JAMMING WITH JAVA™ TECHNOLOGY: MAKING MUSIC WITH JFUGUE AND JFRETS

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Learn how to create music from within your own Java™ application

Recapture the joy of programming
Agenda

- Introduction to JFugue
- Making Music with JFugue
- JFugue’s Advanced Features
- JFugue Under the Hood
- Applications of JFugue
- JFugue and JFrets
Introduction to JFugue

- JFugue is an open-source API for programming music in Java code
- Prevents you from dealing with MIDI messages!
  - But generates MIDI behind the scenes
- Allows you to specify music naturally
  - `player.play("C D E F G A B");`
- Provides classes that make music exploration fun and easy
  - Microtonal music
  - Rhythms
  - Interacting with external devices
  - Many other easy-to-use features
- Enables interaction with other music tools and formats
  - Read or write musical data from MIDI, MusicXML, etc.
  - Extensible architecture
How hard is music programming?

Music without JFugue

// 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();
}
How hard is music programming?
Music without JFugue – another way

// Play a Middle-C
try {
    Synthesizer synthesizer = MidiSystem.getSynthesizer();
    synthesizer.open();
    MidiChannel[] channels = synthesizer.getChannels();
    channels[0].noteOn(60, 128);
    try {
        Thread.sleep(200);
    } catch (InterruptedException e) {
        // handle exception
    }
    channels[0].noteOff(60);
    synthesizer.close();
} catch (MidiUnavailableException e) {
    // handle exception
}
Make it easy!
Music with JFugue

// Play a Middle-C
Player player = new Player();
player.play("C");
Wow, only 2 lines of code?

- The Magic of JFugue: Music is specified using JFugue’s “MusicString”
  - `player.play("C")` is a simple case
  - J. S. Bach’s *Inventio 13*
    
    
    ```
    player.play("E5s A5s C6s B5s E5s B5s D6s C6i E6i G#5i E6i | A5s E5s A5s C6s B5s E5s B5s D6s C6i A5i Ri");
    ```

- JFugue creates all of the MIDI messages behind the scenes
But… it creates MIDI… that’s so 1980

- Problem: You heard the notes, but it doesn’t sound like *Music*
- Bias: MIDI is dead. MP3 rules!
  - But MIDI specifies musical messages; MP3 is a compression format
- Cause: The MIDI synthesizer doesn’t have a good soundbank
  - People tend to associate MIDI with bad-sounding music
  - But MIDI is just a specification for musical messages
  - What you’re hearing is messages turned into sound using synthesizer
  - Soundbanks are replaceable, thanks to the Audio Synthesis Engine Project
    http://openjdk.java.net/projects/audio-engine/
- Solution: Use a synthesizer that can load better soundbanks!
  - There are a lot of soundbanks in the world that sound **fantastic**!
- Use Gervill, an audio synthesis engine, to load new soundbanks
  https://gervill.dev.java.net/
Code for adding Gervill to JFugue

// There is no code!
//
// Just add gervill.jar to your classpath,
// and MidiSystem.getSynthesizer() will return
// an instance of a Gervill Synthesizer.
Code for loading a better soundbank

    // Really, the hardest part is finding
    // a soundbank you like.
    Soundbank soundbank =
        MidiSystem.getSoundbank(new File("filename"));

    // Load instruments from the soundbank
    // into the synthesizer
    Synthesizer synth = MidiSystem.getSynthesizer();
    synth.loadAllInstruments(soundbank);

    // Create a JFugue Player object that is attached
    // to the synthesizer with the new instrument
    Player player = new Player(synth);

    // Now play your music with better results!
    player.play(your music here);
Using a better soundbank

- Find new soundbanks… Some are free, some cost money
- My favorite: SONiVOX’s 250 Meg GM Wavetable

  SONiVOX sound that rocks.

