Structuring Music

CS1316: Representing Structure and Behavior

Story

- Using JMusic
  - With multiple Parts and Phrases
- Creating music objects for exploring composition
  - Version 1: Using an array for Notes, then scooping them up into Phrases.
  - Version 2: Using a *linked list* of song elements.
  - Version 3: General song elements and song phrases
    - Computing phrases
    - Repeating and weaving
  - Version 4: Creating a tree of song parts, each with its own instrument.

JMusic: Java Music library

- JMusic knows about WAV files and many other formats, too (e.g., QuickTime)
- We'll use it for manipulating *MIDI*
  - Musical Instrument Digital Interface, an industry-standard interface used on electronic musical keyboards and PCs for computer control of musical instruments and devices.
- MIDI is about recording *music*, not *sound.*

Creating Notes

```
Welcome to DrJava.
> import jm.music.data.*
> import jm.JMC;
> import jm.util.*;
> Note n = new Note(JMC.C4,JMC.QUARTER_NOTE);
> n
jMusic NOTE: [Pitch = 60][RhythmValue = 1.0][Dynamic = 85][Pan = 0.5][Duration = 0.9]
> JMC.C4
60
> JMC.QUARTER_NOTE
1.0
> JMC.QN
1.0
> Note n2 = new Note(64,2.0);
> n2
jMusic NOTE: [Pitch = 64][RhythmValue = 2.0][Dynamic = 85][Pan = 0.5][Duration = 1.8]
```

JMC=JMusic Constants

Makes code easier to read from a music perspective

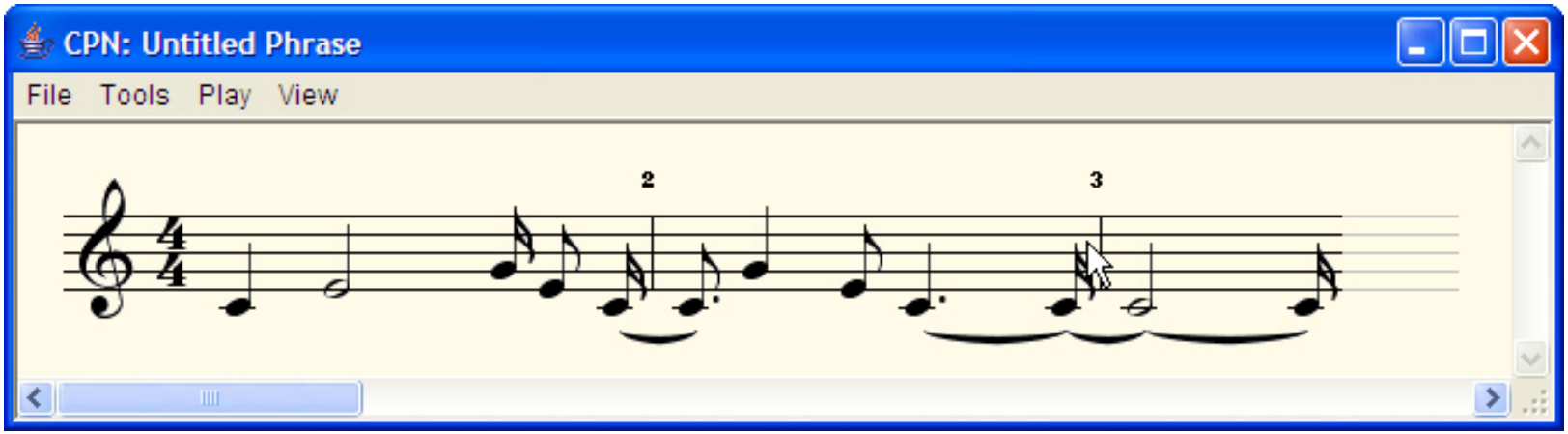
Creating Phrases

```
> Phrase phr = new Phrase();
> phr.addNote(n);
> phr.addNote(n2);
> double [] notes1 = {67, 0.25, 64, 0.5, 60, 1.0}
> phr.addNoteList(notes1)
> double [] notes2 = {JMC.G4,JMC.QN, JMC.E4,
   JMC.EN, JMC.C4, JMC.WN}
> phr.addNoteList(notes2)
```

Using notes, or an array of note pieces.

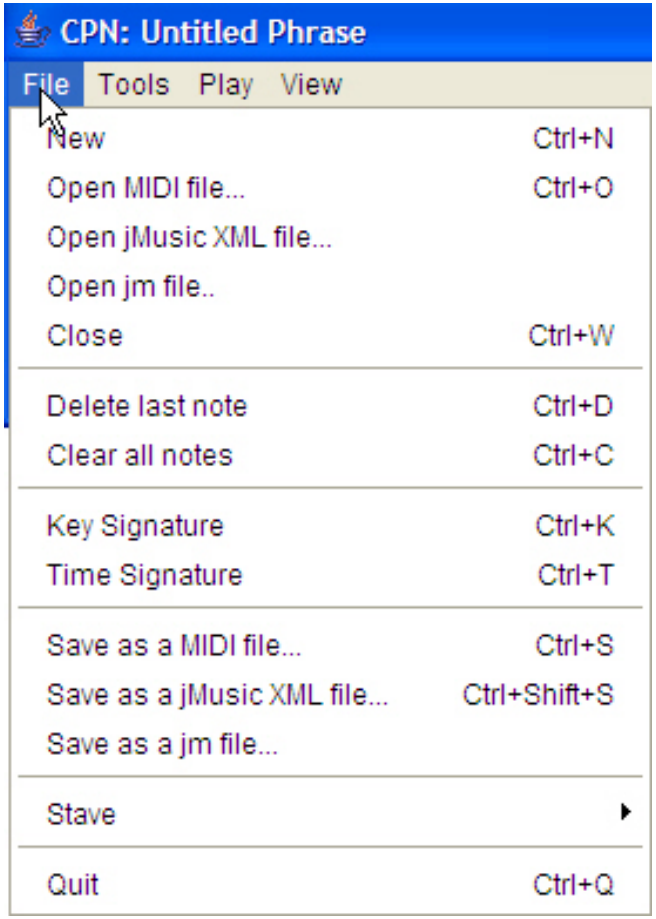
Viewing Phrases

```
> View.notate(phr)
```



From Viewer: Manipulate and MIDI

- Can save or open MIDI files
- Can change key or time signature.
- Other tools allow changing other characteristics, like tempo.



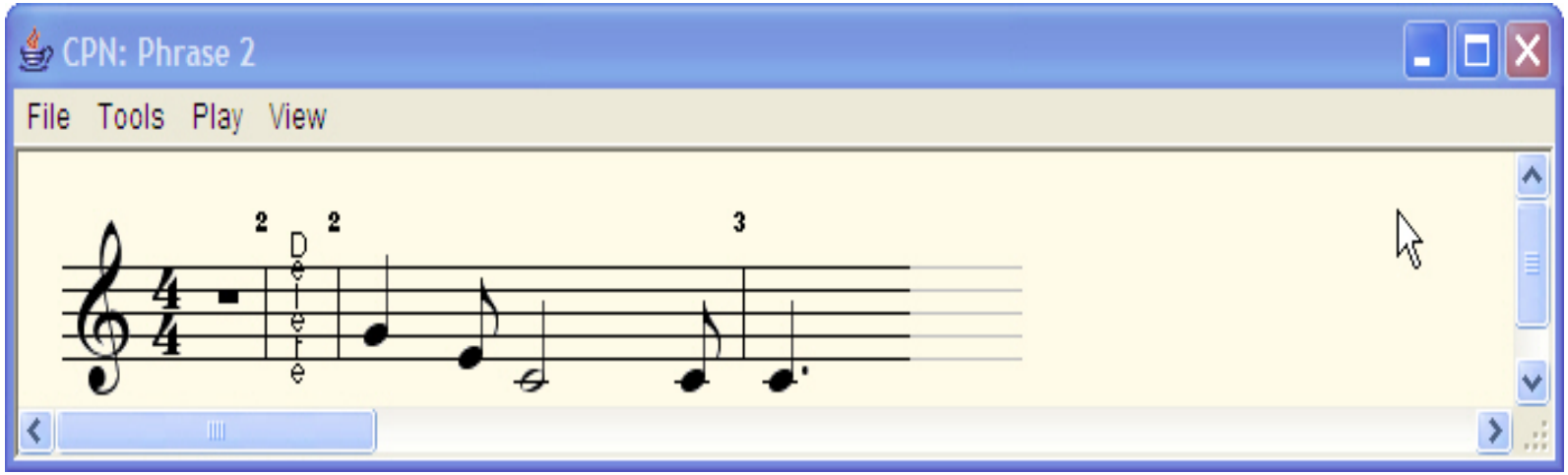
Different ways of creating Phrases

```
> Phrase phr2 = new
    Phrase("Phrase
    2",4.0,JMC.FLUTE);
> phr2.addNoteList(notes2)
```

`Phrase(double startTime, int instrument)` Creates an empty Phrase
`Phrase(Note note)` Constructs a new Phrase containing the specified `note`.
`Phrase(Note[] notes)` Constructs a new Phrase containing the specified `notes`.
`Phrase(Note[] notes, java.lang.String title)` Constructs a new Phrase containing the specified `notes` with the specified `title`.
`Phrase(Note note, double startTime)` Constructs a new Phrase containing the specified `note` with the specified `title`.
`Phrase(Note note, java.lang.String title)` Constructs a new Phrase containing the specified `note` with the specified `title`.
`Phrase(java.lang.String title)` Creates an empty Phrase
`Phrase(java.lang.String title, double startTime)` Creates an empty Phrase.
`Phrase(java.lang.String title, double startTime, int instrument)` Creates an empty Phrase.

A Phrase that starts later

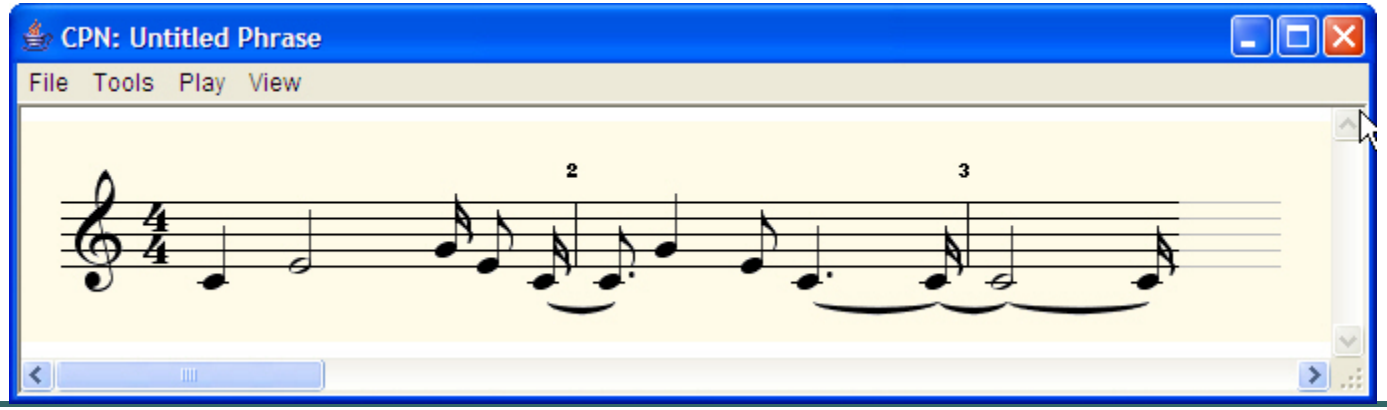
```
> Phrase phr2 = new Phrase("Phrase
   2",4.0,JMC.FLUTE);
> phr2.addNoteList(notes2)
> View.notate(phr2)
```



Adding parts into phrases (Wrong way first)

```
> Part part1 = new Part();
> part1.addPhrase(phr);
> part1.addPhrase(phr2);
> View.notate(part1);
```

Kinda lost the phrase distinctions.

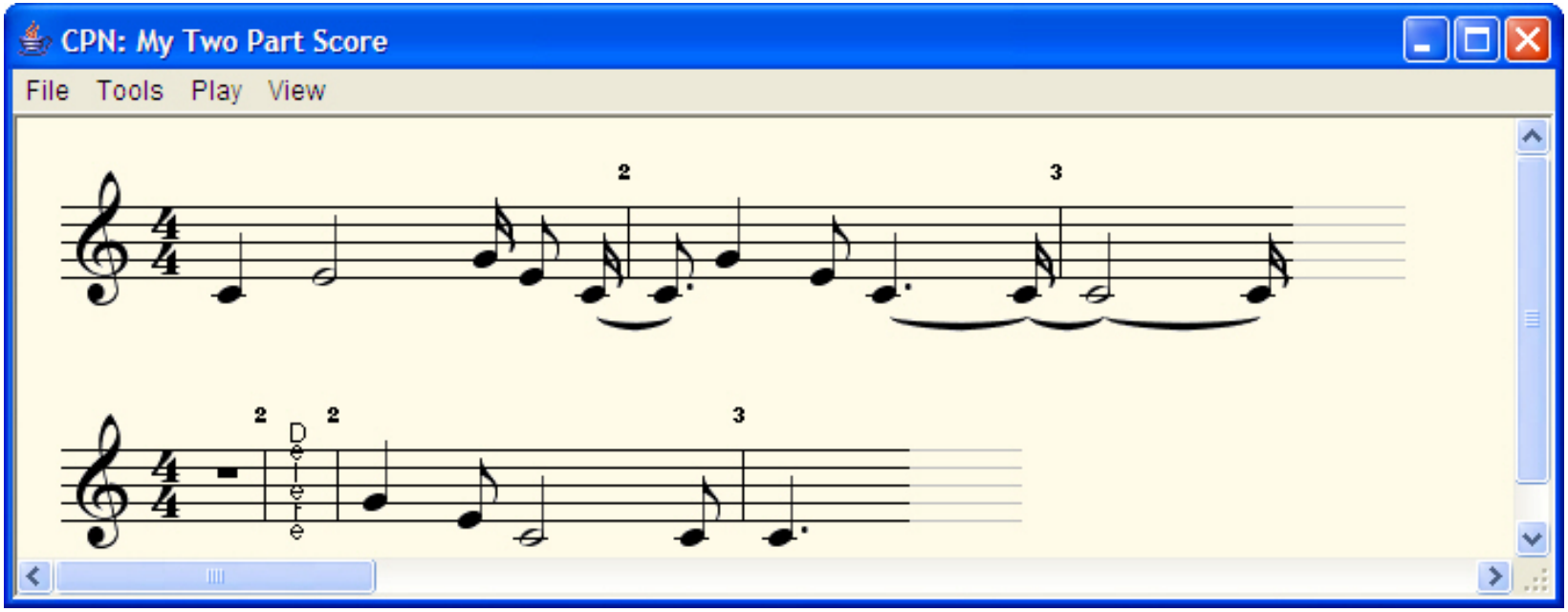


Building Parts and Scores

```
> Part partA = new Part("Part A",JMC.PIANO,1)
> partA.addPhrase(phr);
> Part partB = new Part("Part B",JMC.SAX,2)
> partB.addPhrase(phr2);
> Score score1 = new Score("My Two Part
   Score");
> score1.addPart(partA);
> score1.addPart(partB);
```

Viewing the Score

```
> View.notate(score1);
```



Amazing Grace

```
> AmazingGraceSong song1 =
new AmazingGraceSong();
> song1.fillMeUp();
> song1.showMe();
```

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.music.tools.*;

public class AmazingGraceSong {
  private Score myScore = new Score("Amazing Grace");

  public void fillMeUp(){
    myScore.setTimeSignature(3,4);

   double[] phrase1data =
   {JMC.G4, JMC.QN,
     JMC.C5, JMC.HN, JMC.E5,JMC.EN, JMC.C5,JMC.EN,
     JMC.E5,JMC.HN,JMC.D5,JMC.QN,
     JMC.C5,JMC.HN,JMC.A4,JMC.QN,
     JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
     JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
     JMC.E5,JMC.HN,JMC.D5,JMC.EN,JMC.E5,JMC.EN,
     JMC.G5,JMC.DHN};
   double[] phrase2data =
   {JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.G5,JMC.EN,
     JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
     JMC.E5,JMC.HN,JMC.D5,JMC.QN,
     JMC.C5,JMC.HN,JMC.A4,JMC.QN,
     JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
     JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
     JMC.E5,JMC.HN,JMC.D5,JMC.QN,
     JMC.C5,JMC.DHN
   };
   Phrase myPhrase = new Phrase();
   myPhrase.addNoteList(phrase1data);
   myPhrase.addNoteList(phrase2data);
   // create a new part and add the phrase to it
   Part aPart = new Part("Parts",
                         JMC.FLUTE, 1);
   aPart.addPhrase(myPhrase);
   // add the part to the score
   myScore.addPart(aPart);

  };

  public void showMe(){

   View.notate(myScore);
  };

}
```

Imports and some *private* data

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.music.tools.*;

public class AmazingGraceSong {
  private Score myScore = new Score("Amazing
   Grace");
```

- *myScore* is *private* instance data

Filling the Score

Each array is note, duration, note, duration, note, duration, etc.

