JFugue: Making Music With Java MIDI and Illustrating API Usability

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Goal
What we hope you’ll take away

Learn about JFugue, an API for creating MIDI music, and learn how an easy-to-use API can make your projects successful.
Agenda

Explore JFugue
Enjoy Demos!
Create JFugue Clients
Examine API Usability
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What Is JFugue?

• An API for Programming Music in Java™ programming language
• Renders music in Java™ platform MIDI
  • … extensible to other formats (more later)
• Intended for multiple purposes
  • Define and play music at runtime
  • Experiment with changing and editing music
  • Inspire future programmers
• Without JFugue, programming music is hard!
Programming Music
With Java Platform MIDI

// Play a Middle-C
Sequencer sequencer = MidiSystem.getSequencer();
Sequence sequence = sequencer.getSequence();
Track track = sequence.createTrack();
ShortMessage onMessage = new ShortMessage();
onMessage.setMessage(ShortMessage.NOTE_ON, 0, 60, 128);
MidiEvent noteOnEvent = new MidiEvent(onMessage, 0);
track.add(noteOnEvent);
ShortMessage offMessage = new ShortMessage();
offMessage.setMessage(ShortMessage.NOTE_OFF, 0, 60, 128);
MidiEvent noteOffEvent = new MidiEvent(offMessage, 200);
track.add(noteOffEvent);
sequencer.start();
try {
    Thread.sleep(track.ticks());
} catch (InterruptedException e) {
    Thread.currentThread().interrupt();
}
Programming Music With JFugue

// Play a Middle-C

Player player = new Player();
player.play("C");
Programming Music With JFugue

// Play first 2 measures (and a bit) of “Für Elise”

Player player = new Player();
player.play("E6s D#6s | E6s D#6s E6s B5s D6s C6s | A5i.");
The Magic of JFugue

Why JFugue makes music programming fun

• Simple and intuitive API—player.play()

• Innovative “Music String”
  • Seems to break object-oriented paradigm, but…
  • More convenient for specifying many notes
    song.add(new Note(Note.A_SHARP,6, Note.QUARTER));
    vs.
    play(“A#6q”);

• Easy to specify all sorts of musical events
  • Notes, Durations, Instruments, Voices, Controller Events…
  • If it makes a sound in MIDI, you can represent it in JFugue
More Fun With the Music String

• Voices and Instruments

V0 I[Alto_Sax] E5s G5s C6s G5s
V1 I[Piano] D4s F4s C4s D4s
More Fun With the Music String

• Chords

Cmaj7q  Dsus4w  Bbmin13q
More Fun With the Music String

• Key Signatures

kGb\text{maj} \ G5i \ A5i \ Bn5i

\textit{The G and A are automatically played as flats, the B has been declared natural}
More Fun With the Music String

• Constants let you specify substitution values
  • To define: $word=definition
  • To use: [word]

• Example:
  • “$base=C [base]4q [base]majw”
  • Actually plays “C4q Cmajw”
  • Want to change all C notes to E? Just change $base
  • Instrument substitution: “$myFave=Piano I[myFave] C6q D6q”
More Fun With the Music String

• Pitch Bend
• Channel Pressure
• Polyphonic Pressure
• MIDI Controllers
Programming Music With JFugue

GrammarRewriter generator = new GrammarRewriter();

generator.setAxiom("T120 V0 I[Flute] Rq C5q " +
"V1 I[Tubular_Bells] Rq Rq Rq G6i+D6i V2 I[Piano] Cmajw E6q "+ "V3
I[Voice] E6q G6i+D6i V4 I[Choir] C5q E6q");

generator.addTransform("Cmajw", "Cmajw Fmajw");
generator.addTransform("Fmajw", "Rw Emajw");
generator.addTransform("Emajw", "Rw Fmajw");
generator.addTransform("C5q", "C5q G5q E6q C6q");
generator.addTransform("E6q", "G6q D6q F6i C6i D6q");
generator.addTransform("G6i+D6i", "Rq Rq G6i+D6i G6i+D6i Rq");

String music = generator.generate(3);
Pattern pattern = new Pattern(music);
Player player = new Player();
player.play(pattern);
What If You Could Manipulate Music?

