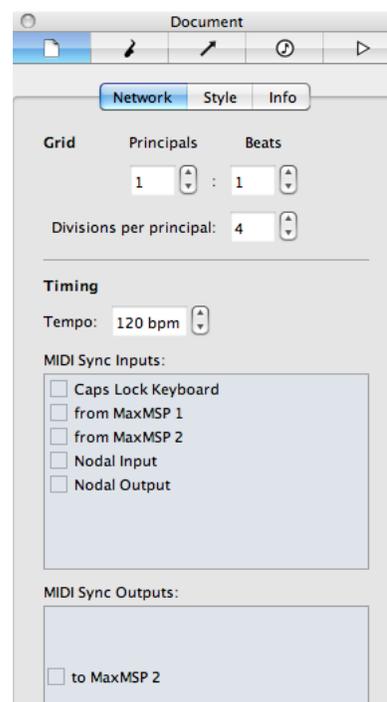
- select options from the *Font* submenu

Inspectors

Inspectors can be selected by clicking on the tabs at the top of the Inspector window. Inspector selection also occurs automatically based on context.

Document

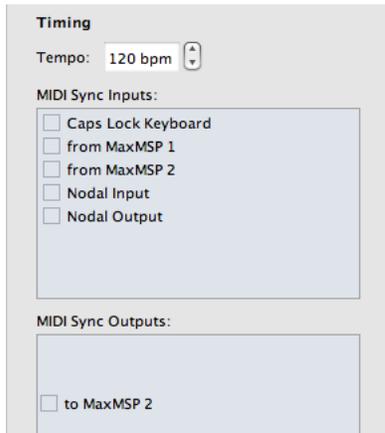
The *Document* Inspector has three tabs; *Network*, *Style* and *Info*:



In the *Network* tab under the heading: **Grid**, the relationship between principals and divisions can be set. By default, 1 principal equals 1 beat. However this relationship can be set to any ratio. For example, it is possible to have 2 principals to 1 beat or 1 principal to 2 beats.

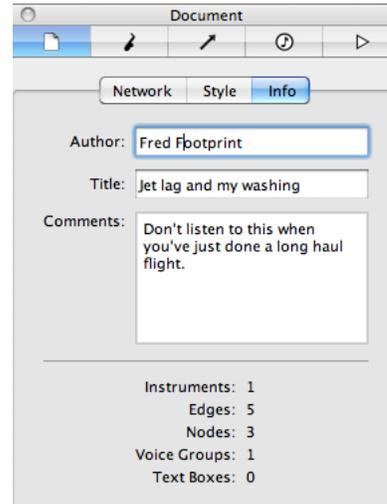
The number of divisions of a principal can also be set. This allows for compound time divisions to be created. The number of divisions can be changed without affecting the position of nodes that have already been placed in the edit space. This

is because the snap to grid function only works on newly created or moved nodes.

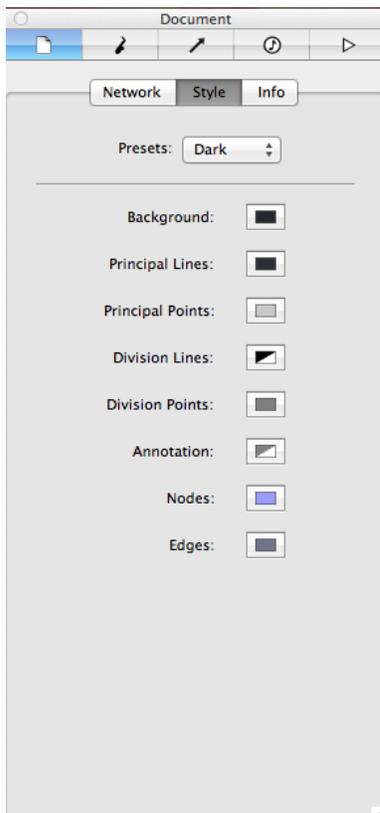


In the *Network* tab under the heading: **Timing**, the tempo, in beats per minute may be set. Also ports for MIDI synchronization may be allocated. For more information about MIDI synchronization see pg 34.

elements in Nodal to be assigned to the colours you choose. Some colour settings also contain a transparency value. There are two presets in the menu in the inspector. These are *Dark* the Nodal default and *Light* which was the default in earlier versions of Nodal.

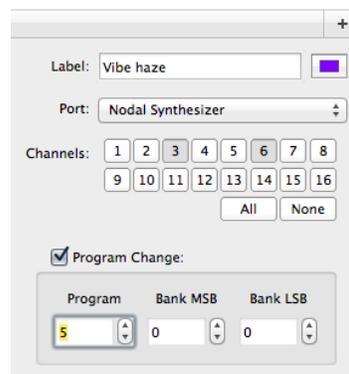


The *Info* tab has fields for *Author*, *Title* and *Comments*. In addition it supplies information on the composition of the network.



The *Style* tab contains a series of colour pickers. This enables various visual

Instrument



Instruments can be created and assigned in the *Instrument* inspector. To create an instrument:

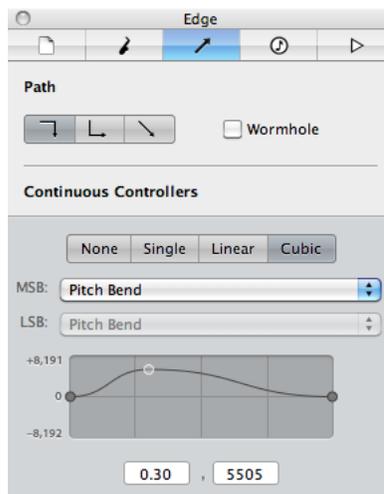
- click on the + button.

When a new instrument is created it will automatically be assigned the lowest available MIDI channel. These parameters can be changed by clicking the MIDI channel buttons and selecting the Port menu. Similarly, instrument names and colours are automatically generated when an instrument is created. These can also be edited. You can give each instrument a more descriptive name (e.g. Piano, Bass Guitar, Melody, etc.) by changing the text in the *Label* box.

Specific MIDI program change values can be assigned to an instrument if required. Bank messages can be assigned as well.

Note that more than one instrument can be selected using shift select methods. This is useful for setting all instruments to the same MIDI port or to the same MIDI program number.