- Sample of MIDI music rendered using SONiVOX soundbanks:

  Revisiting “Inventio 13”
  Using standard soundbank
  Using SONiVOX 250 Meg GM Wavetable soundbank
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Making Music with JFugue
Two building blocks

Programming music in JFugue comes down to two key ideas:

- **MusicString** – a String that contains notation for specifying music
  - Example: “C5q E5q Cmajq”

- **Pattern** – a class that allows MusicStrings to be built, altered, recombined, etc.
  - Example:
    ```java
    Pattern pattern = new Pattern("C5q E5q Cmajq");
    pattern.add("D5s");
    ```
  - Most features in JFugue API return instances of Pattern
Specifying Music in JFugue
The JFugue MusicString

➢ Three rules of thumb when using JFugue:
  • If it can be specified in MIDI, JFugue can create it
  • If it requires memorization, JFugue has predefined constants
  • If it takes work to make it right, JFugue simplifies it
Specifying Music in JFugue
Anatomy of a MusicString

player.play("T[Adagio] V0 I[Piano] C5q F#5q CmajQ V1 I[Flute] C3q+E3q E3q+G3q Ri C2majI");
Specifying Music in JFugue
Anatomy of a MusicString

player.play("T[Adagio] V0 I[Piano] C5q F#5q CmajQ V1 I[Flute] C3q+E3q E3q+G3q Ri C2majI");

> Tempo
• Indicates speed of music
• Letter T followed by Beats Per Minute (as of JFugue 4.0)
• Pre-defined constants, like ‘Adagio’ or ‘Largo’, also provided
Specifying Music in JFugue
Anatomy of a MusicString

```java
player.play("T[Adagio] V0 I[Piano] C5q F#5q CmajQ V1 I[Flute] C3q+E3q E3q+G3q Ri C2majI");
```

> Voice

- Specifies MIDI channel for subsequent notes and other musical events
- Letter V followed by one of the 16 MIDI channels (0-15)
- The 10th voice (V9) is special – that’s MIDI’s percussion track
Specifying Music in JFugue
Anatomy of a MusicString

```java
player.play("T[Adagio] V0 I[Piano] C5q F#5q CmajQ V1 I[Flute] C3q+E3q E3q+G3q Ri C2majI");
```

**Instrument**

- Selects which instrument to use for playing music
- Letter `I` followed by a number from 0-127, representing the 128 MIDI instruments
- Pre-defined constants, like “Piano” and “Flute”, are provided for each of the MIDI instruments
Specifying Music in JFugue
Anatomy of a MusicString

```java
player.play("T[Adagio] V0 I[Piano] C5q F#5q
Cmaj0 V1 I[Flute] C3q+E3q E3q+G3q Ri
C2majI");
```

Notes, Rests, and Chords
- Note letter (C, D, E, F, G, A, or B), accidental (#, b, natural), and octave
  - Rest is specified with an R
- Duration: w, h, q, i, s, t, x, o (whole, half, etc. down to 128th)
  - Dotted notes, tuplets, ties, and combined durations are all supported
- Note and duration can each be specified numerically: [60], C5/0.5
- Notes in harmony indicated with +: C3q+E3q

Chords
- Root note plus chord identifier (maj, min, aug, etc), then duration
- Chord inversions can be specified with ^
Specifying Music in JFugue

Anatomy of a MusicString

- JFugue supports 30 types of chord (maj, min, aug, etc)
- Chord inversions are specified with ^

FmajQ  Gsus2H  Cdim7^^Q
Specifying Music in JFugue

Additional MusicString commands

➢ Key Signature
  • Letter $K$ followed by a key. Examples: $KA_{bmin}$, $KF_{maj}$
  • All notes in the composition will be automatically played in the key
    • Example: a $B$ note in an F-major key will be converted to $B$-flat.

➢ Timing Information
  • @ followed by a time in milliseconds to play next token
  • Seen especially when parsing MIDI files

➢ Grab bag of MIDI events
  • Pitch Wheel – useful for getting microtones out of MIDI!
  • Channel Pressure
  • Polyphonic Pressure
  • Controller Events – JFugue combines low- and high-bytes into one token
JFugue’s Patterns
Music is Poetic

> Music frequently has repeated phrases

> “Frere Jacques”

```
\begin{music}
    \begin{music}
    C5 q D5 q E5 q C5 q \text{ \quad} \\
    C5 q D5 q E5 q C5 q \text{ \quad}
    \end{music}
\end{music}
```

> Patterns allow common bits of music to be re-used:
```
Pattern pattern1 = new Pattern("C5q D5q E5q C5q");
Pattern song = new Pattern();
song.add(pattern1, 2); // Adds 'pattern1' to 'song' twice
```
JFugue’s Patterns
Music is Poetic

- Patterns are more than just MusicStrings…
- …Patterns can be altered in interesting ways
  - Reverse, invert, change durations, change pitches, swap instruments, etc.