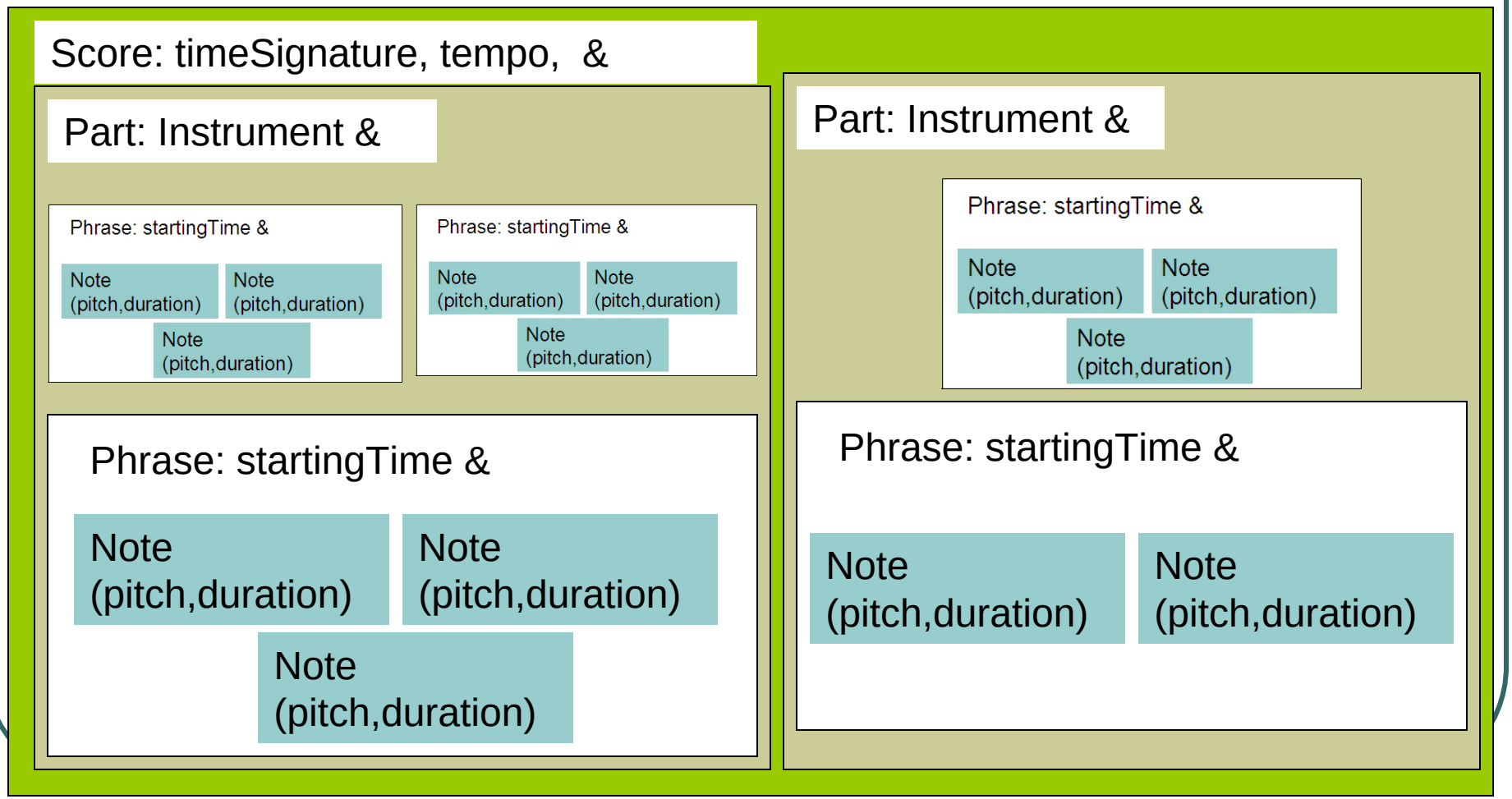
I broke it roughly into halves.

```
public void fillMeUp(){
   myScore.setTimeSignature(3,4);

  double[] phrase1data =
  {JMC.G4, JMC.QN,
    JMC.C5, JMC.HN, JMC.E5,JMC.EN, JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.HN,JMC.A4,JMC.QN,
    JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
    JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.EN,JMC.E5,JMC.EN,
    JMC.G5,JMC.DHN};
  double[] phrase2data =
  {JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.G5,JMC.EN,
    JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.HN,JMC.A4,JMC.QN,
    JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
    JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.DHN
  };
  Phrase myPhrase = new Phrase();
  myPhrase.addNoteList(phrase1data);
  myPhrase.addNoteList(phrase2data);
  // create a new part and add the phrase to it
  Part aPart = new Part("Parts",
                        JMC.FLUTE, 1);
  aPart.addPhrase(myPhrase);
  // add the part to the score
  myScore.addPart(aPart);

 };
```

Showing the Score

```
public void showMe(){
  View.notate(myScore);
 };
```

The Organization of JMusic Objects



Thought Experiment

- How are they doing that?
- How can there be *any number* of Notes in a Phrase, Phrases in a Part, and Parts in a Score?
  - (Hint: They ain't usin' arrays!)

How do we *explore* composition here?

- We want to quickly and easily throw together notes in different groupings and see how they sound.
- The current JMusic structure *models* music.
  - Let's try to create a structure that *models* thinking about music as bunches of *riffs/SongElements* that we want to combine in different ways.

Version 1: Notes in an array

- Let's just put notes of interest (for now, just random) in an array.
- We'll *traverse* the array to gather the notes up into a Phrase, then use View to notate the Phrase.

Using an array to structure Notes

```
> Note [] someNotes = new Note[100];
> for (int i = 0; i < 100; i++)
   {someNotes[i]= new Note((int)
   (128*Math.random()),0.25);}
> // Now, traverse the array and gather them up.
> Phrase myphrase = new Phrase()
> for (int i=0; i<100; i++)
  {myphrase.addNote(someNotes[i]);}
> View.notate(myphrase);
```

Critique of Version 1

- So where's the music?
  - 100 random notes isn't the issue.
  - It's that we don't think about notes as just one long strand.
- Where are the phrases/riffs/elements?
  - We just have one long line of notes.
- How do we explore patterns like this?
  - insertAfter and delete are just as hard here as in sampled sounds!

Version 2: Using a linked list of song elements

- Let's re-think *Amazing Grace* as a collection of *elements* that we can shuffle around as we'd like.
- We can make any element follow any other element.

What's in each element?

AmazingGraceSongElement

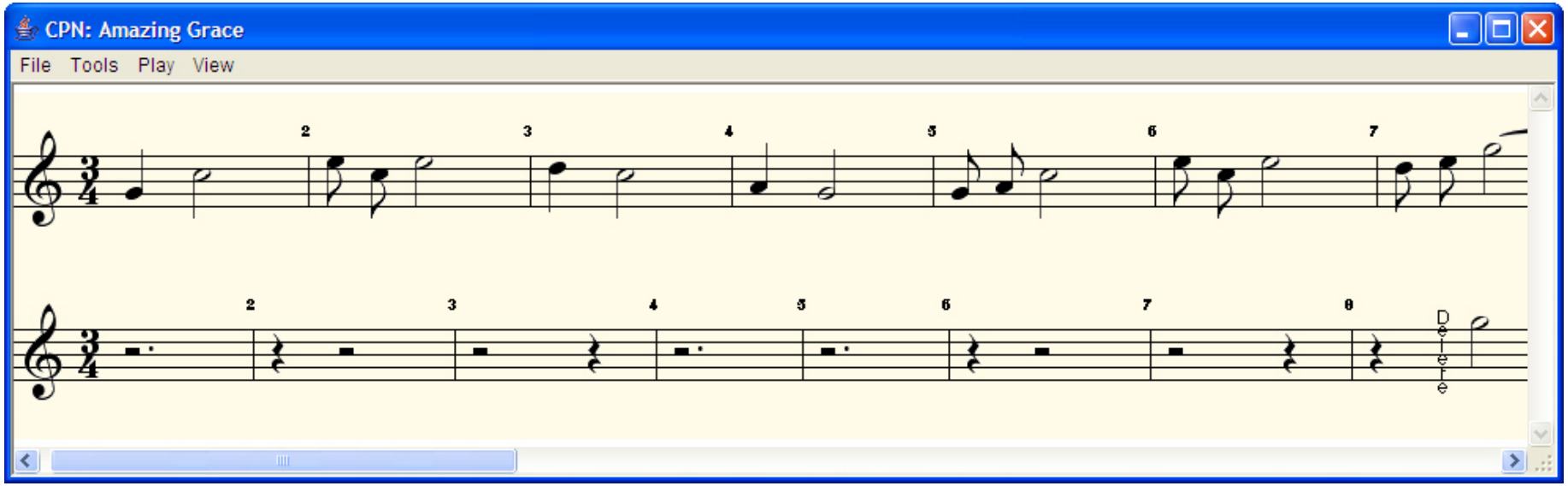
It **KNOWS:** it's Part and what comes *next*

It **CAN DO:** filling itself from the first or second phrase (with a given start time and instrument), setting the next one, getting the next one, and showing (notating) myself and all others.

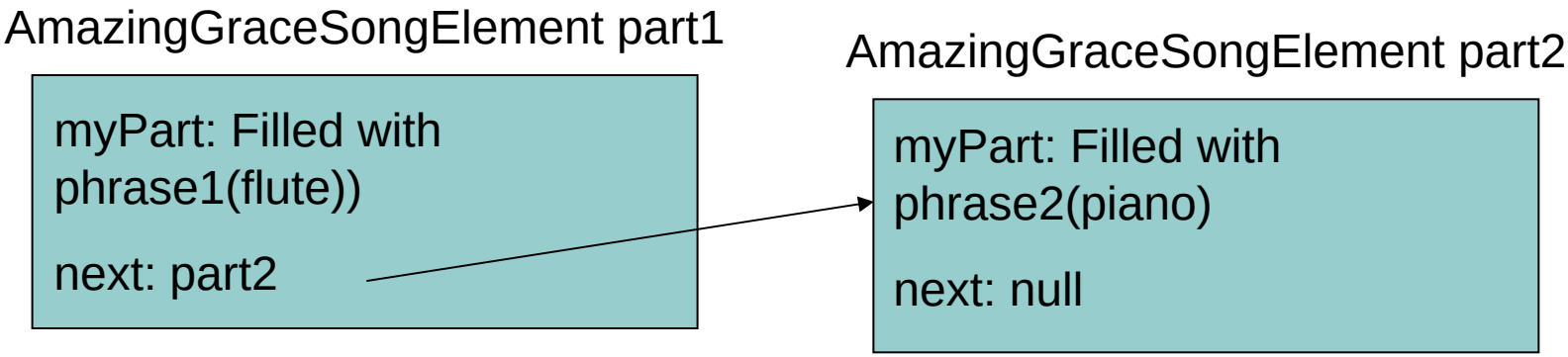
What that would look like to use it

```
Welcome to DrJava.
> import jm.JMC;
> AmazingGraceSongElement2 part1 = new
    AmazingGraceSongElement2();
> part1.setPhrase(part1.phrase1(),0.0,JMC.FLUTE);
> AmazingGraceSongElement2 part2 = new
    AmazingGraceSongElement2();
> part1.getEndTime()
22.0
> part2.setPhrase(part2.phrase2(),22.0,JMC.PIANO);
> part1.setNext(part2);
> part1.showFromMeOn();
```

Part1.showFromMeOn()



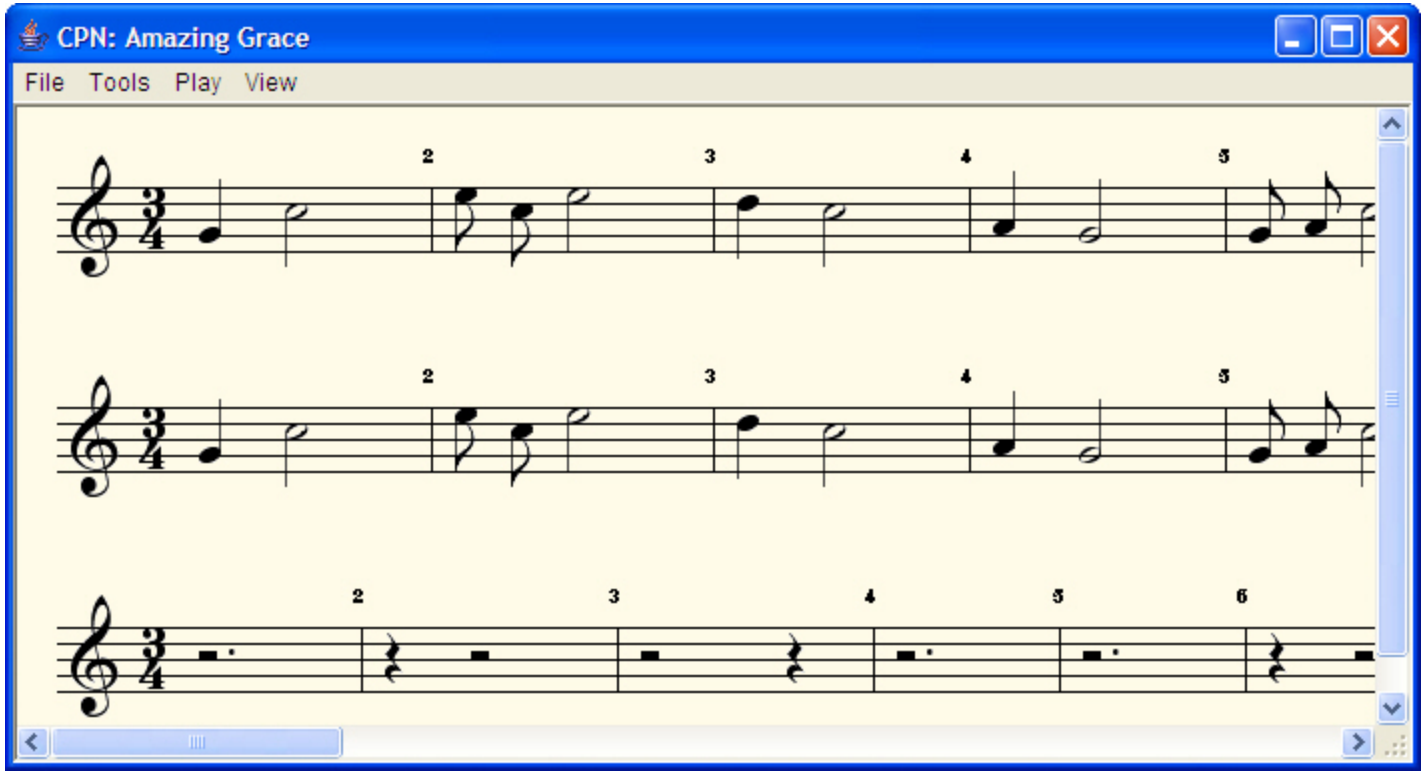
What's going on here?