Edge



This inspector is active only when an edge has been selected using the *Selection* tool, or when a node has been created using the *Create Node* and *Edge* tool. Edits made in this inspector apply to any edges that have been selected or created with the exception of continuous

controller information which must be entered on an object by object basis.

The **Path** section enables *City Block*, *Direct* and *Wormhole* edge types to be selected. There are two options for the city block edge, enabling you to flip over the direction of the bend in the edge. This can sometimes make the layout of a network easier to see, without changing its behavior.

In the **Continuous Controllers** section it is possible to send one or more continuous controller (CC) or pitchbend MIDI messages. The MIDI channel for these messages is the channel of the instrument assigned to a voice group. Note that in cases where a voice group has more than one voice and where a network might have a number of edges with controller curves, it is possible to generate conflicting controller messages. Note also that the *Mute* function does not stop pitchbend or CC messages being sent.

There are three types of controller messaging:

- *Single*: creates a single CC message that is sent *prior* to the MIDI note on message. This is useful for CC messages such as pan, volume or sustain;
- *Linear*: enables linearly interpolated values drawn as lines. Messages are sent continuously as the edge is traversed, with the value changing according to the distance along the edge;
- *Cubic*: enables cubic interpolated values drawn as curves. Messages are sent continuously as the edge is traversed.

To select a messaging type:

- Click on either the: *None*, *Single*, *Linear* or *Cubic* tabs in the **Continuous Controllers** section of the *Edge* inspector.

Clicking on the *Single*, *Linear* or *Cubic* tabs will create an edit space in which you can designate the CC type and draw the curve or line in the case of *Linear* and *Cubic*. Clicking on *None* will remove the existing type from the *Edge* inspector.

Nodal has the facility to send high resolution CC and pitchbend values by combining *Most Significant Byte* (MSB) and *Least Significant Byte* (LSB) MIDI messages. The default is to send CC messages at normal resolution by using MSB messages only.



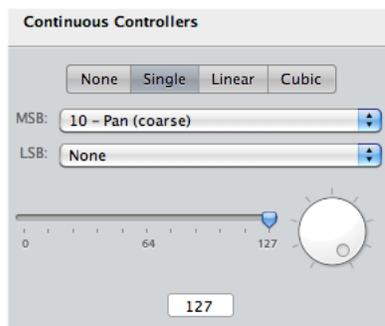
To send normal resolution CC messages:

- select the MSB CC type for the MSB menu only



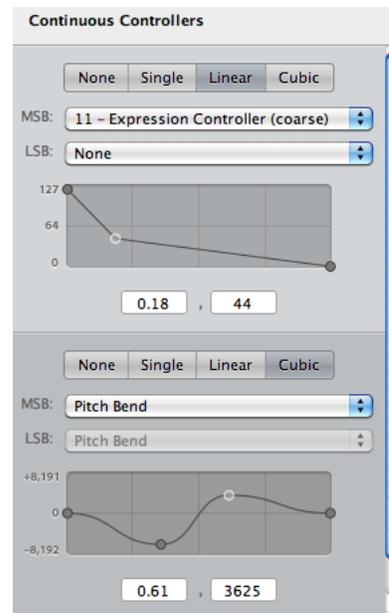
To send high resolution CC messages:

- select the MSB CC type for the MSB menu, then:
- select the corresponding LSB CC type from the LSB menu below.



To enter a value in the *Single* inspector space:

- Click and drag either the horizontal slider or the rotary dial, or:
- Type in the value and the number box below the slider, or:
- Using an external MIDI controller, send the CC value to Nodal. This works so long as the slider, dial or number box is selected.



Interpolators in the *Linear* and *Cubic* inspector spaces are made from lines or curves that can be edited by moving the control points. The duration of the interpolator will be the same as that of the edge to which the curve is associated.

To move an existing handle:

- Click and drag the handle (horizontally for its placement in time and vertically to set the CC value), or:
- Select the handle and using an external MIDI controller, send the CC value to Nodal.

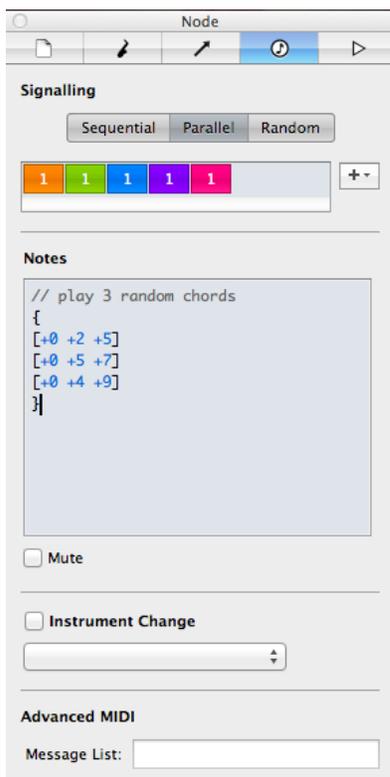
To create new handles:

- Click in the line or curve edit space.

To remove handles:

- Select a handle by clicking on it then
- Press the delete key

Node



The *Node* inspector is active only when a node has been selected or created. Edits made in this inspector apply to all nodes that are selected, or a node that has just been created.

The **Signalling** menu allows a choice of three signalling methods:

- *Sequential*
- *Parallel*
- *Random*

Sequential signalling selects output edges according to the sequence given by the coloured tiles below the Signalling menu. The tiles appear in the order in which the edges were made. Numbers in the tiles refer to the number of times the output edge will be traversed before the next output edge is traversed. In the figure given above, the sequence is orange 7 times then green once. This pattern is then repeated. The order of the tiles can be changed by clicking and dragging them. More tiles can be added by clicking on the + button to the right of the tile field.



In *Random* signalling the output edges are chosen with a probability weighted by the numbers written on the tiles. In the example given above the aqua output is 7 times more likely to be selected than the orange one.

The *Parallel* signalling method sends a voice along all output edges, thus spawning multiple voices. The tile field order does not affect output when parallel signalling is selected.



The **Note** section of the *Node* inspector allows the entry of pitch, velocity and duration sequences. Notes can be edited by typing, or by using a MIDI keyboard.

