Exploring Melody Space in a Live Context Using Declarative Functional Programming

FARM Workshop at ICFP 2014, Gothenburg

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Composer is a simple, responsive and extensible system utilising logic programming to allow novices to explore and learn music rules

Background

Background

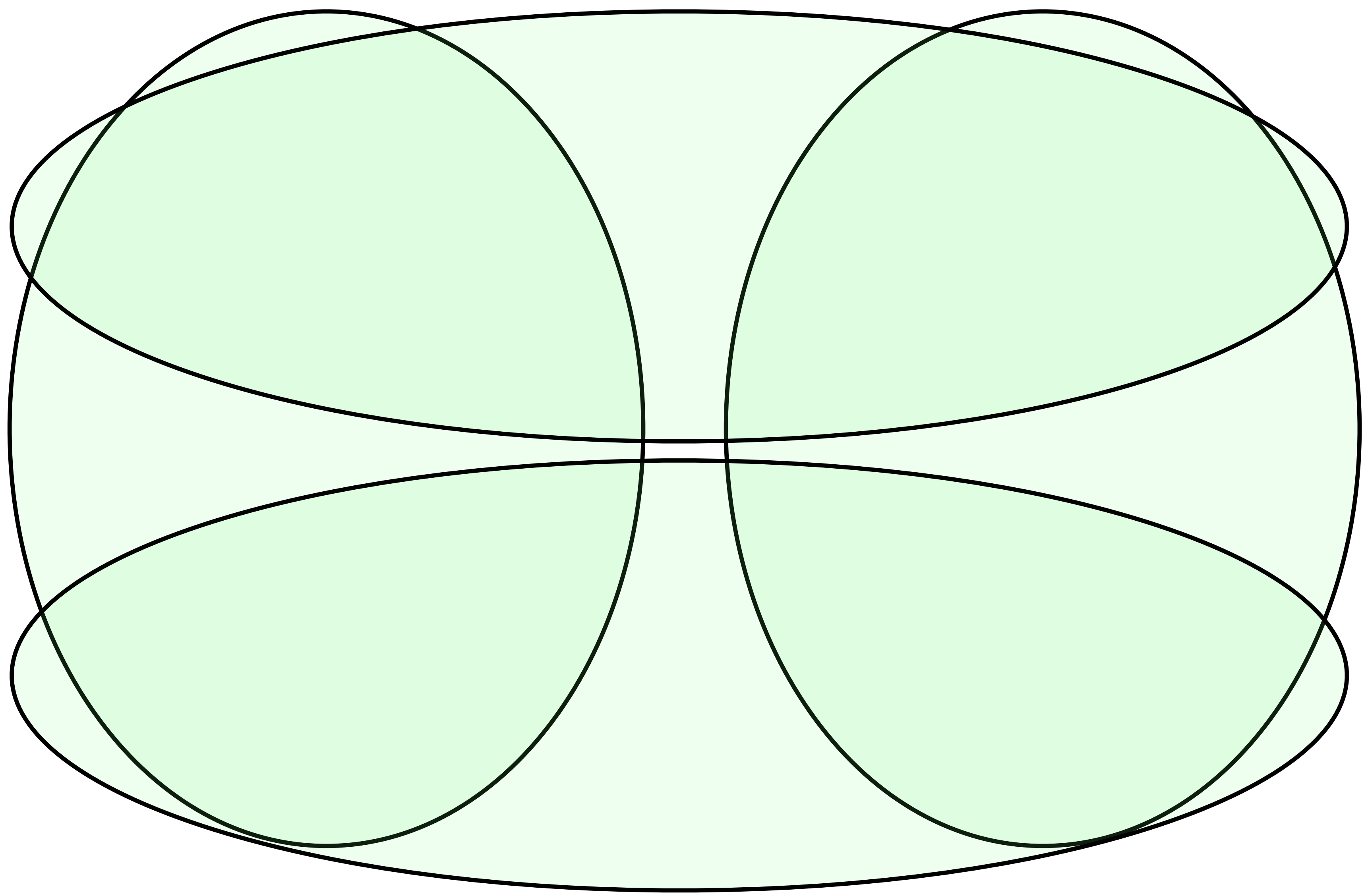
offline

online

Background

	programmers	musicians
offline		
online		

Background



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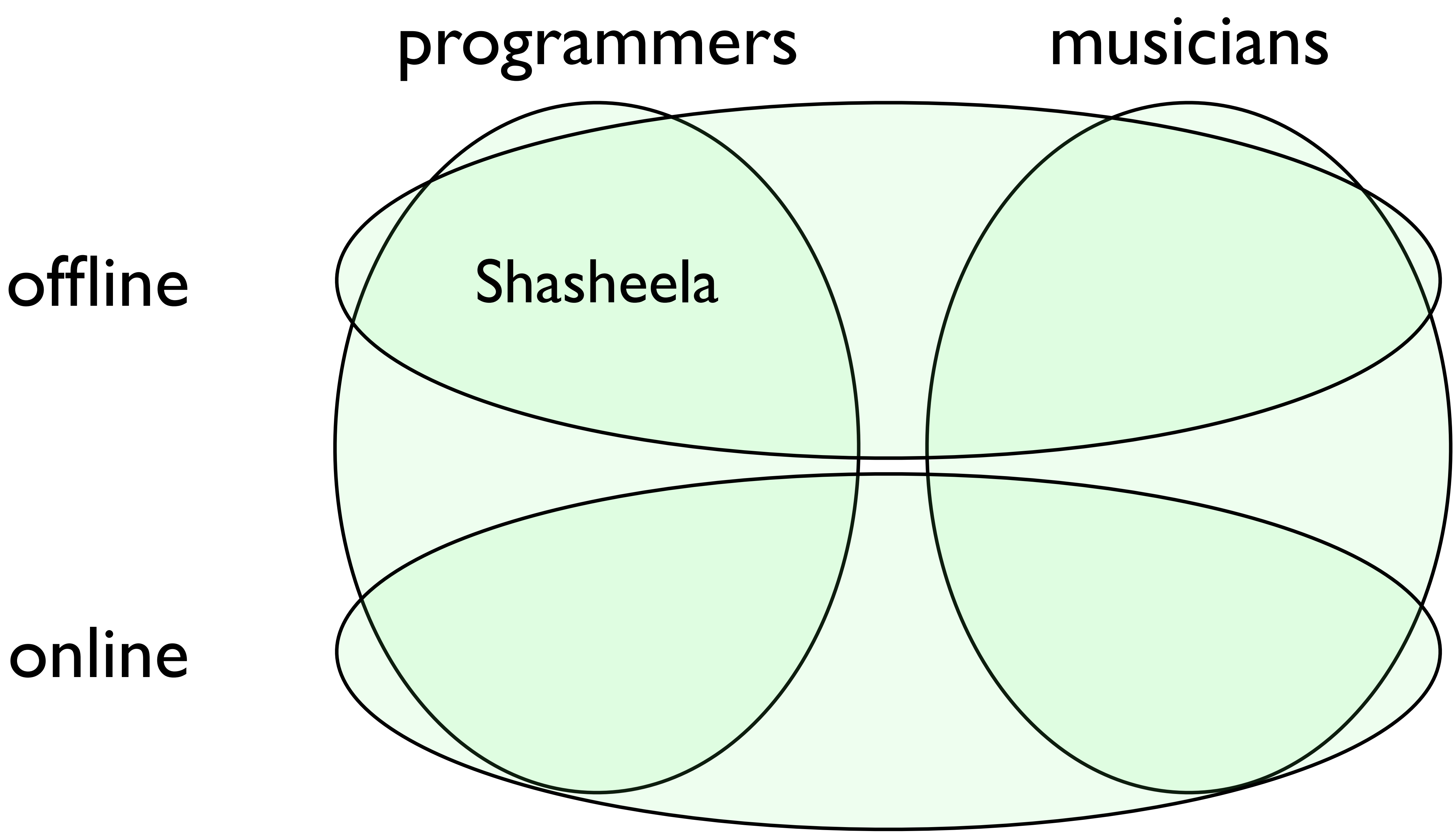