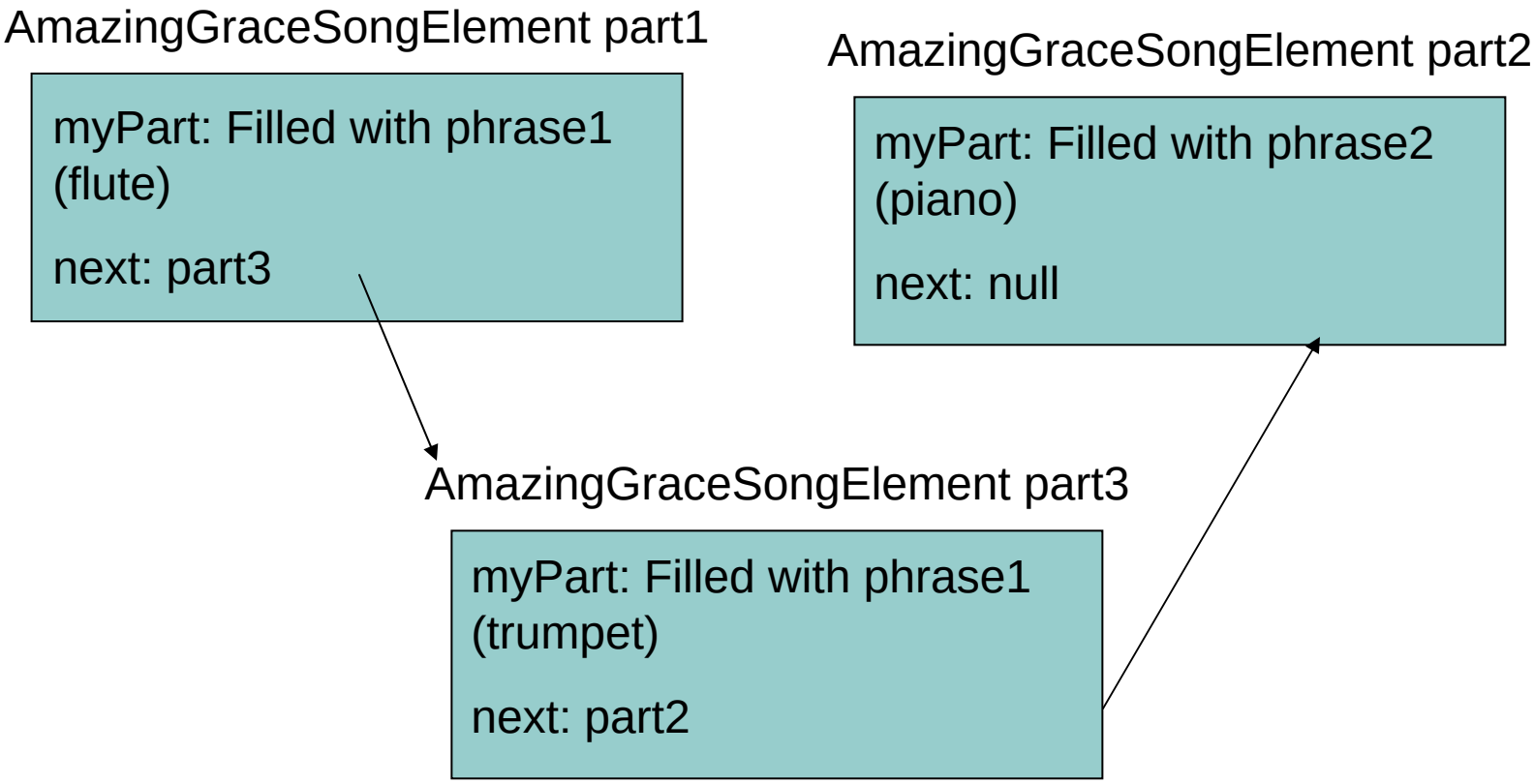
Adding a third part

```
> AmazingGraceSongElement2 part3 =
  new AmazingGraceSongElement2();
> part3.setPhrase(part3.phrase1(),0.0,
  JMC.TRUMPET);
> part1.setNext(part3);
> part3.setNext(part2);
> part1.showFromMeOn();
```

part1.showFromMeOn();
Now has three parts

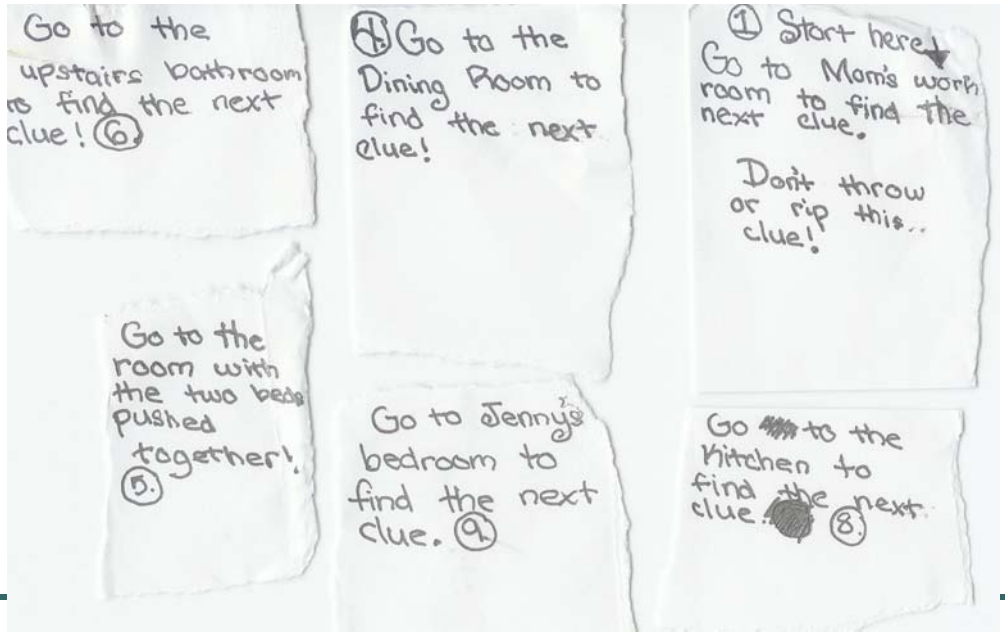


What's going on here?



Introducing the *Linked List*

- A linked list is information broken into smaller pieces, where each piece knows the next piece, but none other.



Another example of a linked list

- Non-linear video editing (like in iMovie)
  - You have a collection of video clips (information)
  - You drag them into a timeline.
    - Each clip still doesn't know all clips, but it knows the next one.

Why use linked lists versus arrays?

- Just two reasons now, more later:
  1. Can grow to *any* size (well, as long as memory permits)
     - Just create a new element and poke it into the list.
  2. *MUCH* easier to insert!
     - Look at how easily we put part3 between part1 and part2.

Implementing AmazingGraceSongElement2

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.music.tools.*;


public class AmazingGraceSongElement2 {
  // Every element knows its next element and its
    part (of the score)
  private AmazingGraceSongElement2 next;
  private Part myPart;
```

It's considered good form to make your object's data *private* unless you need to make it *public.*

Our Constructor

```
// When we make a new element, the next
   part is empty, and ours is a blank new
   part
 public AmazingGraceSongElement2(){
    this.next = null;
    this.myPart = new Part();
 }
```

What setPhrase does

```
// setPhrase takes a phrase and makes it the one for this element
 // at the desired start time with the given instrument
 public void setPhrase(Phrase myPhrase, double startTime, int
    instrument) {
   //Phrases get returned from phrase1() and phrase2() with
    default (0.0) startTime
   // We can set it here with whatever setPhrase gets as input
   myPhrase.setStartTime(startTime);
   this.myPart.addPhrase(myPhrase);
    this.myPart.setInstrument(instrument);
 }
```

Don’t get hung up on these details—this is just manipulating the JMusic classes so that we can store the information we want.

The Phrases

```
static public Phrase phrase1() {
     double[] phrase1data =
  {JMC.G4, JMC.QN,
    JMC.C5, JMC.HN, JMC.E5,JMC.EN,
       JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.HN,JMC.A4,JMC.QN,
    JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
    JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.EN,JMC.E5,JMC.EN,
    JMC.G5,JMC.DHN};

    Phrase myPhrase = new Phrase();
     myPhrase.addNoteList(phrase1data);
     return myPhrase;
  }
```

```
static public Phrase phrase2() {
   double[] phrase2data =
 {JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.G5,JMC.EN,
    JMC.G5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.HN,JMC.A4,JMC.QN,
    JMC.G4,JMC.HN,JMC.G4,JMC.EN,JMC.A4,JMC.EN,
    JMC.C5,JMC.HN,JMC.E5,JMC.EN,JMC.C5,JMC.EN,
    JMC.E5,JMC.HN,JMC.D5,JMC.QN,
    JMC.C5,JMC.DHN
  };

     Phrase myPhrase = new Phrase();
     myPhrase.addNoteList(phrase2data);
     return myPhrase;
}
```

Static? This means that we can actually access them without any instances. Is that useful here? Well, not *yet…*

Handling the linked list

```
// Here are the two methods needed to make a linked list of
   elements
 public void setNext(AmazingGraceSongElement2
   nextOne){
   this.next = nextOne;
 }

 public AmazingGraceSongElement2 next(){
   return this.next;
 }
```

Controlling access: An *accessor method*

```
// We could just access myPart directly
 // but we can CONTROL access by using
  a method
 // (called an accessor)
 private Part part(){
   return this.myPart;
 }
```

A little object manipulation

```
// Why do we need this?
 // If we want one piece to start after another, we need
 // to know when the last one ends.
 // Notice: It's the phrase that knows the end time.
 //    We have to ask the part for its phrase (assuming only
   one)
 //    to get the end time.
 public double getEndTime(){
   return this.myPart.getPhrase(0).getEndTime();
 }
```

showFromMeOn()

This is called *traversing* the linked list.

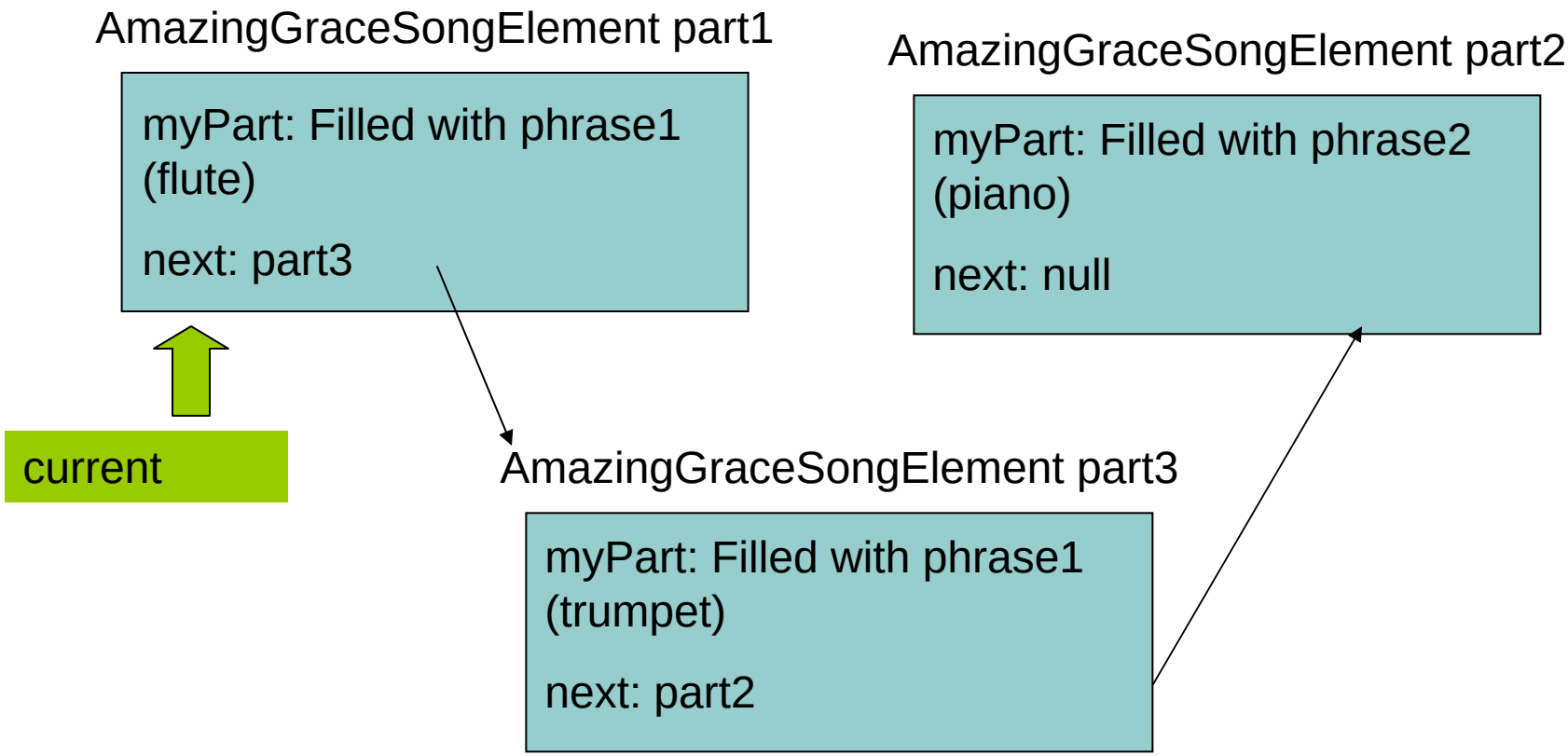
```
public void showFromMeOn(){
   // Make the score that we'll assemble the elements into
   // We'll set it up with the time signature and tempo we like
    Score myScore = new Score("Amazing Grace");
    myScore.setTimeSignature(3,4);
    myScore.setTempo(120.0);