- J. S. Bach’s “Crab Canon” from “The Musical Offering”
  - Two players, playing simultaneously
  - The second player plays a mirror image of the first player’s notes
  - See Douglas R. Hofstadter’s “Gödel, Escher, Bach”

- CrabCanon in JFugue:
  (MusicString available at http://www.jfugue.org)
  ```java
  Pattern voice1 = new Pattern(notes for one voice);
  Pattern voice2 = new RevesePatternTransformer.transform(voice1);
  ```
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Microtonal Music
“The notes between the cracks” – Charles Ives

- Occurrences of microtones:
  - Eastern music (Indian, Turkish)
  - Gamelan (Javanese, Balinese)
  - Modernist compositions (Charles Ives, Philip Glass)
  - Musical effects – portamento, slide trombone

- MIDI is capable of playing microtones, but it’s hard to do
  - Requires combination of Note and Pitch Wheel events, and lots of math

- JFugue… wait for it… makes it easy!

- Three steps:
  - 1. Assign frequencies to microtonal notes
  - 2. Define your music
  - 3. Generate a Pattern and play it
public static void main(String[] args) {
    MicrotoneNotation microtone = new MicrotoneNotation();
microtone.put("A440", 440.00); microtone.put("z3", 704.00);
microtone.put("z1", 528.00); microtone.put("z4", 792.00);
microtone.put("z2", 616.00); microtone.put("A880", 880.00);

    String micro1 = "<A440>s Rt <A440>s Rt <z1>s Rt <z1>s Rt";
    String micro2 = "<A440>q."
    String micro3 = "<A880>t <z3>t <z4>t <z2>t <z3>t <z2>t"

    Pattern pattern = new Pattern();
    pattern.add("V0 I[SKAKUHACHI]" unlawfully);
    pattern.add(microtone.getPattern(micro1), 3);
    pattern.add(microtone.getPattern(micro2));
    pattern.add("V1 I[VOICE_OOHS]" unlawfully);
    pattern.add(microtone.getPattern(micro3), 8);

    new Player().play(pattern);
}
Microtonal Music

public static void main(String[] args) {
    MicrotoneNotation microtone = new MicrotoneNotation();
    microtone.put("A440", 440.00); microtone.put("z3", 704.00);
    microtone.put("z1", 528.00); microtone.put("z4", 792.00);
    microtone.put("z2", 616.00); microtone.put("A880", 880.00);

    String micro1 = "<A440>s Rt <A440>s Rt <z1>s Rt <z1>s Rt";
    String micro2 = "<A440>q.";
    String micro3 = "<A880>t <z3>t <z4>t <z2>t <z3>t <z2>t";

    Pattern pattern = new Pattern();
    pattern.add("V0 I[SKAKUHACHI]" );
    pattern.add(microtone.getPattern(micro1), 3);
    pattern.add(microtone.getPattern(micro2));
    pattern.add("V1 I[VOICE_OOHS]" );
    pattern.add(microtone.getPattern(micro3), 8);

    new Player().play(pattern);
}
Microtonal Music

```java
public static void main(String[] args) {
    MicrotoneNotation microtone = new MicrotoneNotation();
    microtone.put("A440", 440.00); microtone.put("z3", 704.00);
    microtone.put("z1", 528.00); microtone.put("z4", 792.00);
    microtone.put("z2", 616.00); microtone.put("A880", 880.00);

    String micro1 = "<A440>s Rt <A440>s Rt <z1>s Rt <z1>s Rt";
    String micro2 = "<A440>q.";
    String micro3 = "<A880>t <z3>t <z4>t <z2>t <z3>t <z2>t";

    Pattern pattern = new Pattern();
    pattern.add("V0 I[SKAKUHACHI]");
    pattern.add(microtone.getPattern(micro1), 3);
    pattern.add(microtone.getPattern(micro2));
    pattern.add("V1 I[VOICE_OOHS]");
    pattern.add(microtone.getPattern(micro3), 8);

    new Player().play(pattern);
}
```
Intervals

> Specify music as intervals instead of actual notes
  * Use the difference between the notes, instead of the notes themselves
  * This is different than Key Signature
  * Intervals can be followed by chords, durations, etc.