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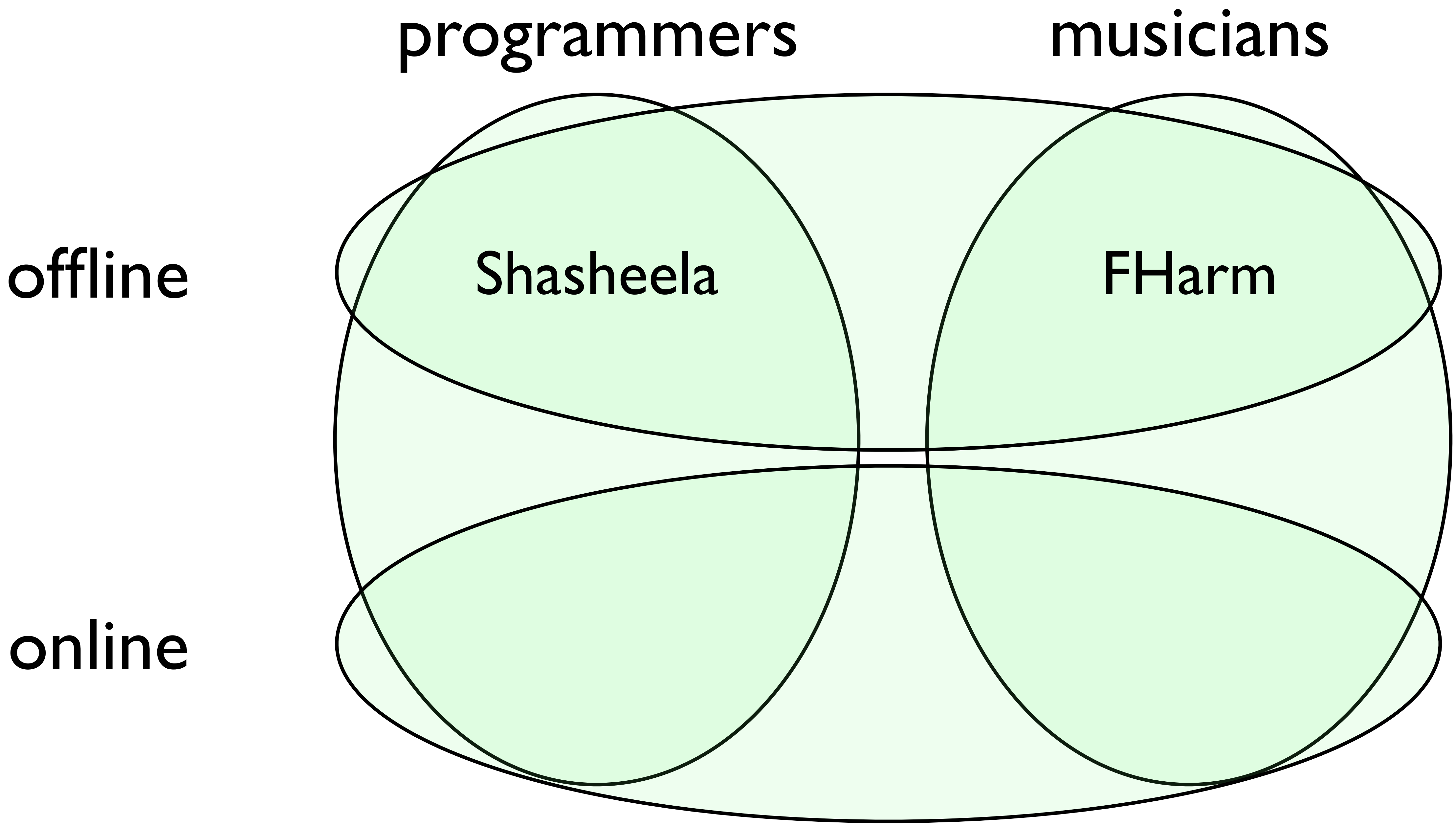