    // Each element will be in its own channel
    int channelCount = 1;

    // Start from this element (this)
    AmazingGraceSongElement2 current = this;
    // While we're not through...
    while (current != null)
    {
      // Set the channel, increment the channel, then add it in.
      current.setChannel(channelCount);
      channelCount = channelCount + 1;
      myScore.addPart(current.part());

      // Now, move on to the next element
       current = current.next();
    };

    // At the end, let's see it!
    View.notate(myScore);

 }
```

The Key Part

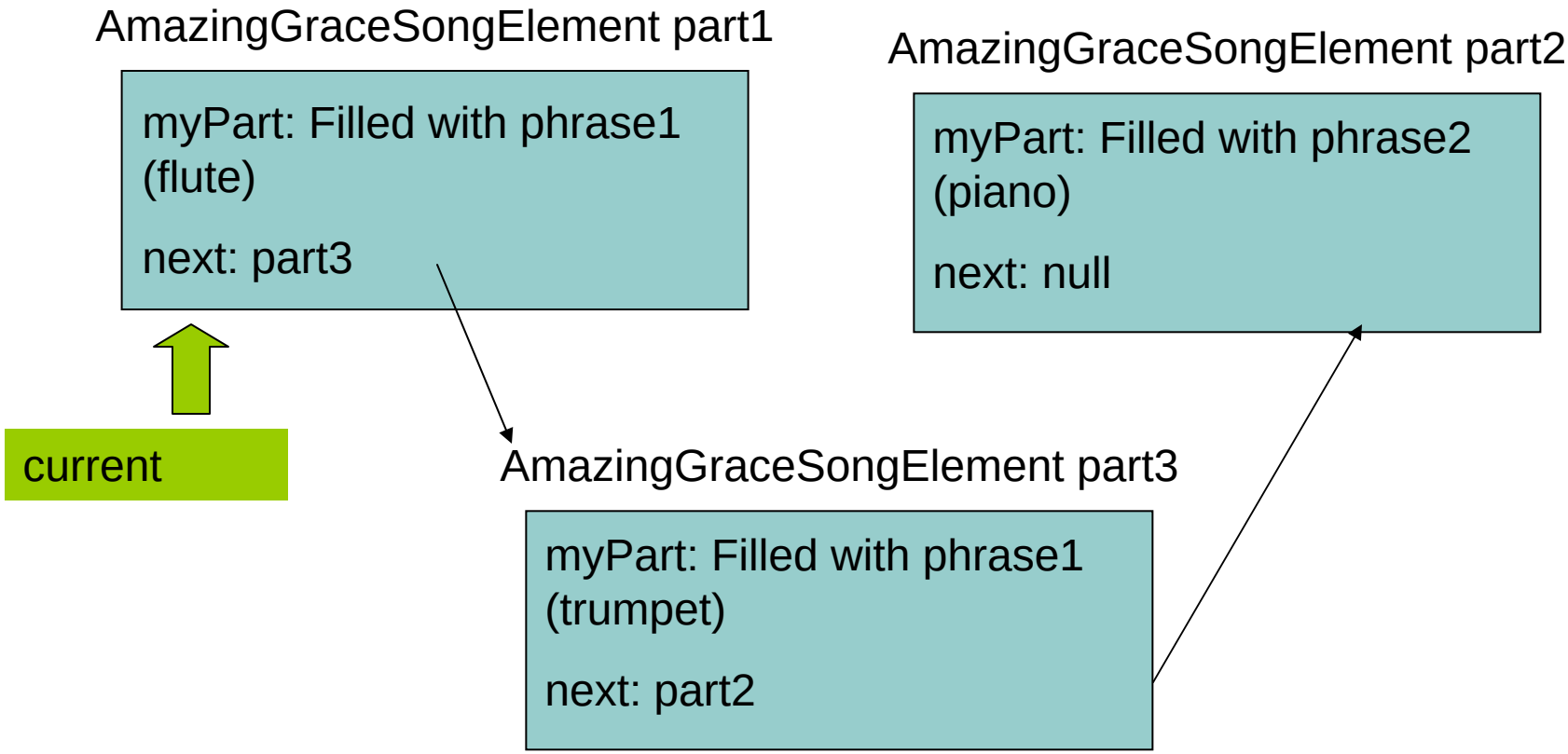
```
    // Start from this element (this)
    AmazingGraceSongElement2 current = this;
    // While we're not through...
    while (current != null)
    {
      // Set the channel, increment the channel, then add it in.
//BLAH BLAH BLAH (Ignore this part for now)

      // Now, move on to the next element
    current = current.next();
    };

    // At the end, let's see it!
    View.notate(myScore);
```

Step 1:

```
// Start from this element (this)
AmazingGraceSongElement2 current = this;
```

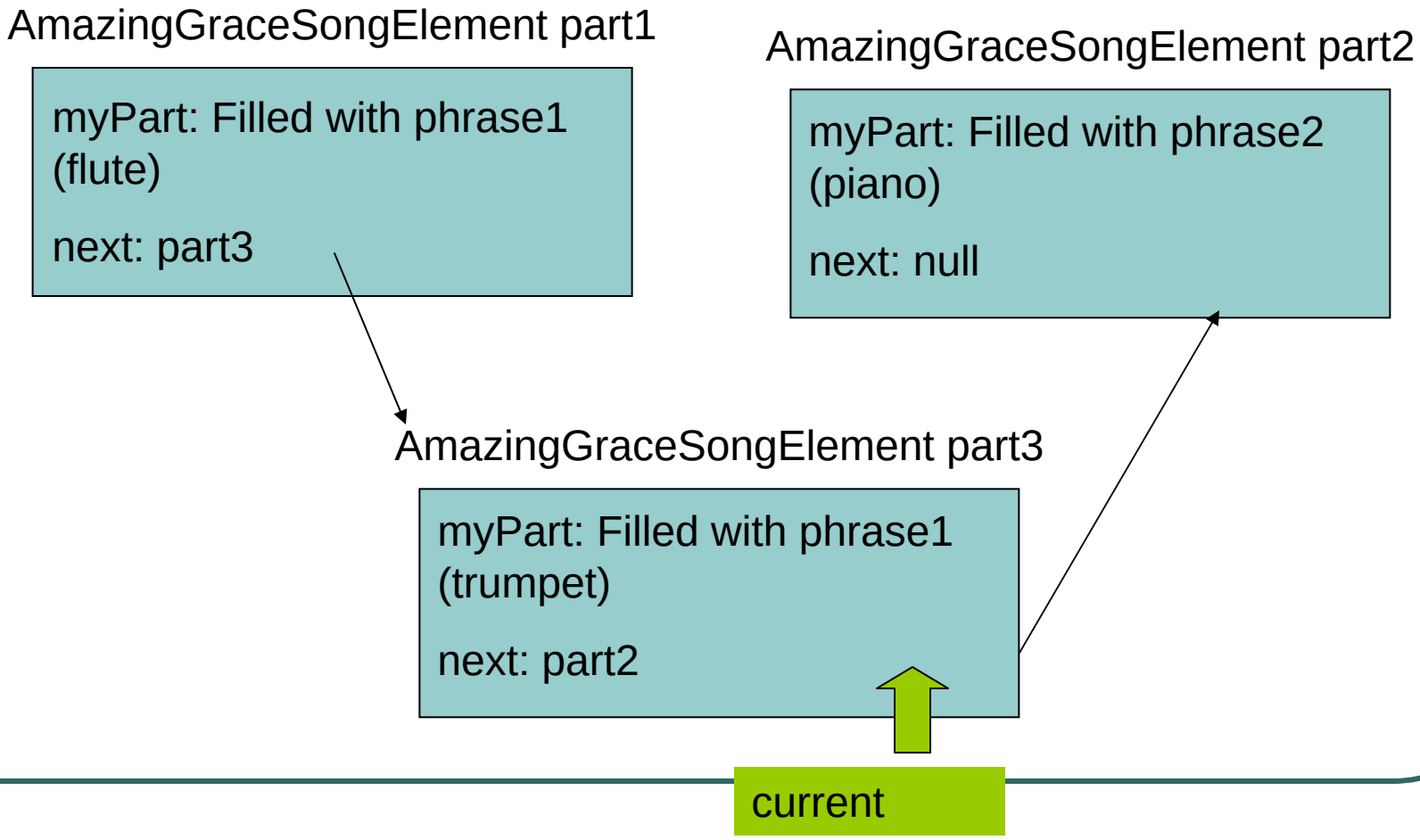


```
Step 2:
   // While we're not through...
    while (current != null)
        {  //BLAH BLAH BLAH – PROCESS THIS PART
```



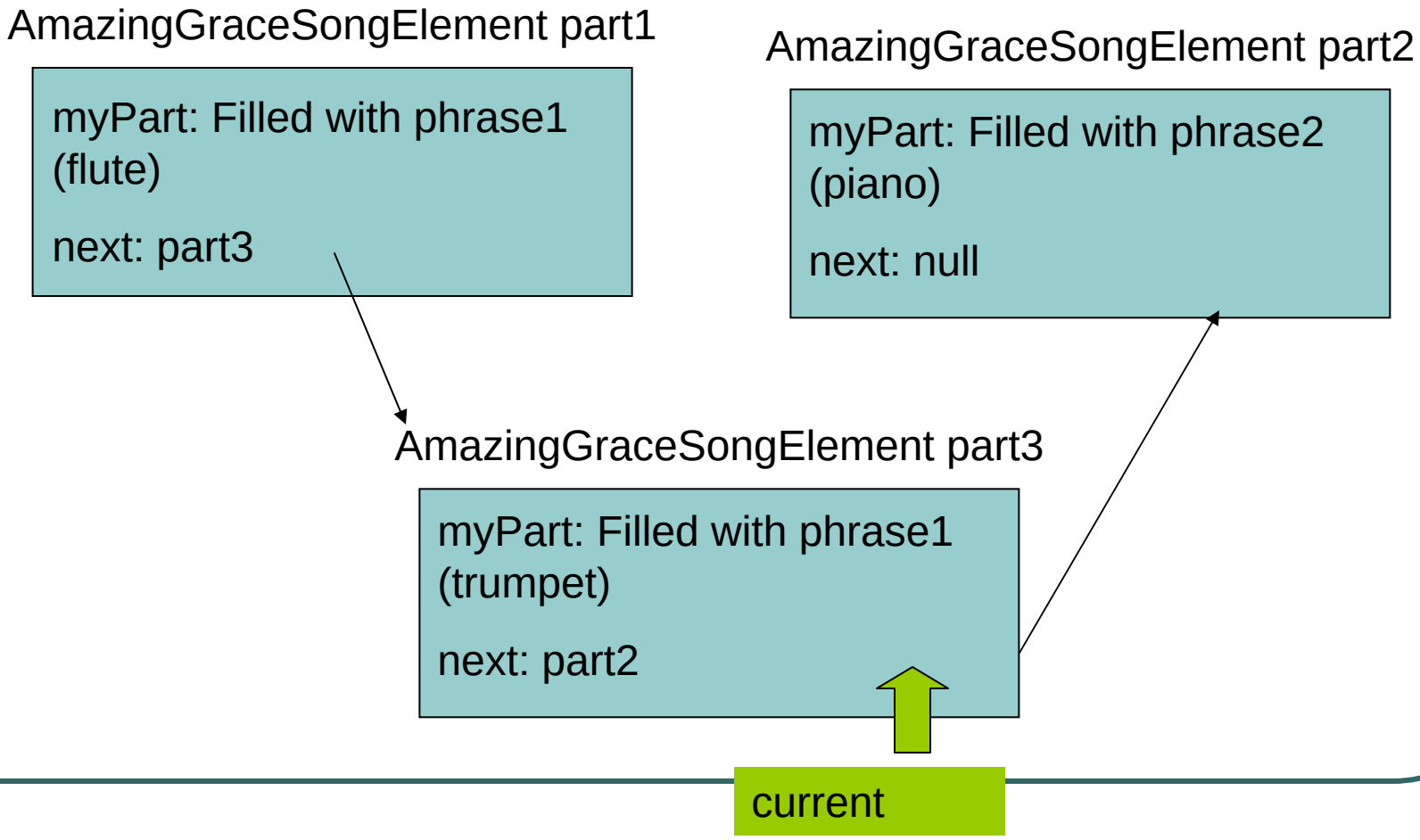
Step 3:

```
  // Now, move on to the next element
 current = current.next();
    };
```



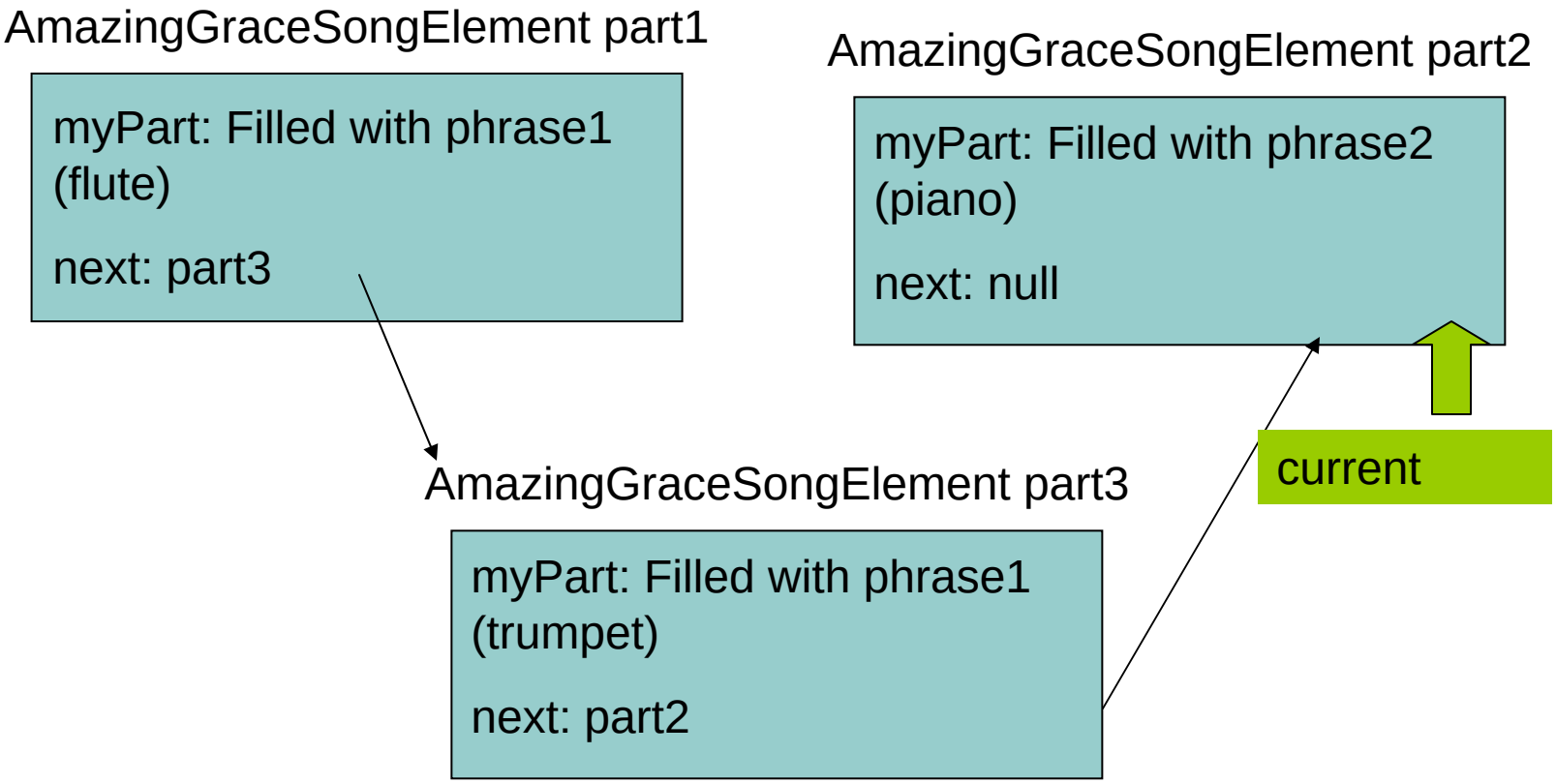
Step 4:

```
// While we're not through...
    while (current != null)
        { //BLAH BLAH BLAH – PROCESS THIS PART
```



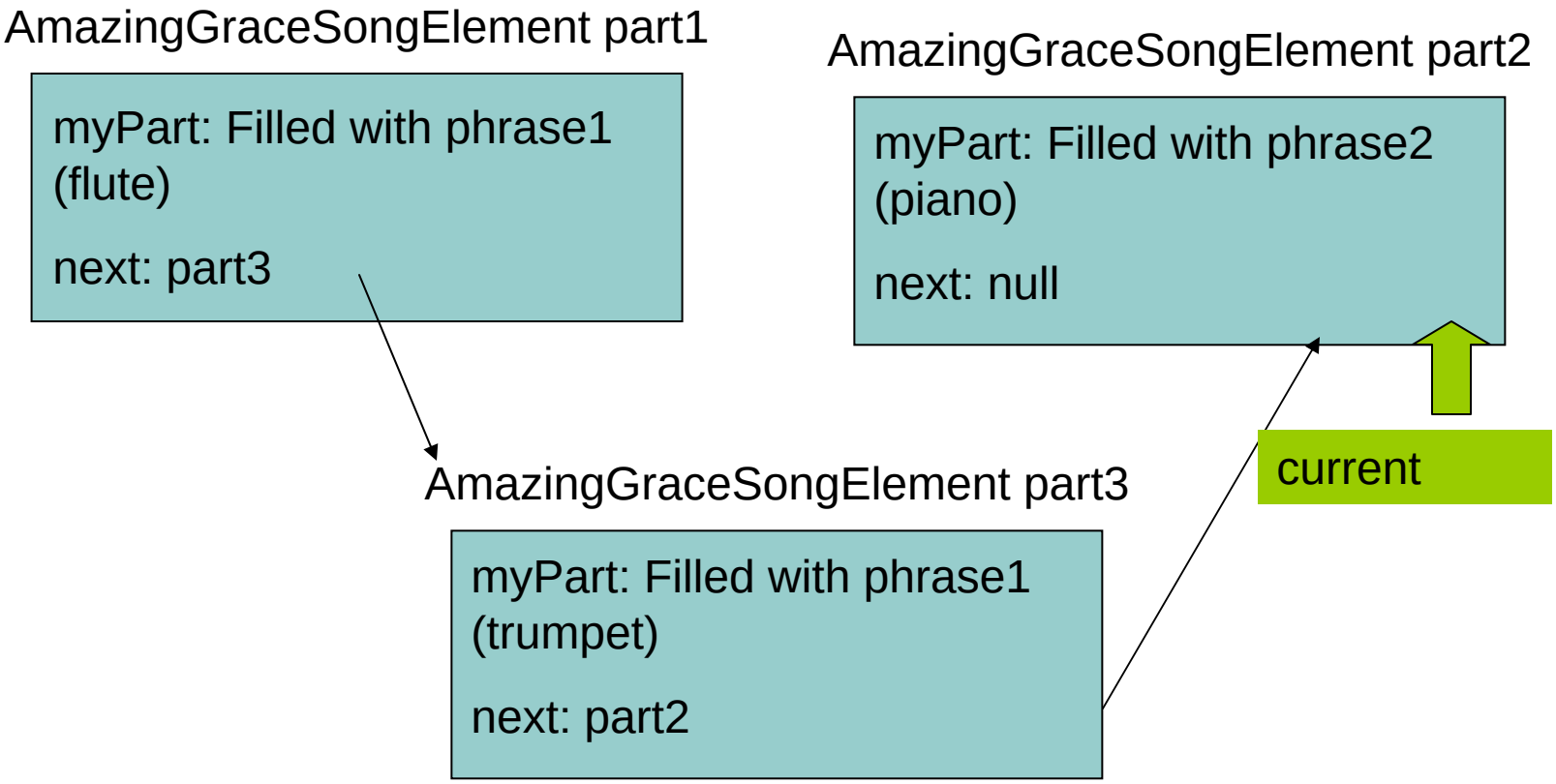
Step 5:

```
// Now, move on to the next element
 current = current.next();
    };
```



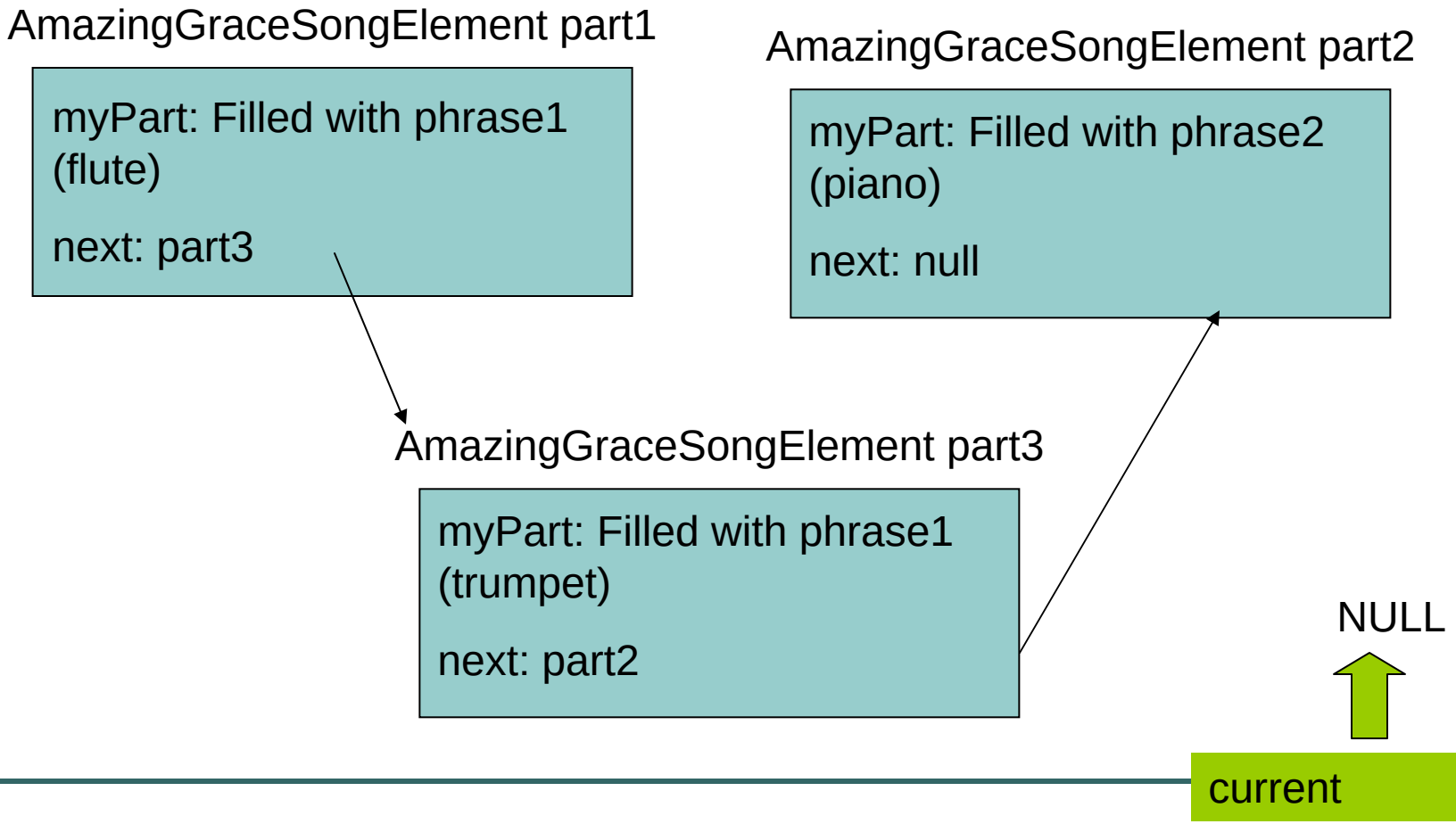
Step 6:

```
// While we're not through...
    while (current != null)
        { //BLAH BLAH BLAH – PROCESS THIS PART
```



Step 7:

```
// Now, move on to the next element
 current = current.next();
    };
```

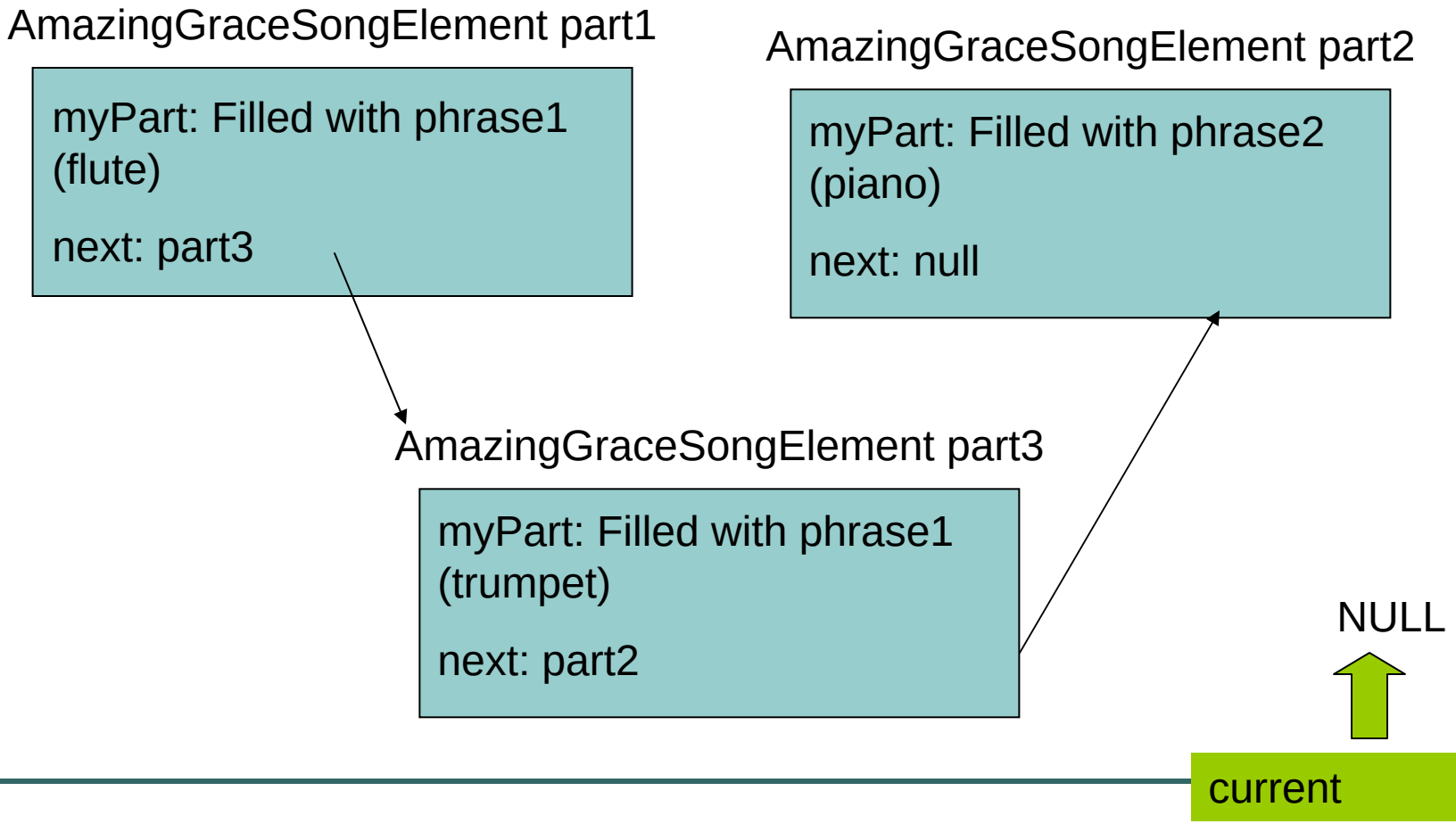


Step 8:

// While we're not through...

while (current != null)

STOP THE LOOP!



Traversing arrays vs. lists

```
//TRAVERSING A LIST
    // Start from this element (this)
    AmazingGraceSongElement2
     current = this;
    // While we're not through...
    while (current != null)
    {
      // Set the channel, increment the
     channel, then add it in.
//BLAH BLAH BLAH (Ignore this part
    for now)


     // Now, move on to the next
     element
     current = current.next();
    };
```

```
> // Now, traverse the array
    and gather them up.
> Phrase myphrase = new
    Phrase()
> for (int i=0; i<100; i++)
  {myphrase.addNote(
    someNotes[i]);}
```

Inserting into lists

```
// Here are the two methods
    needed to make a linked list
    of elements
 public void
    setNext(AmazingGraceSong
    Element2 nextOne){
   this.next = nextOne;
 }


 public
    AmazingGraceSongElement
    2 next(){
   return this.next;
 }
```

```
> part1.setNext(part3);
> part3.setNext(part2);
> part1.showFromMeOn();
```

Inserting into arrays

```
public void insertAfter(Sound inSound, int start){

    SoundSample current=null;
    // Find how long insound is
    int amtToCopy = inSound.getLength();
    int endOfThis = this.getLength()-1;
    // If too long, copy only as much as will fit
    if (start + amtToCopy > endOfThis)
    {amtToCopy = endOfThis-start-1;};

    // ** First, clear out room.
    // Copy from endOfThis-amtToCopy up to endOfThis
    for (int i=endOfThis-amtToCopy; i > start ; i--)
    {
      current = this.getSample(i);
      current.setValue(this.getSampleValueAt(i+amtToCopy));
    }

    //** Second, copy in inSound up to amtToCopy
    for (int target=start,source=0;
         source < amtToCopy;
         target++, source++) {
      current = this.getSample(target);
      current.setValue(inSound.getSampleValueAt(source));
    }
  }
```