> Example:

```java
public static void main(String[] args) {
    IntervalNotation riff =
        new IntervalNotation("<1>q <5>q <8>q <1>majH");

    Player player = new Player();
    player.play(riff.getPatternForRootNote("C5"));
    player.play(riff.getPatternForRootBote("Ab6"));
}
```
Rhythms

Define beats in a natural, intuitive manner
- Use your computer’s keyboard like a drum machine

Example:

```
O...o0...O...O00...
```

Three steps:
- 1. Bang out your beat
- 2. Assign MusicStrings to keys
- 3. Generate a Pattern and play it
Rhythms

// This is a complete program for a 16-Beat Rock Rhythm
public static void main(String[] args) {
    Rhythm rhythm = new Rhythm();
rhythm.setLayer(1, "O..oO...O..oOO..");
rhythm.setLayer(2, "...*....*....*....*.");
rhythm.setLayer(3, "^^^^^^^^^^^^^^^^");
rhythm.setLayer(4, "...............!");

    rhythm.addSubstitution('O', "[BASS_DRUM]i");
rhythm.addSubstitution('o', "Rs [BASS_DRUM]s");
rhythm.addSubstitution('*', "[ACOUSTIC_SNARE]i");
rhythm.addSubstitution('^', "[PEDAL_HI_HAT]s Rs");
rhythm.addSubstitution('!', "[CRASH_CYMBAL_1]s Rs");
rhythm.addSubstitution('.', "Ri");

    Pattern pattern = rhythm.getPattern();
    pattern.repeat(4);
    Player player = new Player();
    player.play(pattern);
}
Rhythms

// This is a complete program for a 16-Beat Rock Rhythm
public static void main(String[] args) {
    Rhythm rhythm = new Rhythm();
    rhythm.setLayer(1, "O..oO...O..oOO..");
    rhythm.setLayer(2, "..*...*...*...*.");
    rhythm.setLayer(3, "^^^^^^^^^^^^^^^^");
    rhythm.setLayer(4, "...............!");

    rhythm.addSubstitution('O', "[BASS_DRUM]i");
    rhythm.addSubstitution('o', "Rs [BASS_DRUM]s");
    rhythm.addSubstitution('*', "[ACOUSTIC_SNARE]i");
    rhythm.addSubstitution('^', "[PEDAL_HI_HAT]s Rs");
    rhythm.addSubstitution('!', "[CRASH_CYMBAL_1]s Rs");
    rhythm.addSubstitution('.', "Ri");

    Pattern pattern = rhythm.getPattern();
    pattern.repeat(4);
    Player player = new Player();
    player.play(pattern);
}
// This is a complete program for a 16-Beat Rock Rhythm
public static void main(String[] args) {
    Rhythm rhythm = new Rhythm();
rhythm.setLayer(1, "O..oO...O..oOO..");
rhythm.setLayer(2, "....*.*....*.*....*.");
rhythm.setLayer(3, "^^^^^^^^^^^^^^^^");
rhythm.setLayer(4, "...............!");

    rhythm.addSubstitution('O', "[BASS_DRUM]i");
rhythm.addSubstitution('o', "Rs [BASS_DRUM]s");
rhythm.addSubstitution('*', "[ACOUSTIC_SNARE]i");
rhythm.addSubstitution('^', "[PEDAL_HI_HAT]s Rs");
rhythm.addSubstitution('!', "[CRASH_CYMBAL_1]s Rs");
rhythm.addSubstitution('.', "Ri");

    Pattern pattern = rhythm.getPattern();
    pattern.repeat(4);
    Player player = new Player();
    player.play(pattern);
}
Rhythms and Intervals

You can use Intervals in your Rhythms to create beats with riffs

```java
rhythm.setLayer(1, "o...o...o...o...o...o...o...o...o...");
rhythm.setLayer(2, "..*...*...*...*...*...*...*...*.");
rhythm.setLayer(3, "...%...%...%...%...%...%...%...%");  
rhythm.setVoice(1, "jjnnjjmlnnllnnlkjjnnjjmlkkklnnnk");

rhythm.addSubstitution('j', "<1>s Rs");
rhythm.addSubstitution('k', "<6>s Rs");
rhythm.addSubstitution('l', "<8>s Rs");
```

// etc.