The format for specifying a note is simple:

NOTE : VELOCITY : DURATION

The VELOCITY and DURATION components are optional. Specification may be absolute or relative, so the following are all valid note specifications:

C3 C3:55 C3:55:150%

+5 -12:96:*2 +0:-10:50%

Relative and absolute values can be mixed in a single note specification. For pitch and velocity, relative values are added or subtracted (+ or -). For durations, relative values may also be multiplied or divided.

If you don't specify a velocity or duration, the current value of the playing voice is used. For starting nodes, the default value is specified in the *Initial Voice* settings in the *Voice Group* editor.

You can also group notes together by placing brackets around them. Different brackets allow notes to be played sequentially (round brackets '(')'), in parallel (square brackets '['') or randomly (curly brackets '{')'). Brackets may be nested to as many levels as you need. Some examples:

[C3 E3 G3] // play a C major chord

{+0:30 +0:60 +0:90 +0:120} // play the previous pitch with velocity randomly selected from the values shown

(+3:100:100% +5:100:200%
+7:100:400%) // play the three notes sequentially with relative pitch increases of +3, +5 and +7 semitones and increasing durations

{
 [+0 +3 +5] [+0 +5 +7] [+0 +7 + 12]
} // randomly play from the 3 specified relative chords.

For relative chord sequences the first pitch in the list becomes the new pitch for the voice traversing the node, so in the example above it remains unchanged (since the first element of each chord is always +0).

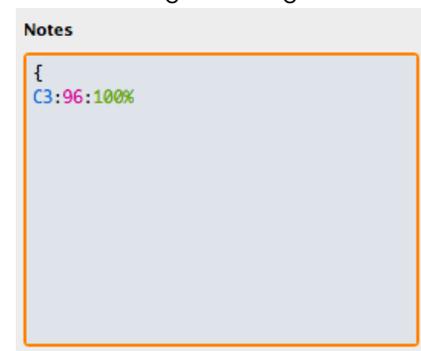
With the addition of scales in voice groups (see page 30), +0 or -0 relative offsets will always 'snap' to the closest legal note for the chosen scale. In the case of a tie the direction of snapping (up or down) will be

determined by the prefix: +0 always snaps up in pitch, -0 always snaps down.

Notes listed without brackets are played sequentially.

You can enter comments for a line in the Note entry by prefixing them with // (like comments in Java or C++). This can be useful for documenting specific sequences, or in a live performance when you want to turn different sequences on or off quickly.

While you enter note sequences, your list is continuously parsed and checked if it is valid. Notes will be automatically changed to upper case, but you can enter them in upper or lower case. An invalid sequence will cause the *Notes* list border to flash with an orange rectangle.



In the example above the closing '}' bracket is missing (notice the orange rectangle indicating the error). As soon as a correct note list is entered, it is activated for that node and will be used when playing (there's no need to hit RETURN or any other key).

The Note editor also has syntax colouring and auto-completion (hit the TAB key to add default velocity and duration fields).

You may be interested to know that internally Nodal takes your note sequences and turns them into a self-contained Nodal network, with the entire network represented by a single node.

You can also enter notes using a MIDI keyboard. To enter notes sequentially,

play them one at a time. To enter chords hold down the chord as you would normally play it.

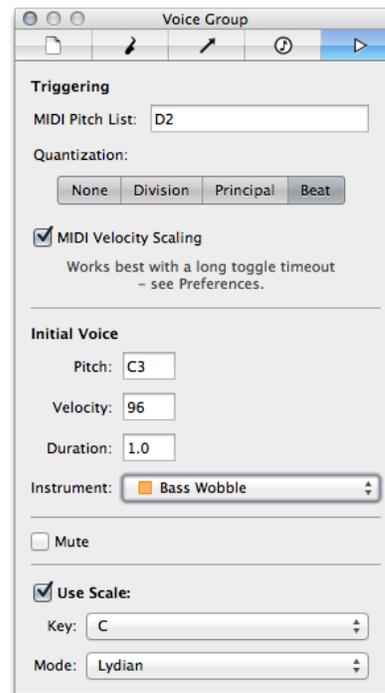
There is also a **Mute** option that mutes the node so that it doesn't sound but it is still active. Note that the *Mute* function does not stop pitchbend or CC messages being sent.

The **Instrument Change** feature forces a voice passing through a node to adopt a particular MIDI instrument. The instrument can be set using the submenu to the right of the checkbox. This associates the voice with a new voice group, ensuring that the voice retains its new voice group and instrument when visiting other nodes in the future.

The *Message List* in the **Advanced MIDI** section enables raw MIDI messages to be programmed. This can be used to send custom MIDI messages such as system exclusive messages. Values are entered using hexadecimal notation, with each value comma separated (e.g. 0xf0,0x42). The box will flash red if you attempt to enter a value that is not recognized. When a voice visits a node, these lists are read, and transmitted to the instrument associated with the voice in sequence. Appendix 3 (pg. 39) and appendix 4 (pg. 40) give decimal to hexadecimal conversion and MIDI message information respectively.

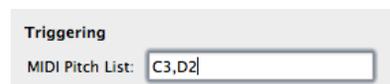
You can turn on display of the last note played by each node using the following menu selection: *View > Show Node last Note(s) Sent*

Voice Group



The *Voice Group* inspector is active when a *Voice Group Triangle* is selected or created. Its primary function is to enable an instrument to be associated with a *Voice Group*. Additionally, triggering and scale settings can be made here also.

In the **Triggering** section a *Voice Group Triangle* can be assigned one or more MIDI pitches that are used to turn the voice group on and off independently of the play button. Note that this feature is only active when in *Triggering Mode* (see pg. 18)



To assign triggering pitches:

- Click in the *MIDI Pitch List*
- Type in the pitch values (comma separated if more than one), or:
- Send the pitch values from an external MIDI source (such as a keyboard or pad controller).

Note that more than one pitch can be assigned for triggering.



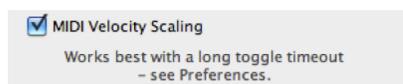
Incoming triggering messages can be quantized to various timing resolutions:

- **None:** no quantizing, triggering occurs as soon as the trigger note or click is received;
- **Division:** triggering is delayed until the next grid division;
- **Principal:** triggering is delayed until the next grid principle;
- **Beat:** triggering is delayed until the next beat.