How JFugue enables musical experimentation

• A Pattern is a fragment of music

• Patterns can be twisted, pulled, contorted…
  • PatternTransformer
  • Examples:
    • Duration Pattern Transformer
    • Bach wrote a song using a melody that was reversed and played on top of itself—The Crab Canon
      • Reverse Pattern Transformer

• PatternTransformers listen to the JFugue parser and create alternate patterns
Anonymous PatternTransformer

// Lower the octave of each note in a pattern
// (Number of notes in one octave = 12)

PatternTransformer octaveChanger = new PatternTransformer() {
    public void noteEvent(Note note) {
        byte currentValue = note.getValue();
        if (currentValue > 12) {
            note.setValue((byte)(currentValue - 12));
            returnPattern.addElement(note);
        }
    }
};

Pattern octaveLowerSong = octaveChanger.transform(song);
What Else Is Cool?
More amazing things you can do in JFugue

• Microtonal music
  • JFugue automatically adjusts pitch bend to change/make microtonal adjustments

• Rhythms
  • JFugue lets you bang on your keyboard like a set of drums

• Follow along with or anticipate MIDI events
  • You’ll see this in the demo!
Microtones in JFugue

MicrotoneHelper microtone = new MicrotoneHelper();
microtone.put("Be", 400.00);
microtone.put("Bf", 405.50);
microtone.put("Bt", 415.67);
microtone.put("Bv", 429.54);

new Player().play(microtone.convertPattern(p));
Rhythms in JFugue

Rhythm rhythm = new Rhythm();
rhythm.addSubstitution('O', "[ACOUSTIC_BASS_DRUM]s");
rhythm.addSubstitution('o', "[ACOUSTIC_SNARE]s");
rhythm.addSubstitution('\', "[CLOSED_HI_HAT]s");
rhythm.addSubstitution('`', "[OPEN_HI_HAT]s");
rhythm.addSubstitution('.', "Rs");

rhythm.setLayer(1, "O.OO...O.OO....O");
rhythm.setLayer(2, "....o.......o...");
rhythm.setLayer(3, ".'..`..`..`..`..`..`..`..");

Pattern pattern = rhythm.getPattern();
pattern.repeat(4);

Player player = new Player();
player.play(pattern);
JFugue and MIDI Devices
Interact with MIDI keyboard and synthesizers
• Send music to an external device
• Listen to music from an external device
Sending Music to a MIDI Device

// Send music to keyboard – without JFugue
MidiDevice.Info[] info = MidiSystem.getMidiDeviceInfo();

// Need to figure out which info[] to use – more lines, need user input!
MidiDevice device = MidiSystem.getMidiDevice(info[x]);
if (!(device.isOpen())) {
    device.open();
}

Receiver receiver = device.getReceiver();
Sequence sequence = MidiSystem.getSequence(midifile);

// Sort all of the MidiEvents in sequence by time – 30/40 more lines
MidiEvent[] events = // sequence sorted by time

// Dole out event messages according to elapsed time
long elapsedTime = 0;
for (int i = 0; i < events.length; i++) {
    MidiEvent event = events[i];
    MidiMessage message = event.getMessage();
    long timestamp = event.getTick();
    long deltaTime = timestamp - elapsedTime;
    elapsedTime = timestamp;
    try {
        // Need to figure out tempoFactor – another 10 lines!
        Thread.sleep((int)(deltaTime * tempoFactor));
    } catch (InterruptedException ex) {
        Thread.currentThread().interrupt();
    }
}
receiver.send(message, -1);
receiver.close();
device.close();

Don’t worry, you’re not supposed to be able to read this.
Sending Music to a MIDI Device

// Send music to keyboard – with JFugue

try {
    MidiOutDevice device = new MidiOutDevice();
    sequence = MidiSystem.getSequence(midifile);
    // OR: sequence = player.getSequence(pattern);
    device.sendSequence(sequence);
} catch (MidiUnavailableException e) { /* handle this */ } catch (InvalidMidiDataException e) { /* handle this */ } catch (IOException e) { /* handle this */ }
Parsers and Renderers
Reading and writing to limitless formats