Now get the music for given a specific root note

```java
Pattern pattern = rhythm.getPatternWithInterval("Bb4");
Pattern pattern = rhythm.getPatternWithInterval("A5");
```
Sharing Music with MIDI Devices
Talk to Your Musical Keyboard

Sending music to an external device is very easy:

```java
DeviceThatWillReceiveMidi device =
    new DeviceThatWillReceiveMidi(MidiDevice.Info);
sequence = player.getSequence(pattern);
device.sendSequence(sequence);
// Also: sequence = MidiSystem.getSequence(File);
```

Reading music from an external device is very easy:

```java
DeviceThatWillTransmitMidi device =
    new DeviceThatWillTransmitMidi(MidiDevice.Info);
device.listenForMillis(5000);
Pattern pattern = device.getPatternFromListening();
```

Each of these handles many of lines of MIDI code
Loading and Saving Patterns and MIDI

- Patterns can be loaded and saved:
  - `pattern.savePattern(File)`
  - `Pattern pattern = Pattern.loadPattern(File)`

- Music can be saved as MIDI
  - `player.saveMidi(Pattern, File)`

- Music can be loaded from MIDI and converted into a Pattern!
  - `Pattern pattern = Pattern.loadMidi(File)`

- JFugue can also be load and save MusicXML
  - Other formats on the horizon!
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JFugue Under the Hood

Parsers & ParserListeners

- JFugue parses musical notation, and generates musical events

- Originally, JFugue parsed MusicStrings and generated MIDI

- Then, JFugue could parse MIDI and generate MusicStrings
  - Get – and play with – JFugue notation for your favorite MIDI files!

- Most recently, JFugue can parse and render MusicXML files
  - Thanks to contributions from the community!

- All of these are interchangeable!
JFugue Under the Hood

Parsers & ParserListeners

- A **Parser** knows how to convert data into musical events
- A **ParserListener** knows how to handle/render musical events

Code to connect Parsers and ParserListeners:
```
YourParser parser = new YourParser();
YourRenderer renderer = new YourRenderer();
parser.addParserListener(renderer);
parser.parse(whatever object the parser can parse);
```
JFugue Under the Hood
Fun with Parsers & ParserListeners

- Parsers and ParserListeners aren’t limited to musical formats!

- Potential types of Parsers or ParserListeners:
  (none of these exist today)
  - SheetnoteRenderer – convert music to a graphical sheet of music
  - VisualizationRenderer – create fancy graphics based on the music
  - SpamParser – take junk email and convert it to music
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JFugue Music NotePad

➤ A simple, standalone application for creating music
  • Uses JFugue API; generates JFugue MusicStrings
➤ User interface is based on the NetBeans platform
➤ Entirely separate open-source project from JFugue
  • Website: https://nbjfuguesupport.dev.java.net/
JFugue + Ant
Hear the status of your build

- From Geertjan Weilenga’s blog
  http://blogs.sun.com/geertjan/entry/ode_to_build_scripts

- AntLogger class can listen to AntEvents
- Play a JFugue pattern when the build finishes
  - Happy tune for a successful build
  - Dark tune for a failed build
import org.apache.tools.ant.module.spi.AntLogger;

public class BuildLogger extends AntLogger {

    public void buildFinished(AntEvent event) {
        Player player = new Player();
        Throwable t = event.getException();
        if (t != null) {
            // There has been an exception
            event.getSession().println(t.toString(), true, null);
            player.play("I[String_Ensemble_1] B3q Bb3q. G3i F3h");
        } else {
            // Build was successful
            player.play("I[French_Horn] As E6h As E6i Rt As E6h");
        }
    }

    public boolean interestedInSession(AntSession session) { return true; }
    public boolean interestedInAllScripts(AntSession session) { return true; }
}
When Programs Create Music

Use JFugue to Make Music Programmatically

What might you create if you could programmatically define music?