To select triggering quantization:

- Click on the *Quantization* tabs in the **Triggering** section of the *Voice Group Inspector*.

The note velocity for incoming MIDI triggers can be used to scale the velocity playback of the triggered voice. This means that is you can trigger a voice to play anywhere from soft to loud depending on the velocity of the incoming trigger note.



To turn on *MIDI Velocity Scaling*:

- Click on the *MIDI Velocity Scaling* check box in the **Triggering** section of the *Voice Group Inspector*.

There are two methods for triggering voices:

- *Switch triggering:* where a MIDI note on will turn on a *Voice Group*

Triangle and a note off message will turn it off, or:

- *Toggle triggering:* where MIDI notes with short durations turn a *Voice Group Triangle* on and off. Also Opt-clicking (Mac) or Alt-clicking (Windows) on a *Voice Group Triangle* function as toggle triggers.

The maximum duration of notes that are recognised by Nodal as toggle triggers can be set in the Preferences window (see pg. 34). The default *Triggering toggle timeout* is 200 ms.

To turn on a voice using normal triggering (assuming Nodal is running and is in *Triggering Mode*):

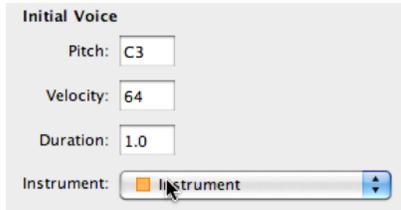
- Send an external MIDI note on message with a corresponding MIDI pitch value.

To turn off a voice using normal triggering:

- Send an external MIDI note off message with a corresponding MIDI pitch value.

To toggle a voice on or off (assuming Nodal is running and is in *Triggering Mode*):

- Send an external MIDI note on message for which you have assigned a MIDI pitch value in the *Triggering* section of the *Voice Group* inspector, and then, within the *Triggering toggle timeout* period, send the corresponding note off message. Or:
- Opt-click (Mac) or Alt-click (Windows) on an assigned *Voice Group Triangle*

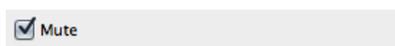


In the *Initial Voice* section there are fields for setting initial note parameters in the case where adjoining nodes are set to relative note parameter values. For more information about relative note parameter values see the tutorial pg. 14.

Pitches for the initial voice are normally specified as absolute notes (e.g. C3), however it is possible to specify an initial pitch in terms of the current scale key (see below).

Instead of setting an absolute pitch, you can set a relative start pitch, specified by a positive or negative number. This number represents the number of notes in the current scale from the middle root key note. So for example if your scale is set to C Major and the Initial voice Pitch is set to +4 the actual initial pitch will be G3. If you change the key to A, the initial pitch will be E3.

This allows you to write a Nodal composition using relative offsets in a particular key and mode and then easily change key or mode without having to change any pitches.



The mute checkbox mutes all MIDI information being sent by the selected voice group. The voices will continue to traverse the network allowing you to temporarily silence particular instruments or groups of instruments.

As a shortcut, you can also mute a voice group by right-clicking on the voice group icon and selecting "Mute" from the context menu.



Muted voice groups are displayed with a dashed outline as shown above and individual voices highlight the nodes with a striped pattern (rather than a solid colour for non-muted voices).

Scales

You can confine the notes played by any voice group to a specified *scale*, consisting of a root *key* and *mode*.



When this option is activated any relative notes specified by an offset will operate within the chosen scale. You can change the key or mode, even while a composition is playing, for interesting harmonic effects.

Note that the scale option only affects relative pitch information. If you want to play a note outside the scale, specify an exact pitch (e.g. C3, D2, F#1, etc.) as these will not be affected by the Scale settings.

A number of different modes are provided, and selected modes are always saved with your file so are transportable between platforms and versions of Nodal.

Editing

All editing may be performed while Nodal is running. This includes the creation of nodes and edges, repositioning nodes, and the editing of all parameters. Most editing can be done on a single selection or simultaneously on multiple selections. Editing is suspended however when Nodal is running in triggering mode.

Note Parameter Types

MIDI pitch and velocity parameters can be set to any valid specified value. For pitches these are C-2 to G-8 and for velocity the values are 0 to 127. Accidentals are only notated as #. Hence C#3 is possible but Db3 is not. Pitch and velocity can also be set as relative values in semitones, such as -1 or +12. These values are relative to the pitch or velocity of the last node that the voice visited. For example if a voice visited a node that produced the pitch C3 and then a node with an incremental pitch value of +12, the pitch that will be produced is C4, 12 semitones or an octave above the previous pitch.

Default duration values are set to a percentage of the time between note events as determined by edge length. As there may be more than one output edge from a node, and each may have a different length, it is useful to set note duration proportionally to edge length. Relative percentage values can also be set, e.g. -20% or +5%.

Duration can also be set to a fixed value. The unit of measurement applied here is the principal which, in most circumstances, is equivalent to a beat. For example a value of 2 will produce a note of 2 beats/principals regardless of any edge length. Fixed duration values less than a principal are notated with a decimal point. For example .5 is half a principle and 1.5 is 1 and a half principals. Relative fixed values can also be set, e.g. -0.1 or +0.1.

It is possible to format parameter lists with a mixture of fixed, percentage and incremental values.

Keyboard Entry and Lists

Pitches and velocities can be entered using a MIDI keyboard (see pg. 34 for information on setting the MIDI input port). Nodes can receive pitch and velocity information if they are selected or when they have just been created. All nodes receive the same information when they are selected simultaneously via multiple selection.

Playing a single note enters a value for a single pitch and velocity (as absolute values). Playing a chord will enter all pitches and velocities for the notes in that chord, at once.

To add to an existing pitch or velocity list:

1. hold down Shift then
2. play a note or chord on the MIDI keyboard.

To enter only pitches or only velocities:

- click on the respective field in the node inspector.

Shift note entry also works when a single field has been selected.