```
> Sound test2 = new
    Sound(
    "D:/cs1316/MediaSourc
    es/thisisatest.wav");
> test.insertAfter(test2,
    40000)
> test.play()
```

More on Arrays vs. Lists

- Arrays
  - Much easier to traverse
  - Very fast to access a specific (n^{th}) element
  - But really a pain to insert and delete.
    - Hard to write the code
    - Can take a long time if it's a big array
- Lists
  - More complex to traverse
  - Slower to access a specific element
  - Very easy to insert (and later we'll see, delete)
    - Simple code
    - Takes no time at all to run

Critique of Version 2

- Lovely *structuring* of data, but just how much can one do with two parts of *Amazing Grace*?
  - We need the ability to have a library of phrases
- But what does the ordering mean? What if we had gone part1->part2->part3 instead?
  - What *should* the order *encode*?
  - Right now, it encodes *nothing*.
- When we're exploring music, do we really want to worry about instruments and start times for *every* phrase?

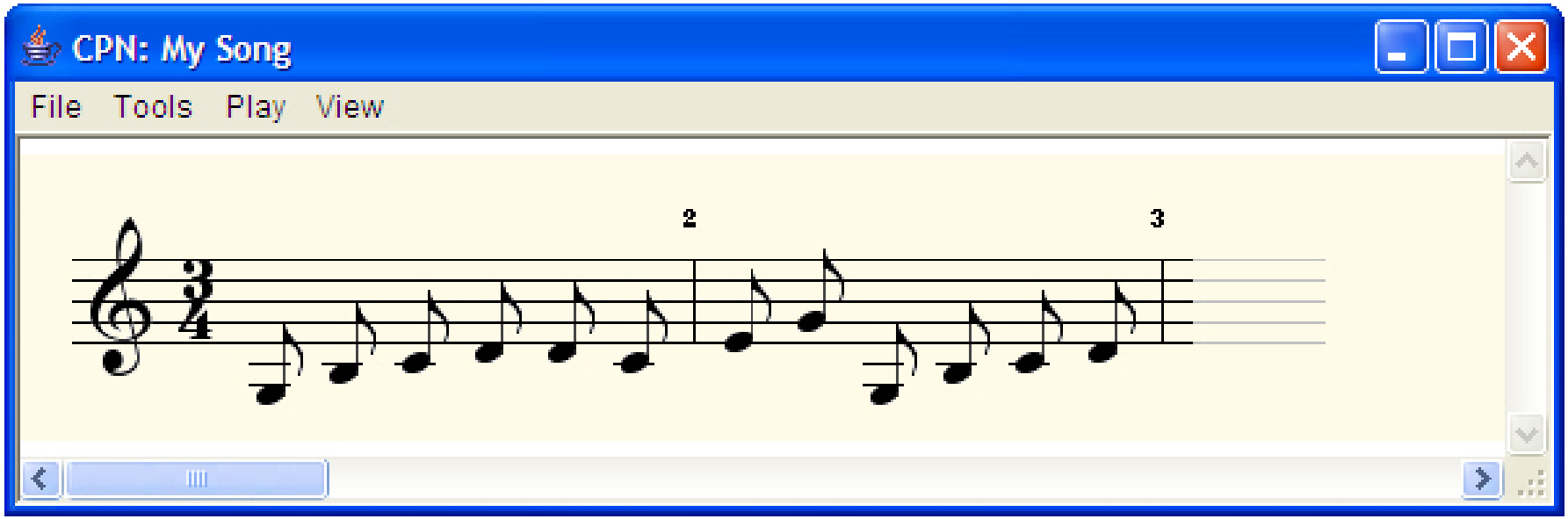
Version 3: SongNode and SongPhrase

- SongNode instances will hold pieces (phrases) from SongPhrase.
- SongNode instances will be the *nodes* in the linked list
  - Each one will know its next.
- Ordering will encode the order in the Part.
  - Each one will get appended after the last.

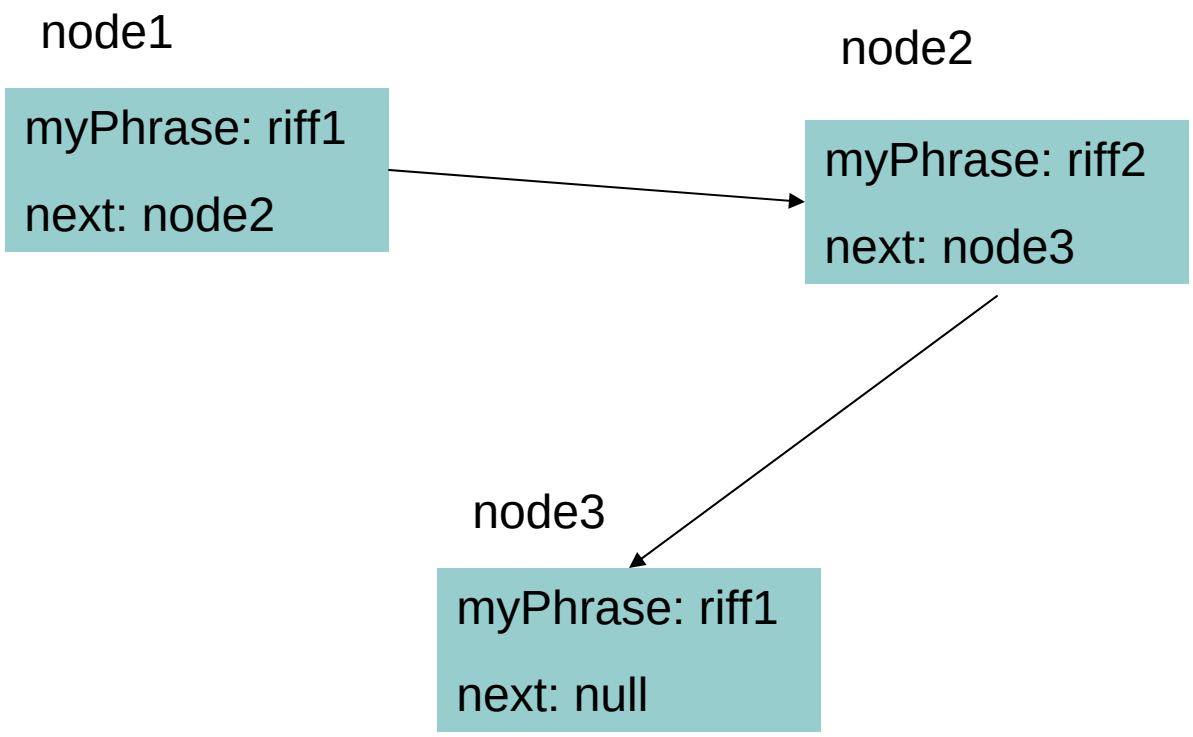
Using SongNode and SongPhrase

```
Welcome to DrJava.
> import jm.JMC;
> SongNode node1 = new SongNode();
> node1.setPhrase(SongPhrase.riff1());
> SongNode node2 = new SongNode();
> node2.setPhrase(SongPhrase.riff2());
> SongNode node3 = new SongNode();
> node3.setPhrase(SongPhrase.riff1());
> node1.setNext(node2);
> node2.setNext(node3);
> node1.showFromMeOn(JMC.SAX);
```

All three SongNodes in one Part



How to think about it



Declarations for SongNode

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.music.tools.*;

public class SongNode {
  /**
   * the next SongNode in the list
   */
  private SongNode next;
  /**
   * the Phrase containing the notes and durations associated with this
     node
   */
  private Phrase myPhrase;
```

SongNode's know their Phrase and the next node in the list

Constructor for SongNode

```
/**
  * When we make a new element, the next part
   is empty, and ours is a blank new part
  */
 public SongNode(){
   this.next = null;
   this.myPhrase = new Phrase();
 }
```

Setting the phrase

```
/**
  * setPhrase takes a Phrase and makes it the
    one for this node
  * @param thisPhrase the phrase for this node
  */
 public void setPhrase(Phrase thisPhrase){
    this.myPhrase = thisPhrase;
 }
```

Linked list methods

```
/**
  * Creates a link between the current node and the input node
  * @param nextOne the node to link to
  */
 public void setNext(SongNode nextOne){
   this.next = nextOne;
 }
/**
  * Provides public access to the next node.
  * @return a SongNode instance (or null)
  */
 public SongNode next(){
   return this.next;
 }
```

insertAfter

```
/**
  * Insert the input SongNode AFTER this node,
  * and make whatever node comes NEXT become the next of the
    input node.
  * @param nextOne SongNode to insert after this one
  */
 public void insertAfter(SongNode nextOne)
 {
     SongNode oldNext = this.next(); // Save its next
     this.setNext(nextOne); // Insert the copy
     nextOne.setNext(oldNext); // Make the copy point on to the rest

 }
```

Using and tracing insertAfter()

```
> SongNode nodeA = new SongNode();
> SongNode nodeB = new SongNode();
> nodeA.setNext(nodeB);
> SongNode nodeC = new SongNode()
> nodeA.insertAfter(nodeC);
```

```
public void insertAfter(SongNode nextOne)
  {
      SongNode oldNext = this.next(); // Save
its next
      this.setNext(nextOne); // Insert the copy
      nextOne.setNext(oldNext); // Make the
copy point on to the rest

  }
```

Traversing the list

```
/**
 * Collect all the notes from this node on
 * in an part (then a score) and open it up for viewing.
 * @param instrument MIDI instrument (program) to be used in playing this list
 */
public void showFromMeOn(int instrument){
  // Make the Score that we'll assemble the elements into
  // We'll set it up with a default time signature and tempo we like
  // (Should probably make it possible to change these -- maybe with inputs?)
   Score myScore = new Score("My Song");
   myScore.setTimeSignature(3,4);
   myScore.setTempo(120.0);

   // Make the Part that we'll assemble things into
   Part myPart = new Part(instrument);

   // Make a new Phrase that will contain the notes from all the phrases
   Phrase collector = new Phrase();

   // Start from this element (this)
   SongNode current = this;
   // While we're not through...
   while (current != null)
   {
     collector.addNoteList(current.getNotes());

     // Now, move on to the next element
     current = current.next();
   };

   // Now, construct the part and the score.
   myPart.addPhrase(collector);
   myScore.addPart(myPart);

   // At the end, let's see it!
   View.notate(myScore);

}
```

The Core of the Traversal

```
// Make a new Phrase that will contain the notes from all the phrases
Phrase collector = new Phrase();

// Start from this element (this)
SongNode current = this;
// While we're not through...
while (current != null)
{
  collector.addNoteList(current.getNotes());

  // Now, move on to the next element
  current = current.next();
};
```

Then return what you collected

```
// Now, construct the part and the score.
    myPart.addPhrase(collector);
    myScore.addPart(myPart);

    // At the end, let's see it!
    View.notate(myScore);

 }
```

getNotes() just pulls the notes back out

```
/**
  * Accessor for the notes inside the node's
   phrase
  * @return array of notes and durations inside
   the phrase
  */
 private Note [] getNotes(){
   return this.myPhrase.getNoteArray();
 }
```

SongPhrase

- SongPhrase is a collection of *static* methods.
- We don’t ever need an instance of SongPhrase.
- Instead, we use it to store methods that return phrases.
  - It’s not very object-oriented, but it’s useful here.

SongPhrase.riff1()

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.music.tools.*;

public class SongPhrase {
 //Little Riff1
   static public Phrase riff1() {
    double[] phrasedata =
   {JMC.G3,JMC.EN,JMC.B3,JMC.EN,JMC.C4,JMC.EN,JMC.D4,JMC.EN};

      Phrase myPhrase = new Phrase();
      myPhrase.addNoteList(phrasedata);
      return myPhrase;
```

SongPhrase.riff2()

```
//Little Riff2
  static public Phrase riff2() {
   double[] phrasedata =

   {JMC.D4,JMC.EN,JMC.C4,JMC.EN,JMC.E4,JMC.EN,JM
   C.G4,JMC.EN};

     Phrase myPhrase = new Phrase();
     myPhrase.addNoteList(phrasedata);
     return myPhrase;
}
```

Computing a phrase

```
//Larger Riff1
static public Phrase pattern1() {
      double[] riff1data =
{JMC.G3,JMC.EN,JMC.B3,JMC.EN,JMC.C4,JMC.EN,JMC.D4,JMC.EN};
 double[] riff2data =
{JMC.D4,JMC.EN,JMC.C4,JMC.EN,JMC.E4,JMC.EN,JMC.G4,JMC.EN};

 Phrase myPhrase = new Phrase();
 // 3 of riff1, 1 of riff2, and repeat all of it 3 times
 for (int counter1 = 1; counter1 <= 3; counter1++)
 {for (int counter2 = 1; counter2 <= 3; counter2++)
   myPhrase.addNoteList(riff1data);
 myPhrase.addNoteList(riff2data);
 };
   return myPhrase;
}
```

As long as it's a phrase...

- The way that we use SongNote and SongPhrase, any method that returns a phrase is perfectly valid SongPhrase method.

10 Random Notes (Could be less random...)

```
/*
   * 10 random notes
   **/
  static public Phrase random() {
    Phrase ranPhrase = new Phrase();
    Note n = null;

    for (int i=0; i < 10; i++) {
      n = new Note((int) (128*Math.random()),0.1);
      ranPhrase.addNote(n);
    }
    return ranPhrase;
  }
```

10 Slightly Less Random Notes

```
/*
   * 10 random notes above middle C
   **/
  static public Phrase randomAboveC() {
    Phrase ranPhrase = new Phrase();
    Note n = null;

    for (int i=0; i < 10; i++) {
      n = new Note((int) (60+(5*Math.random())),0.25);
      ranPhrase.addNote(n);
    }
    return ranPhrase;
  }
```

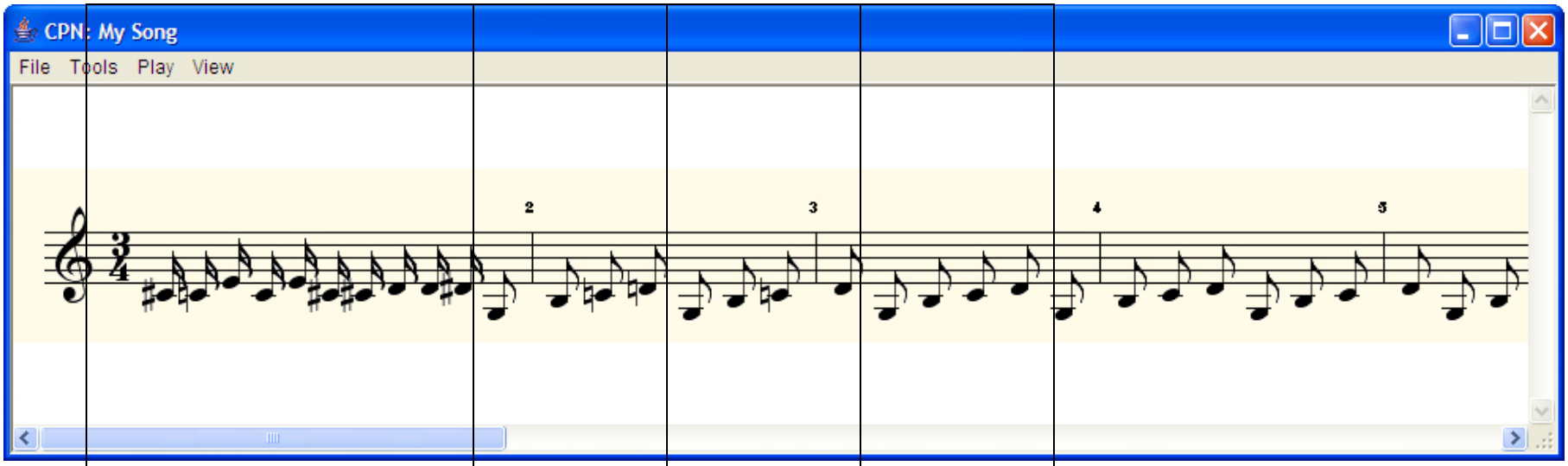
Going beyond connecting nodes

- So far, we've just created nodes and connected them up.
- What else can we do?
- Well, music is about repetition and interleaving of themes.
  - Let's create those abilities for SongNodes.

Repeating a Phrase

```
Welcome to DrJava.
> SongNode node = new SongNode();
> node.setPhrase(SongPhrase.randomAboveC());
> SongNode node1 = new SongNode();
> node1.setPhrase(SongPhrase.riff1());
> node.repeatNext(node1,10);
> import jm.JMC;
> node.showFromMeOn(JMC.PIANO);
```

What it looks like



node	node1	node1	node1	...

Repeating

Note! What happens to this's **next**? How would you create a *looong* repeat chain of *several* types of phrases with this?