- There’s something you can’t do with a graphical music editor!
JFugue Drum Circle

We Got the Beat

> Start with JFugue’s Rhythm class, with layers set to empty

\[ t_0: \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \]

> Gradually and randomly add and remove ‘strikes’ from layers

\[
\begin{align*}
 t_1: & \quad a\ldots\ldots\ldots\ldots\quad b\ldots\ldots\ldots\ldots\quad c\ldots\ldots\ldots\ldots \\
 t_2: & \quad a\ldots a\ldots a\ldots \quad b\ldots\ldots b\ldots\ldots \quad c\ldots\ldots c\ldots\ldots \\
 t_3: & \quad a\ldots a\ldots a\ldots a\ldots \quad b\ldots\ldots b\ldots\ldots \quad c\ldots\ldots c\ldots\ldots \\
 t_4: & \quad a\ldots a\ldots a\ldots a\ldots \quad b\ldots\ldots b\ldots b\ldots \quad c\ldots\ldots c\ldots c\ldots
\end{align*}
\]

> Assign tones to strikes

```java
rhythm.addSubstitution("a", "[HAND_CLAP]i");
rhythm.addSubstitution("b", "[BASS_DRUM]i");
rhythm.addSubstitution("c", "[LOW_BONGO]i");
```

> Play the rhythm!

```java
player.play(rhythm.getPattern());
```
“The Sound of Shopping”
Turning Barcodes into Music

Interactive exhibit turns barcodes, date and time of purchase into sequence of numbers

A human composer specifies how numbers are made into music

http://www.soundofshopping.com
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What Is JFrets?

- Teaches guitar in an interactive desktop tool
- Displays notes, chords, and scales
- Plays sounds to aid in learning process
- Provides tutorials and exercises
- Ability to create and save guitar tablature
- Guitar tablature playback
What is JFrets?
How is JFugue used in JFrets?

- User selects MIDI voice
- User selects a note/chord
- User can set the Beats Per Minute
- The selection is parsed into a JFugue format and played
JFugue Code

Player player = new Player();
String patternString =
    getMidiType((String)this.voiceBox.getSelectedItem()) +
    noteName;
patternString = "T" + bpm + " " + patternString;
Pattern pattern = new Pattern(patternString);
player.play(pattern);
Audio Streaming Code

```java
try {
    File audio = new File(getClass().getResource("/org/jfrets/sounds/" + file).toURI());
    float sample = 128000;
    AudioInputStream ais = AudioSystem.getAudioInputStream(audio);
    AudioFormat af = ais.getFormat();
    AudioFormat target = new AudioFormat(AudioFormat.Encoding.PCM_SIGNED, af.getSampleRate(), 16,
                                          af.getChannels(), af.getChannels() * 2, af.getSampleRate(), false);
    AudioInputStream decode = AudioSystem.getAudioInputStream(target, ais);
    DataLine.Info info = new DataLine.Info(SourceDataLine.class, target);
    SourceDataLine line = (SourceDataLine) AudioSystem.getLine(info);
    line.open(target);
    if (line != null) {
        byte[] data = new byte[4096];
        line.start();
        int bytesRead;
        while ((bytesRead = decode.read(data, 0, data.length)) != -1) {
            line.write(data, 0, bytesRead);
        }
        line.drain();
        line.stop();
        line.close();
        decode.close();
    }
} catch (IOException e) { /* handle this exception */
} catch (LineUnavailableException e) { /* handle this exception */
} catch (URISyntaxException e) { /* handle this exception */
} catch (UnsupportedAudioFileException e) { /* handle this exception */
}
```

Don’t worry, you’re not supposed to be able to read this.

And you certainly shouldn’t have to program it.
JFrets Capabilities

- Saves, displays, and plays guitar tablature
- Creates songs in tab or note format
- Provides a Metronome
- Provides a Scale Player
- Contains a guitar tuner with various tunings
- Prints tabs or songs
JFrets Demo
Summary

➢ JFugue makes music programming easy and fun
   • Create exciting new musical things!
   • Get your kids interested in programming!
   • Impress your co-workers!
   • Rekindle your joy of programming!

➢ JFrets exemplifies the kind of musical tools that JFugue can help make possible

➢ Java API Rocks!

➢ Project websites
   • JFugue – http://www.jfugue.org
   • JFrets - https://jfrets.dev.java.net
THANK YOU

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