Continuous Controllers and Edges

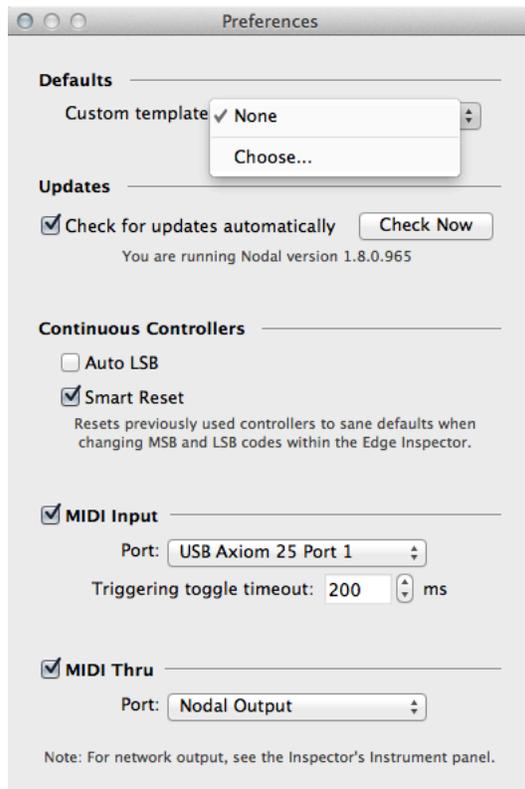
Contextual Menus

Many settings and parameters found in the inspector windows are directly accessible in the edit space using contextual menus. These can be accessed by selecting the object that you wish to edit, then right-clicking the mouse.

Cut, Copy Paste and Undo

You can apply these operations to any object or multiple selection in the edit space. It is possible to copy and paste between documents.

Preferences



Defaults: Custom templates

It is possible to make templates that can load automatically each time a new document is created. To create a new template:

1. Create a new file and add changes that you desire (such as Instrument configurations, a default starting network, or sync settings).
2. Save the file. You may wish to call the file something like " *my template*".

To designate a file as a template:

1. Open the *Preference* window,
2. Click on the *Custom template* menu and select *Choose...*
3. Navigate to the file you wish to use as a template and *open*.

The designated template file will load each time a new document is created. This file will remain "Untitled" until you save for the first time.

MIDI Input

The MIDI input port for keyboard entry is set in:

Nodal > Preferences

A MIDI thru port can be set which enables a sound to be heard when entering note values with the keyboard.

MIDI Communication in Windows

Nodal creates its own MIDI ports, *Nodal Input* and *Nodal Output*, which can be used to drive external synths and communicate with DAW software such as Logic Studio or Ableton Live (see the next section for details on how to synchronise Nodal with your DAW).

MacOS has built-in support for inter-app MIDI communication, so these ports should appear automatically in any other MIDI applications.

Windows does not have native support for inter-application MIDI, but this is easily addressed by installing software such as *MIDI Yoke* (<http://www.midiox.com>). This utility provides "virtual patch cable" support to connect MIDI from different applications together. Once installed the *Nodal Input* and *Nodal Output* ports should be visible to other applications

MIDI Synchronisation

Nodal can synchronise timing events with another MIDI application either as a *slave* or *master* timing reference. In *Slave Mode*, Nodal will receive tempo and time position from a host application via designated MIDI ports. *Master Mode* is the opposite to

slave, but it requires the slaved software to be specifically set for external synchronization.

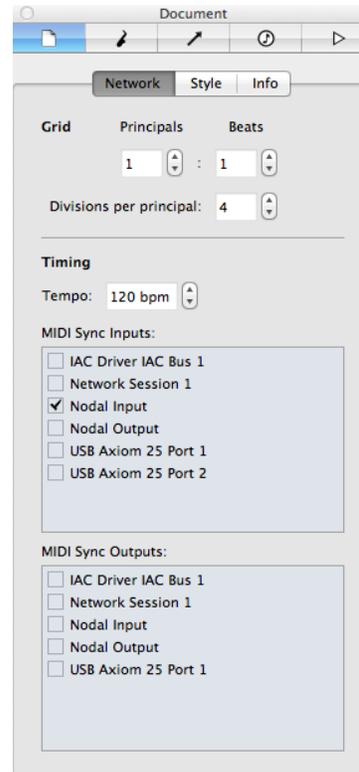
Most DAW software will send and receive MIDI sync and the process for setting it up should be relatively simple. In most cases it is desirable to run Nodal as a slave. You can also synchronise two or more copies of Nodal running on different computers, during a live performance, for example.

Sync Settings in Nodal

To set Nodal for incoming synchronization:

1. select the document inspector,
2. select the *Network* tab,
3. click a check box in the MIDI Sync Inputs field corresponding with the desired MIDI port.

Unlike many DAWs where an external sync mode must be specified, is not necessary to make any settings other than those given above. If Nodal receives sync messages in the designated port it will automatically go into slave mode.



MIDI output ports, for sending synchronization messages, can also be set in the *Document Inspector* in the *MIDI Sync Inputs* field.

On the Macintosh platform it is possible to sync two copies of Nodal running on two different computers. This is done by connecting them using the *Network* ports in Nodal. These ports can then be connected over a computer network using Core MIDI.

Please note that due to the non-deterministic nature of Nodal's MIDI generation (e.g. random nodes), seeking to a particular time may not necessarily result in the same notes being played each time. For this and other reasons, Nodal will always give highly accurate sync, but may not necessarily respond to seek messages in the way that DAW or linear editors do.

Sync Settings in another program.

As an example of how to set up software acting as the Master sync source, the correct settings and processes for Ableton Live are given below. While the

terminology may differ in other applications these differences usually are minor.

To send sync from Live to Nodal:

1. Make sure both Nodal and Live are open.
2. Open the *Preferences* window in Live.
3. In the *MIDI Ports* section, for the Live output port labelled *Nodal Input* click the *Sync* box, as shown below.



This will enable Live to send MIDI sync to Nodal. When play is activated in Live, Nodal will start in sync. There is an option to set a delay value. MIDI sync has a delay inherent in the way it operates in inter-application environments. You might find that you need to set a delay value somewhere in the order of 20 – 40 ms depending on your computer and hardware configuration. The value determines the duration of the delay that Live will use in playing back tracks within Live. This compensates for the delayed messages received by Live from Nodal via MIDI sync.