```
/**
 * Repeat the input phrase for the number of
   times specified.
 * It always appends to the current node, NOT
   insert.
 * @param nextOne node to be copied in to list
 * @param count number of times to copy it in.
 */
public void repeatNext(SongNode nextOne,int
   count) {
  SongNode current = this; // Start from here
  SongNode copy; // Where we keep the current
   copy

  for (int i=1; i <= count; i++)
  {
    copy = nextOne.copyNode(); // Make a copy
    current.setNext(copy); // Set as next
    current = copy; // Now append to copy
  }
}
```

Here's making a copy

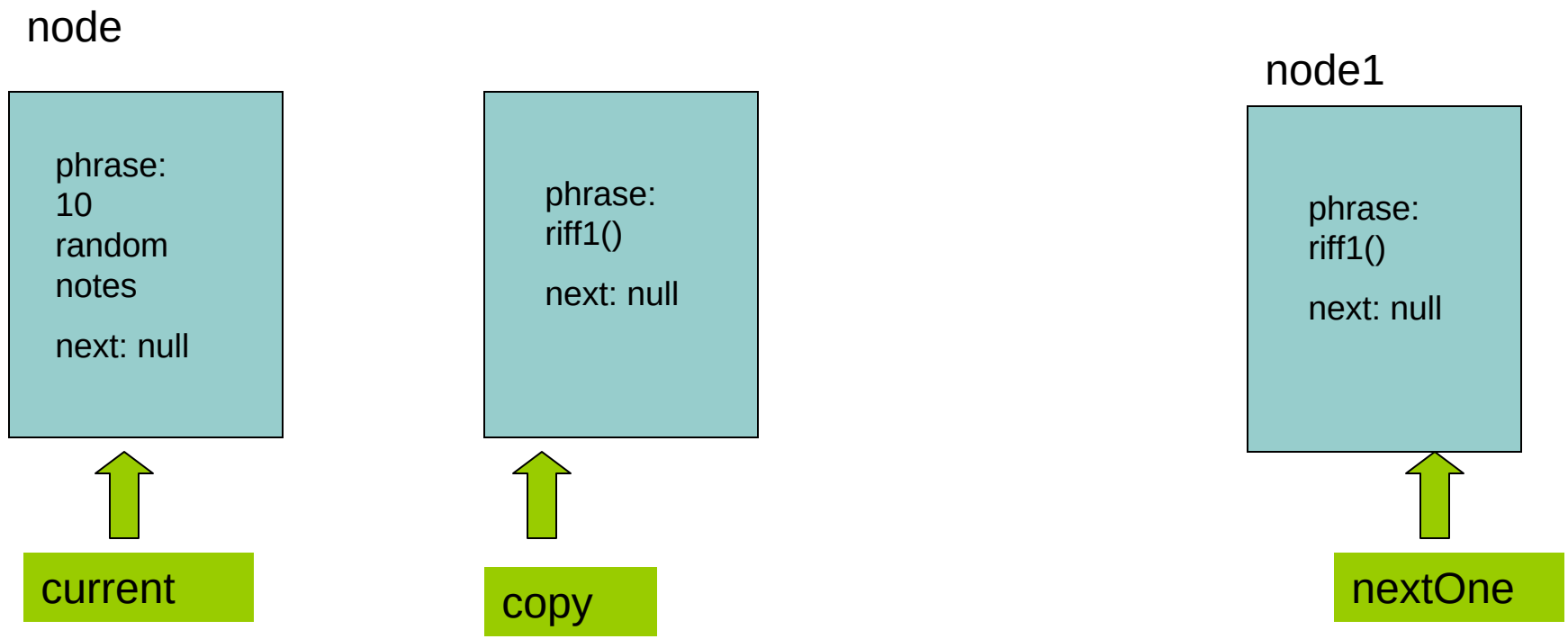
```
/**
  * copyNode returns a copy of this node
  * @return another song node with the same
   notes
  */
 public SongNode copyNode(){
   SongNode returnMe = new SongNode();
   returnMe.setPhrase(this.getPhrase());
   return returnMe;
 }
```

Step 1:

```
public void repeatNext(SongNode nextOne,int count) {
    SongNode current = this; // Start from here
    SongNode copy; // Where we keep the current copy
```

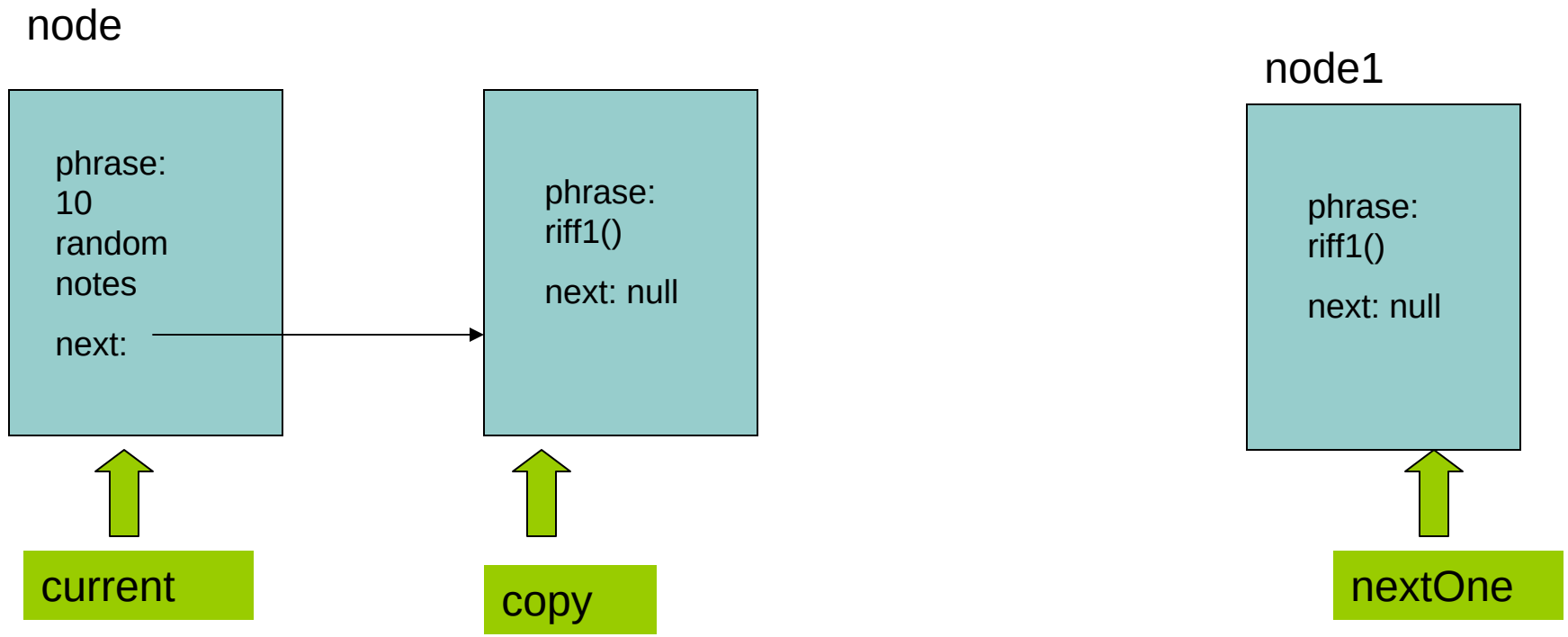
Step 2:

copy = nextOne.copyNode(); // Make a copy



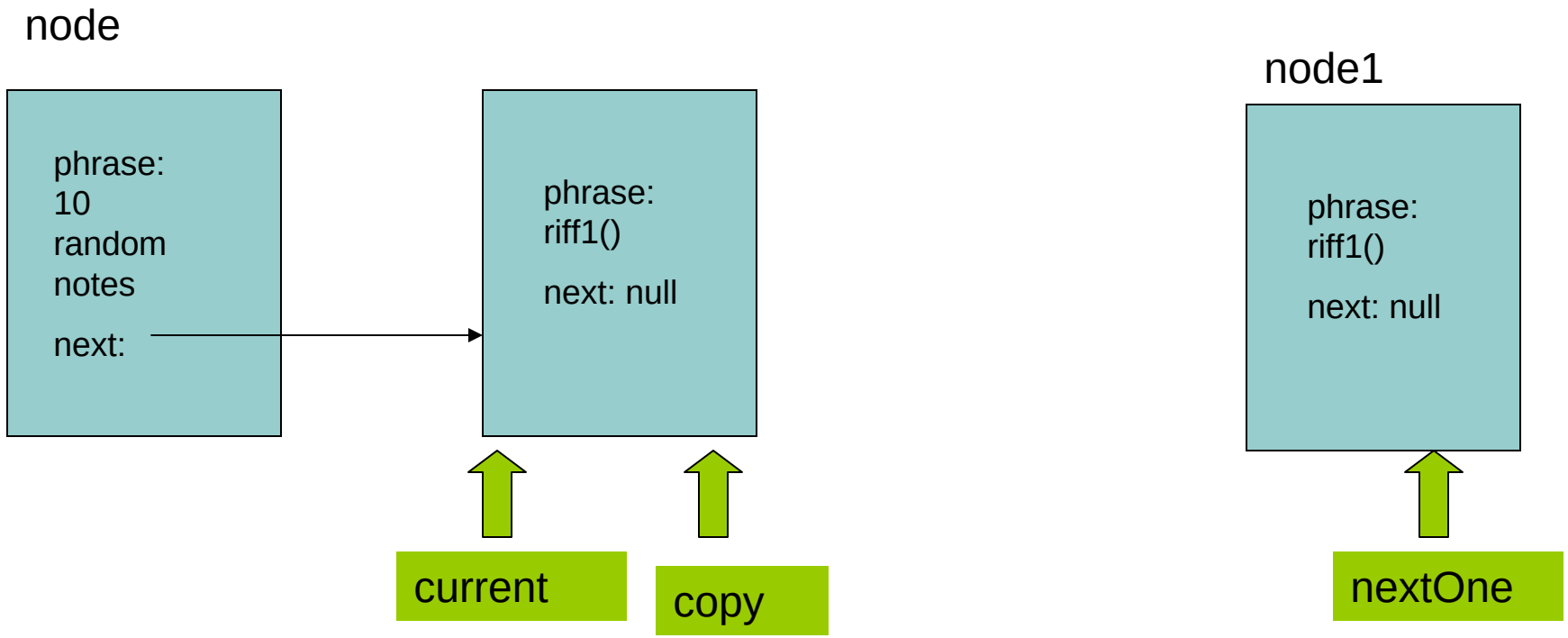
Step 3:

current.setNext(copy); // Set as next



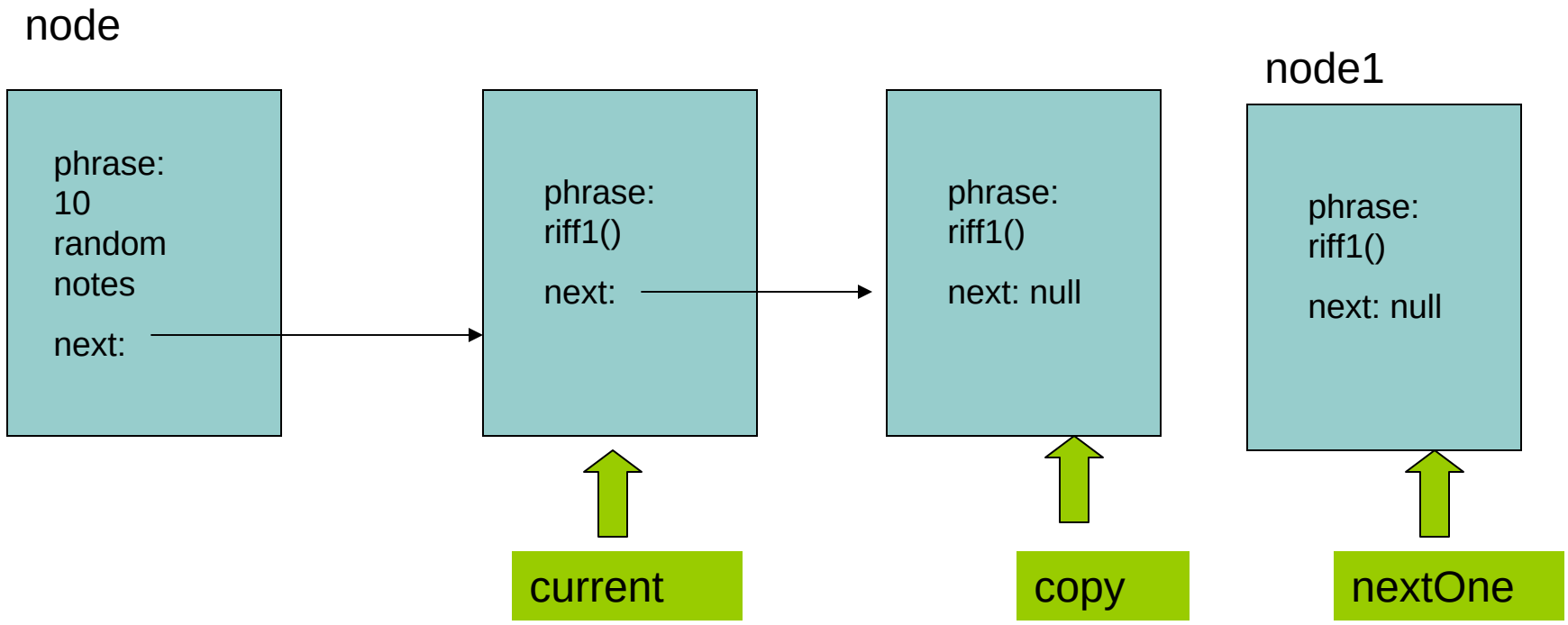
Step 4:

current = copy; // Now append to copy



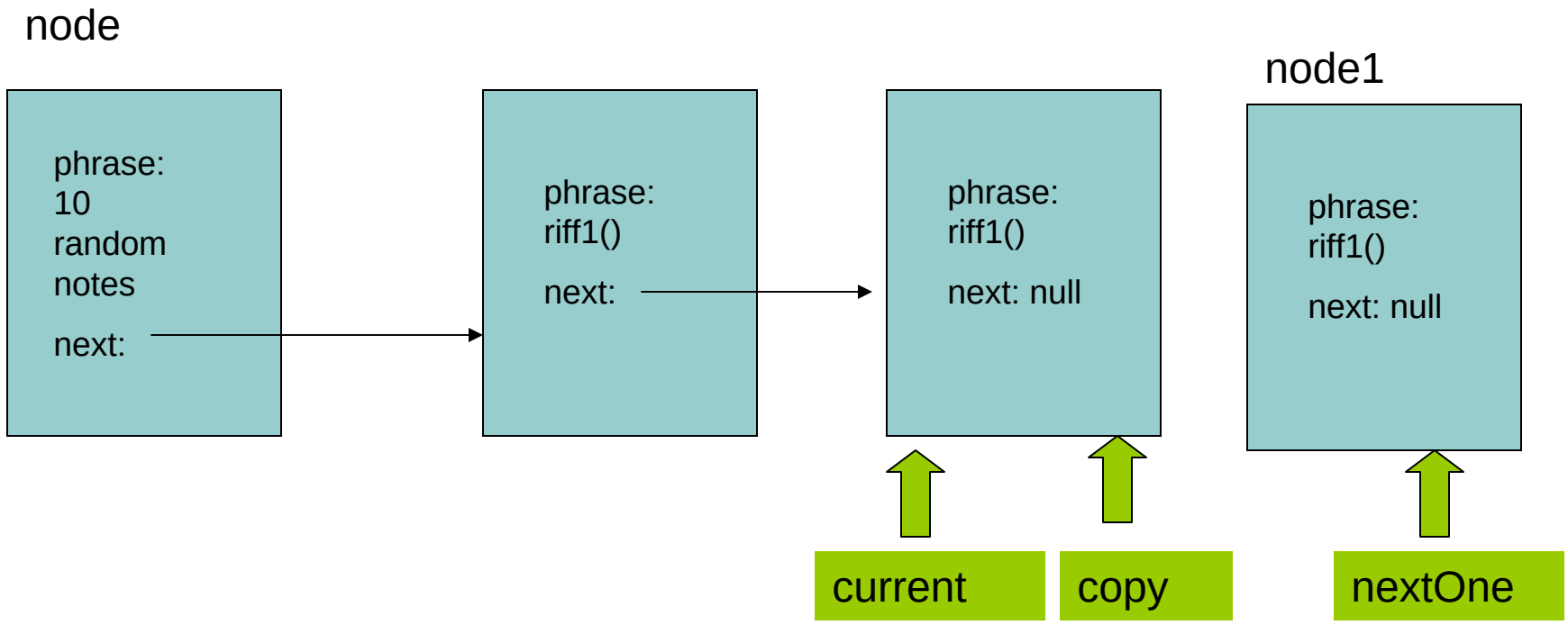
Step 5 & 6:

```
copy = nextOne.copyNode(); // Make a copy
current.setNext(copy); // Set as next
```



Step 7 (and so on):

current = copy; // Now append to copy



What happens if the node already points to something?

- Consider **repeatNext** and how it inserts: It simply sets the next value.
- What if the node *already had* a **next**?
- **repeatNext** will *erase* whatever *used* to come next.
- How can we fix it?

repeatNextInserting

```
/**
  * Repeat the input phrase for the number of times specified.
  * But do an insertion, to save the rest of the list.
  * @param nextOne node to be copied into the list
  * @param count number of times to copy it in.
  **/
 public void repeatNextInserting(SongNode nextOne, int count){
   SongNode current = this; // Start from here
   SongNode copy; // Where we keep the current copy

   for (int i=1; i <= count; i++)
   {
     copy = nextOne.copyNode(); // Make a copy
     current.insertAfter(copy); // INSERT after current
     current = copy; // Now append to copy
   }
 }
```

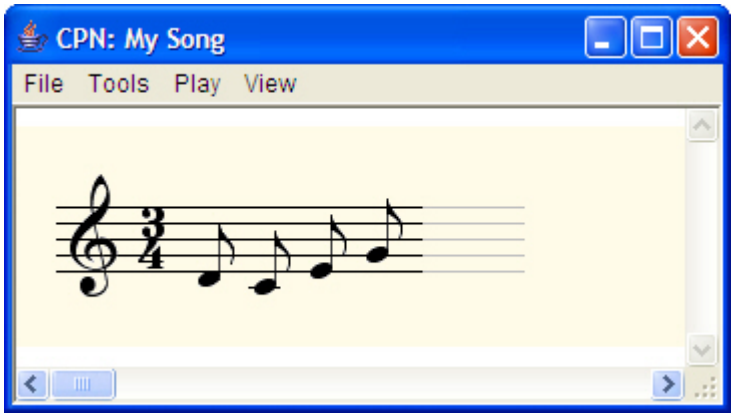
Weaving

```
/**
 * Weave the input phrase count times every skipAmount nodes
 * @param nextOne node to be copied into the list
 * @param count how many times to copy
 * @param skipAmount how many nodes to skip per weave
 */
public void weave(SongNode nextOne, int count, int skipAmount)
{
  SongNode current = this; // Start from here
  SongNode copy; // Where we keep the one to be weaved in
  SongNode oldNext; // Need this to insert properly
  int skipped; // Number skipped currently

  for (int i=1; i <= count; i++)
  {
    copy = nextOne.copyNode(); // Make a copy

    //Skip skipAmount nodes
    skipped = 1;
    while ((current.next() != null) && (skipped < skipAmount))
    {
      current = current.next();
      skipped++;
    };

    oldNext = current.next(); // Save its next
    current.insertAfter(copy); // Insert the copy after this one
    current = oldNext; // Continue on with the rest
    if (current.next() == null) // Did we actually get to the end early?
       break; // Leave the loop

  }
}
```

Should we break before the last insert (when we get to the end) or after?

Creating a node to weave

```
> SongNode node2 = new SongNode();
> node2.setPhrase(SongPhrase.riff2());
> node2.showFromMeOn(JMC.PIANO);
```

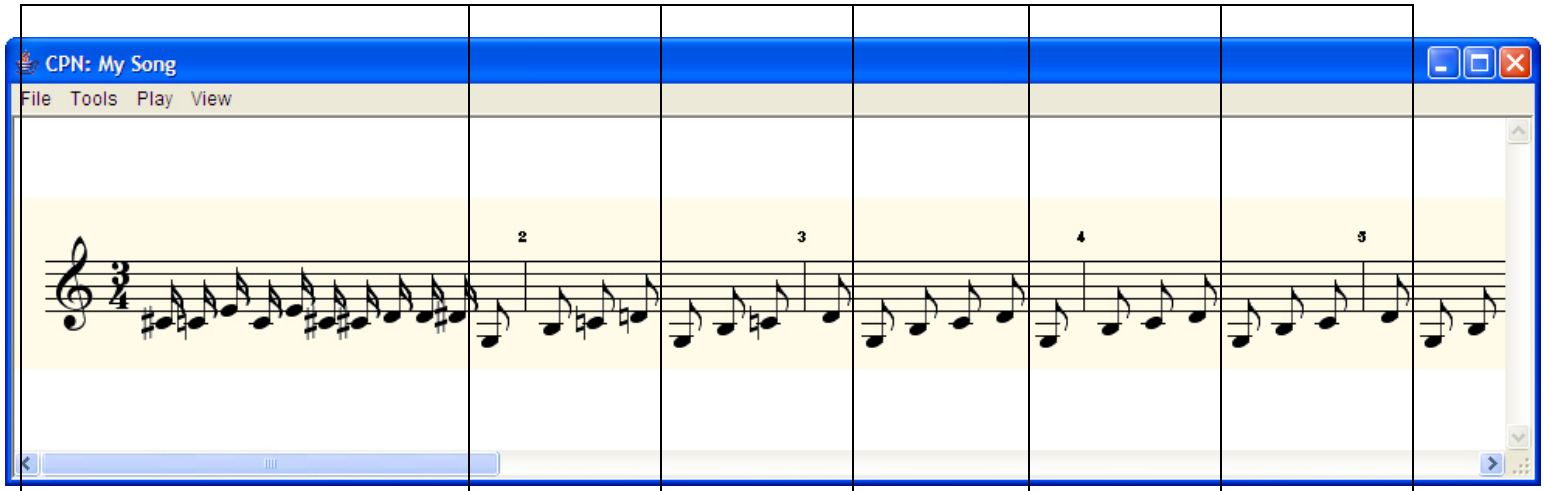


Doing a weave

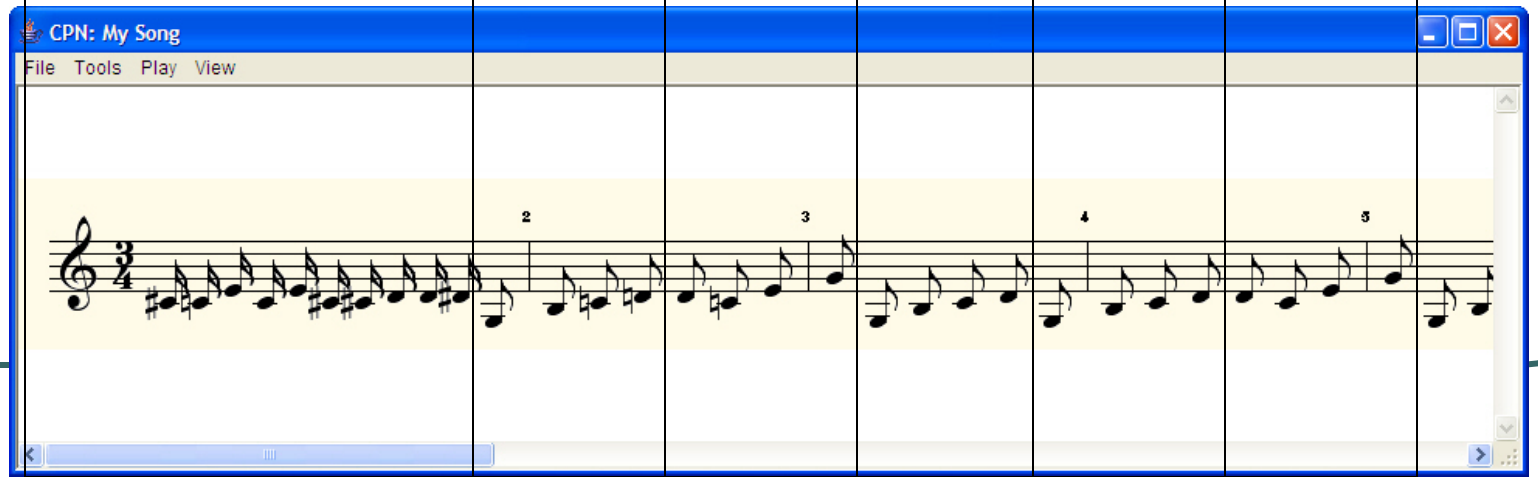
```
> node.weave(node2,4,2);
> node.showFromMeOn(JMC.PIANO);
```

Weave Results

Before:



After



Walking the Weave

```
public void weave(SongNode nextOne, int count,
    int skipAmount)
 {
    SongNode current = this; // Start from here
    SongNode copy; // Where we keep the one to be
    weaved in
    SongNode oldNext; // Need this to insert
    properly
    int skipped; // Number skipped currently
```

Skip forward

```
for (int i=1; i <= count; i++)
    {
      copy = nextOne.copyNode(); // Make a copy

      //Skip skipAmount nodes
      skipped = 1;
      while ((current.next() != null) && (skipped < skipAmount))
      {
        current = current.next();
        skipped++;
      };
```

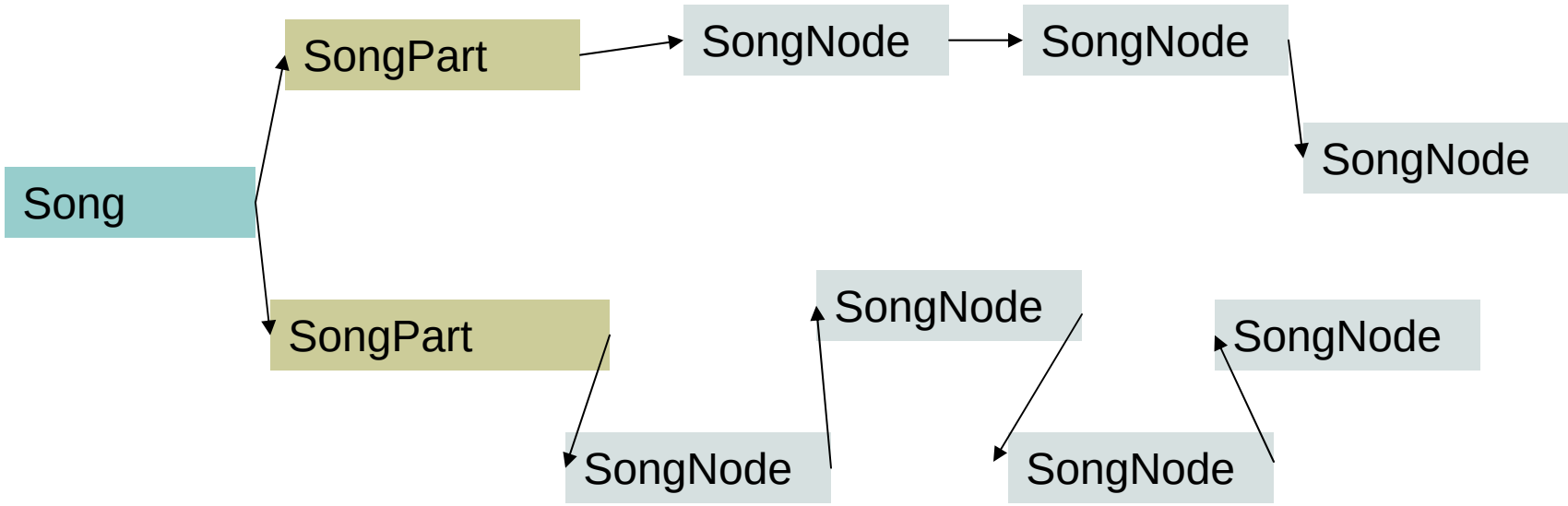
Then do an insert

```
  if (current.next() == null) // Did we actually get to the end early?
    break; // Leave the loop

  oldNext = current.next(); // Save its next
  current.insertAfter(copy); // Insert the copy after this one
  current = oldNext; // Continue on with the rest
}
```

Version 4: Creating a tree of song parts, each with its own instrument

- SongNode and SongPhrase offer us enormous flexibility in exploring musical patterns.
- But it’s only one part!
- We’ve lost the ability of having different parts starting at different time!
- Let’s get that back.

The Structure We're Creating



Starting to look like a tree…

Example Song

```
import jm.music.data.*;
import jm.JMC;
import jm.util.*;
import jm.JMC;

public class MyFirstSong {
  public static void main(String [] args) {
    Song songroot = new Song();

    SongNode node1 = new SongNode();
    SongNode riff3 = new SongNode();
    riff3.setPhrase(SongPhrase.riff3());
    node1.repeatNext(riff3,16);
    SongNode riff1 = new SongNode();
    riff1.setPhrase(SongPhrase.riff1());
    node1.weave(riff1,7,1);
    SongPart part1 = new SongPart(JMC.PIANO, node1);

    songroot.setFirst(part1);

    SongNode node2 = new SongNode();
    SongNode riff4 = new SongNode();
    riff4.setPhrase(SongPhrase.riff4());
    node2.repeatNext(riff4,20);
    node2.weave(riff1,4,5);
    SongPart part2 = new SongPart(JMC.STEEL_DRUMS, node2);

    songroot.setSecond(part2);
    songroot.show();
  }
}
```