• JFugue has a clear architectural design
  • **Parsers** convert some format into musical events
  • **Renderers** turn musical events into something meaningful

• Examples
  • Parsers: MusicStringParser, MidiParser
  • Renderers: MidiRenderer, MusicStringRenderer
Parsers and Renderers in JFugue

// General Example
XxxxParser parser = new XxxxParser();
XxxxRenderer renderer = new XxxxRenderer();
parser.addParserListener(renderer);
parser.parse(whatever object the parser can parse);
Parsers and Renderers in JFugue

// Specific: Convert MIDI into a JFugue MusicString
MidiParser parser = new MidiParser();
MusicStringRenderer renderer = new MusicStringRenderer();
parser.addParserListener(renderer);
parsed.parse(MidiSystem.getSequence(file));

// Wishlist: Convert MusicXML Format into Sheet Music
// (neither parser/renderer currently exists)
MusicXmlParser parser = new MusicXmlParser();
SheetMusicRenderer renderer = new SheetMusicRenderer();
parsed.addParserListener(renderer);
parsed.parse(new File("music.xml"));
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Examine API Usability
DEMO

Seeing (or Hearing) JFugue in Action
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**Create JFugue Clients**
Examine API Usability
JFugue Provides Functionality…

…so a client only needs to provide a user interface

• To generate JFugue music strings
• To invoke the playing of JFugue music strings
• To invoke the saving of JFugue music strings
• To invoke the loading of MIDI files
Open Sourced JFugue Music Notepad
DEMO

JFugue Music NotePad

https://nbjfuguesupport.dev.java.net/
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Examine API Usability
What Is API Usability?

• Designing an interface for the user
  • Like usability design for graphical interfaces…
  • …but the users are other developers…
  • …so it’s easy to relate!

• “Interface” = your API

• “User” = other developers

• API Usability is the intersection of user-centered design and excellent coding practices
API Usability Tips

…illustrated through JFugue

• Start with the end in mind
  • Think to yourself: What do I want to accomplish?

• Develop examples as you develop your API
  • Example: JFugue’s Rhythm class

```java
Rhythm rhythm = new Rhythm();
rhythm.addSubstitution('O', "[ACOUSTIC_SNARE]q");
rhythm.setLayer(1, "oo'O' oo'O' oo'O' oo'O' ");
Player player = new Player();
player.play(rhythm);
```
API Usability Tips
…illustrated through JFugue

• Make conceptually easy things simple to do
  • Player player = new Player();
  • player.play(“musical notes”);

• Create a compact API
  • Require the user to type as few lines as possible
    • song.add(pattern, 2); // Add the pattern twice
  • Don’t flood the API with unnecessary methods
    • Player had a “allNotesOff” method… thought I needed it, I was wrong
API Usability Tips

…illustrated through JFugue

• Be absolutely correct
  • If people are relying on your API, it must work!
  • Be available for comments and bugs

• Construct complete objects only
  • Don’t rely on methods that the user must call after the
    construct your object…because they won’t

• Catch errors right away

• Be verbose in reporting errors
  • Exception in thread “main” org.jfugue.JFugueException: The
    word DBF has no definition; Check the spelling, or define
    the word before using it
API Usability Tips

…illustrated through JFugue

• Follow Joshua Bloch’s “Effective Java”

• Tips for evolving APIs
  • Once you release an API, people will rely on it
  • If you change the API, change the major version number of your release
  • Provide documentation for converting between versions

• Finally: The success of your API project also depends on your presentation
  • Webpage, communications, etc.
Summary

- JFugue lets you do wonderful things with music
- JFugue Music NotePad lets you build music graphically, and turn it into JFugue strings
- A usable API is important towards getting a programming library adopted and enjoyed
For More Information

• Java platform and music
  • Paul Lamere’s “Search Inside the Music”, TS-1548

• JFugue
  • JFugue—http://www.jfugue.org
  • The Complete Guide to JFugue

• Music NotePad
  • Music Notepad—https://nbjfuguesupport.dev.java.net
  • Geertjan’s blog—http://blogs.sun.com/geertjan

• API usability
  • Joshua Bloch’s Effective Java session and book
  • Dave Koelle’s website—http://www.DaveKoelle.com
Q&A

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