The best way to test the delay is to set up a simple repeated clip in Live and replicate this in Nodal. Set the port for the instrument in Nodal to play an identical sound (but on another track) in Live. Then with Nodal synced play both the clip and Nodal and adjust the *MIDI Clock Sync Delay* value until you hear one note being played.

Note that the *MIDI Clock Type* is set to *Song* in Live in the example given here. This is the best option to use in most circumstances.

Since Nodal is a generative program, the concept of a time-line is not as straightforward as it is in other pieces of software. Therefore, it may be the case that Nodal may take a short time to find the appropriate point to sync to in the generative process.

Appendix 1: Commands and Functions

Tool or Input	Keys or action	Function
	Space bar	Toggles <i>Play / Pause</i>
	Right-click	Contextual menus
<i>Selection</i>	Click and drag	Selects one or more objects
<i>Selection</i>	Shift-click	Multiple selection
<i>Selection</i>	Command-click (Mac), Control-click (PC)	Multiple selection
<i>Zoom</i>	Click in edit space	Zoom in
<i>Zoom</i>	Option-click (Mac), Alt-click (PC)	Zoom out
<i>Create Node and Edge</i>	Click in edit space	Makes a single node
<i>Create Node and Edge</i>	Click and drag from existing node to anywhere	Connects an existing node to a new node
<i>Create Node and Edge</i>	Click and drag from existing node to existing node	Connects two nodes with an edge
<i>Create Node and Edge</i>	Shift during click and drag	Flips city block corners
<i>Create Voice Group</i>	Click on a node	Creates a <i>Voice Group Triangle</i> (a voices starting point)
<i>Create Text Box</i>	Click in edit space	Creates a box for entering headings or comments
MIDI Note input	Single note when a node or nodes are selected	Enters a new pitch and velocity into a node/s
MIDI Note input	Chord when a node or nodes are selected	Enters a list of pitches and velocities into a node or nodes
MIDI Note input	Single note when a node or nodes is selected and either the <i>Pitch List</i> or <i>Velocity List</i> field is selected in the <i>Node</i> inspector	Enters a new pitch <u>or</u> velocity into a node or nodes
MIDI Note input	Chord when a node/s is selected and either the pitch or velocity field is selected in the <i>Node</i> inspector	Enters a list of pitches <u>or</u> velocities into a node or nodes
MIDI Controller input	When editing Continuous Controllers in the <i>Edge inspector</i> .	Sets continuous controller values for control points or single value.

Appendix 2: General MIDI Program Number

1 Acoustic Grand Piano	41 Violin	86 Lead 6 (voice)
2 Bright Acoustic Piano	42 Viola	87 Lead 7 (fifths)
3 Electric Grand Piano	43 Cello	88 Lead 8 (bass + lead)
4 Honky-tonk Piano	44 Contrabass	89 Pad 1 (new age)
5 Electric Piano 1	45 Tremolo Strings	90 Pad 2 (warm)
6 Electric Piano 2	46 Pizzicato Strings	91 Pad 3 (polysynth)
7 Harpsichord	47 Orchestral Harp	92 Pad 4 (choir)
8 Clavi	48 Timpani	93 Pad 5 (bowed)
9 Celesta:+12	49 String Ensemble 1	94 Pad 6 (metallic)
10 Glockenspiel:+24	50 String Ensemble 2	95 Pad 7 (halo)
11 Music Box	51 Synth Strings 1	96 Pad 8 (sweep)
12 Vibraphone	52 Synth Strings 2	97 FX 1 (rain)
13 Marimba	53 Choir Aahs	98 FX 2 (Soundtrack)
14 Xylophone:+12	54 Voice Oohs	99 FX 3 (crystal)
15 Tubular Bells	55 Synth Voice	100 FX 4 (atmosphere)
16 Dulcimer	56 Orchestra Hit	101 FX 5 (brightness)
17 Drawbar Organ	57 Trumpet:-2	102 FX 6 (goblins)
18 Percussive Organ	58 Trombone	103 FX 7 (echoes)
19 Rock Organ	59 Tuba	104 FX 8 (sci-fi)
20 Church Organ	60 Muted Trumpet	105 Sitar
21 Reed Organ	61 French Horn:-7	106 Banjo
22 Accordion	62 Brass Section	107 Shamisen
23 Harmonica	63 SynthBrass 1	108 Koto
24 Tango Accordion	64 SynthBrass 2	109 Kalimba
25 Acoustic Guitar (nylon):-12	65 Soprano Sax:-2	110 Bag pipe
26 Acoustic Guitar (steel):-12	66 Alto Sax:-9	111 Fiddle
27 Electric Guitar (jazz):- 12	67 Tenor Sax:-14	112 Shanai
28 Electric Guitar (clean):-12	68 Baritone Sax:-21	113 Tinkle Bell
29 Electric Guitar (muted):-12	69 Oboe	114 Agogo
30 Overdriven Guitar:-12	70 English Horn:-7	115 Steel Drums
31 Distortion Guitar:-12	71 Bassoon	116 Woodblock
32 Guitar Harmonics:-12	72 Clarinet:-2	117 Taiko Drum
33 Acoustic Bass	73 Piccolo:+12	118 Melodic Tom
34 Electric Bass (finger)	74 Flute	119 Synth Drum
35 Electric Bass (pick)	75 Recorder	120 Reverse Cymbal
36 Fretless Bass	76 Pan Flute	121 Guitar Fret Noise
37 Slap Bass 1	77 Blown Bottle	122 Breath Noise
38 Slap Bass 2	78 Shakuhachi	123 Seashore
39 Synth Bass 1	79 Whistle	124 Bird Tweet
40 Synth Bass 2	80 Ocarina	125 Telephone Ring
	81 Lead 1 (square)	126 Helicopter
	82 Lead 2 (sawtooth)	127 Applause
	83 Lead 3 (calliope)	128 Gunshot
	84 Lead 4 (chiff)	
	85 Lead 5 (charang)	

Appendix 3: Decimal to Hexadecimal Conversion table

Decimal Hex		43	0x2B	87	0x57
0	0x00	44	0x2C	88	0x58
1	0x01	45	0x2D	89	0x59
2	0x02	46	0x2E	90	0x5A
3	0x03	47	0x2F	91	0x5B
4	0x04	48	0x30	92	0x5C
5	0x05	49	0x31	93	0x5D
6	0x06	50	0x32	94	0x5E
7	0x07	51	0x33	95	0x5F
8	0x08	52	0x34	96	0x60
9	0x09	53	0x35	97	0x61
10	0x0A	54	0x36	98	0x62
11	0x0B	55	0x37	99	0x63
12	0x0C	56	0x38	100	0x64
13	0x0D	57	0x39	101	0x65
14	0x0E	58	0x3A	102	0x66
15	0x0F	59	0x3B	103	0x67
16	0x10	60	0x3C	104	0x68
17	0x11	61	0x3D	105	0x69
18	0x12	62	0x3E	106	0x6A
19	0x13	63	0x3F	107	0x6B
20	0x14	64	0x40	108	0x6C
21	0x15	65	0x41	109	0x6D
22	0x16	66	0x42	110	0x6E
23	0x17	67	0x43	111	0x6F
24	0x18	68	0x44	112	0x70
25	0x19	69	0x45	113	0x71
26	0x1A	70	0x46	114	0x72
27	0x1B	71	0x47	115	0x73
28	0x1C	72	0x48	116	0x74
29	0x1D	73	0x49	117	0x75
30	0x1E	74	0x4A	118	0x76
31	0x1F	75	0x4B	119	0x77
32	0x20	76	0x4C	120	0x78
33	0x21	77	0x4D	121	0x79
34	0x22	78	0x4E	122	0x7A
35	0x23	79	0x4F	123	0x7B
36	0x24	80	0x50	124	0x7C
37	0x25	81	0x51	125	0x7D
38	0x26	82	0x52	126	0x7E
39	0x27	83	0x53	127	0x7F
40	0x28	84	0x54		
41	0x29	85	0x55		
42	0x2A	86	0x56		

Appendix 4: Continuous Controller Messages

Control Number (2nd Byte Value)			Control Function	3rd Byte Value	
Decimal	Binary	Hex		Value	Used As
0	00000000	0x00	Bank Select	0-127	MSB
1	00000001	0x01	Modulation Wheel or Lever	0-127	MSB
2	00000010	0x02	Breath Controller	0-127	MSB
3	00000011	0x03	Undefined	0-127	MSB
4	00000100	0x04	Foot Controller	0-127	MSB
5	00000101	0x05	Portamento Time	0-127	MSB
6	00000110	0x06	Data Entry MSB	0-127	MSB
7	00000111	0x07	Channel Volume (formerly Main Volume)	0-127	MSB
8	00001000	0x08	Balance	0-127	MSB
9	00001001	0x09	Undefined	0-127	MSB
10	00001010	0x0A	Pan	0-127	MSB
11	00001011	0x0B	Expression Controller	0-127	MSB
12	00001100	0x0C	Effect Control 1	0-127	MSB
13	00001101	0x0D	Effect Control 2	0-127	MSB
14	00001110	0x0E	Undefined	0-127	MSB
15	00001111	0x0F	Undefined	0-127	MSB
16	00010000	0x10	General Purpose Controller 1	0-127	MSB
17	00010001	0x11	General Purpose Controller 2	0-127	MSB
18	00010010	0x12	General Purpose Controller 3	0-127	MSB
19	00010011	0x13	General Purpose Controller 4	0-127	MSB
20	00010100	0x14	Undefined	0-127	MSB
21	00010101	0x15	Undefined	0-127	MSB
22	00010110	0x16	Undefined	0-127	MSB
23	00010111	0x17	Undefined	0-127	MSB
24	00011000	0x18	Undefined	0-127	MSB
25	00011001	0x19	Undefined	0-127	MSB
26	00011010	0x1A	Undefined	0-127	MSB
27	00011011	0x1B	Undefined	0-127	MSB
28	00011100	0x1C	Undefined	0-127	MSB
29	00011101	0x1D	Undefined	0-127	MSB
30	00011110	0x1E	Undefined	0-127	MSB
31	00011111	0x1F	Undefined	0-127	MSB
32	00100000	0x20	LSB for Control 0 (Bank Select)	0-127	LSB
33	00100001	0x21	LSB for Control 1 (Modulation Wheel or Lever)	0-127	LSB
34	00100010	0x22	LSB for Control 2 (Breath Controller)	0-127	LSB
35	00100011	0x23	LSB for Control 3 (Undefined)	0-127	LSB
36	00100100	0x24	LSB for Control 4 (Foot Controller)	0-127	LSB
37	00100101	0x25	LSB for Control 5 (Portamento Time)	0-127	LSB
38	00100110	0x26	LSB for Control 6 (Data Entry)	0-127	LSB
39	00100111	0x27	LSB for Control 7 (Channel Volume, formerly Main Volume)	0-127	LSB
40	00101000	0x28	LSB for Control 8 (Balance)	0-127	LSB
41	00101001	0x29	LSB for Control 9 (Undefined)	0-127	LSB
42	00101010	0x2A	LSB for Control 10 (Pan)	0-127	LSB
43	00101011	0x2B	LSB for Control 11 (Expression Controller)	0-127	LSB
44	00101100	0x2C	LSB for Control 12 (Effect control 1)	0-127	LSB

45	00101101	0x2D	LSB for Control 13 (Effect control 2)	0-127	LSB
46	00101110	0x2E	LSB for Control 14 (Undefined)	0-127	LSB
47	00101111	0x2F	LSB for Control 15 (Undefined)	0-127	LSB
48	00110000	0x30	LSB for Control 16 (General Purpose Controller 1)	0-127	LSB
49	00110001	0x31	LSB for Control 17 (General Purpose Controller 2)	0-127	LSB
50	00110010	0x32	LSB for Control 18 (General Purpose Controller 3)	0-127	LSB
51	00110011	0x33	LSB for Control 19 (General Purpose Controller 4)	0-127	LSB
52	00110100	0x34	LSB for Control 20 (Undefined)	0-127	LSB
53	00110101	0x35	LSB for Control 21 (Undefined)	0-127	LSB
54	00110110	0x36	LSB for Control 22 (Undefined)	0-127	LSB
55	00110111	0x37	LSB for Control 23 (Undefined)	0-127	LSB
56	00111000	0x38	LSB for Control 24 (Undefined)	0-127	LSB
57	00111001	0x39	LSB for Control 25 (Undefined)	0-127	LSB
58	00111010	0x3A	LSB for Control 26 (Undefined)	0-127	LSB
59	00111011	0x3B	LSB for Control 27 (Undefined)	0-127	LSB
60	00111100	0x3C	LSB for Control 28 (Undefined)	0-127	LSB
61	00111101	0x3D	LSB for Control 29 (Undefined)	0-127	LSB
62	00111110	0x3E	LSB for Control 30 (Undefined)	0-127	LSB
63	00111111	0x3F	LSB for Control 31 (Undefined)	0-127	LSB
64	01000000	0x40	Damper Pedal on/off (Sustain)	<63 off, >64 on	---
65	01000001	0x41	Portamento On/Off	<63 off, >64 on	---
66	01000010	0x42	Sostenuto On/Off	<63 off, >64 on	---
67	01000011	0x43	Soft Pedal On/Off	<63 off, >64 on	---
68	01000100	0x44	Legato Footswitch	<63 Normal, >64 Legato	---
69	01000101	0x45	Hold 2	<63 off, >64 on	---
70	01000110	0x46	Sound Controller 1 (default: Sound Variation)	0-127	LSB
71	01000111	0x47	Sound Controller 2 (default: Timbre/Harmonic Intens.)	0-127	LSB
72	01001000	0x48	Sound Controller 3 (default: Release Time)	0-127	LSB
73	01001001	0x49	Sound Controller 4 (default: Attack Time)	0-127	LSB
74	01001010	0x4A	Sound Controller 5 (default: Brightness)	0-127	LSB
75	01001011	0x4B	Sound Controller 6 (default: Decay Time - see MMA RP-021)	0-127	LSB
76	01001100	0x4C	Sound Controller 7 (default: Vibrato Rate - see MMA RP-021)	0-127	LSB
77	01001101	0x4D	Sound Controller 8 (default: Vibrato Depth - see MMA RP-021)	0-127	LSB
78	01001110	0x4E	Sound Controller 9 (default: Vibrato Delay - see MMA RP-021)	0-127	LSB
79	01001111	0x4F	Sound Controller 10 (default undefined - see MMA RP-021)	0-127	LSB
80	01010000	0x50	General Purpose Controller 5	0-127	LSB
81	01010001	0x51	General Purpose Controller 6	0-127	LSB
82	01010010	0x52	General Purpose Controller 7	0-127	LSB
83	01010011	0x53	General Purpose Controller 8	0-127	LSB
84	01010100	0x54	Portamento Control	0-127	LSB
85	01010101	0x55	Undefined	---	---
86	01010110	0x56	Undefined	---	---
87	01010111	0x57	Undefined	---	---
88	01011000	0x58	Undefined	---	---
89	01011001	0x59	Undefined	---	---

90	01011010	0x5A	Undefined	---	---
91	01011011	0x5B	Effects 1 Depth (default: Reverb Send Level - see MMA RP-023) (formerly External Effects Depth)	0-127	LSB
92	01011100	0x5C	Effects 2 Depth (formerly Tremolo Depth)	0-127	LSB
93	01011101	0x5D	Effects 3 Depth (default: Chorus Send Level - see MMA RP-023) (formerly Chorus Depth)	0-127	LSB
94	01011110	0x5E	Effects 4 Depth (formerly Celeste [Detune] Depth)	0-127	LSB
95	01011111	0x5F	Effects 5 Depth (formerly Phaser Depth)	0-127	LSB
96	01100000	0x60	Data Increment (Data Entry +1) (see MMA RP-018)	N/A	---
97	01100001	0x61	Data Decrement (Data Entry -1) (see MMA RP-018)	N/A	---
98	01100010	0x62	Non-Registered Parameter Number (NRPN) - LSB	0-127	LSB
99	01100011	0x63	Non-Registered Parameter Number (NRPN) - MSB	0-127	MSB
100	01100100	0x64	Registered Parameter Number (RPN) - LSB*	0-127	LSB
101	01100101	0x65	Registered Parameter Number (RPN) - MSB*	0-127	MSB
102	01100110	0x66	Undefined	---	---
103	01100111	0x67	Undefined	---	---
104	01101000	0x68	Undefined	---	---
105	01101001	0x69	Undefined	---	---
106	01101010	0x6A	Undefined	---	---
107	01101011	0x6B	Undefined	---	---
108	01101100	0x6C	Undefined	---	---
109	01101101	0x6D	Undefined	---	---
110	01101110	0x6E	Undefined	---	---
111	01101111	0x6F	Undefined	---	---
112	01110000	0x70	Undefined	---	---
113	01110001	0x71	Undefined	---	---
114	01110010	0x72	Undefined	---	---
115	01110011	0x73	Undefined	---	---
116	01110100	0x74	Undefined	---	---
117	01110101	0x75	Undefined	---	---
118	01110110	0x76	Undefined	---	---
119	01110111	0x77	Undefined	---	---
Note:	Controller numbers 120-127 are reserved for Channel Mode Messages, which rather than controlling sound parameters, affect the channel's operating mode.				
120	01111000	0x78	[Channel Mode Message] All Sound Off	0	---
121	01111001	0x79	[Channel Mode Message] Reset All Controllers (See MMA RP-015)	0	---
122	01111010	0x7A	[Channel Mode Message] Local Control On/Off	0 off, 127 on	---
123	01111011	0x7B	[Channel Mode Message] All Notes Off	0	---
124	01111100	0x7C	[Channel Mode Message] Omni Mode Off (+ all notes off)	0	---
125	01111101	0x7D	[Channel Mode Message] Omni Mode On (+ all notes off)	0	---
126	01111110	0x7E	[Channel Mode Message] Poly Mode On/Off (+ all notes off)	**	---
127	01111111	0x7F	[Channel Mode Message] Poly Mode On (+ mono off +all notes off)	0	---

** Note: This equals the number of channels, or zero if the number of channels equals the number of voices in the receiver.