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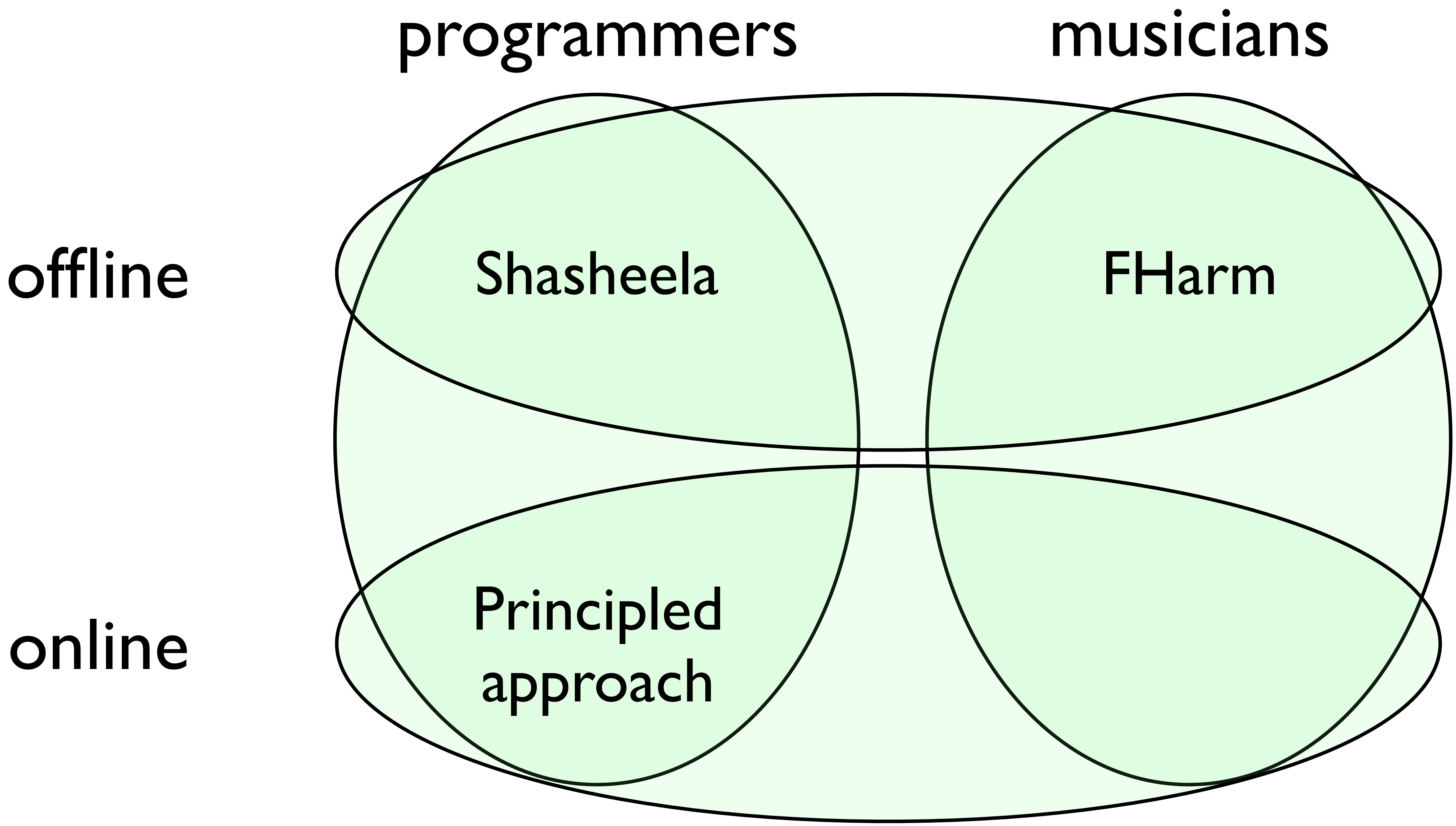
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Shasheela
FHarm
Principled
approach

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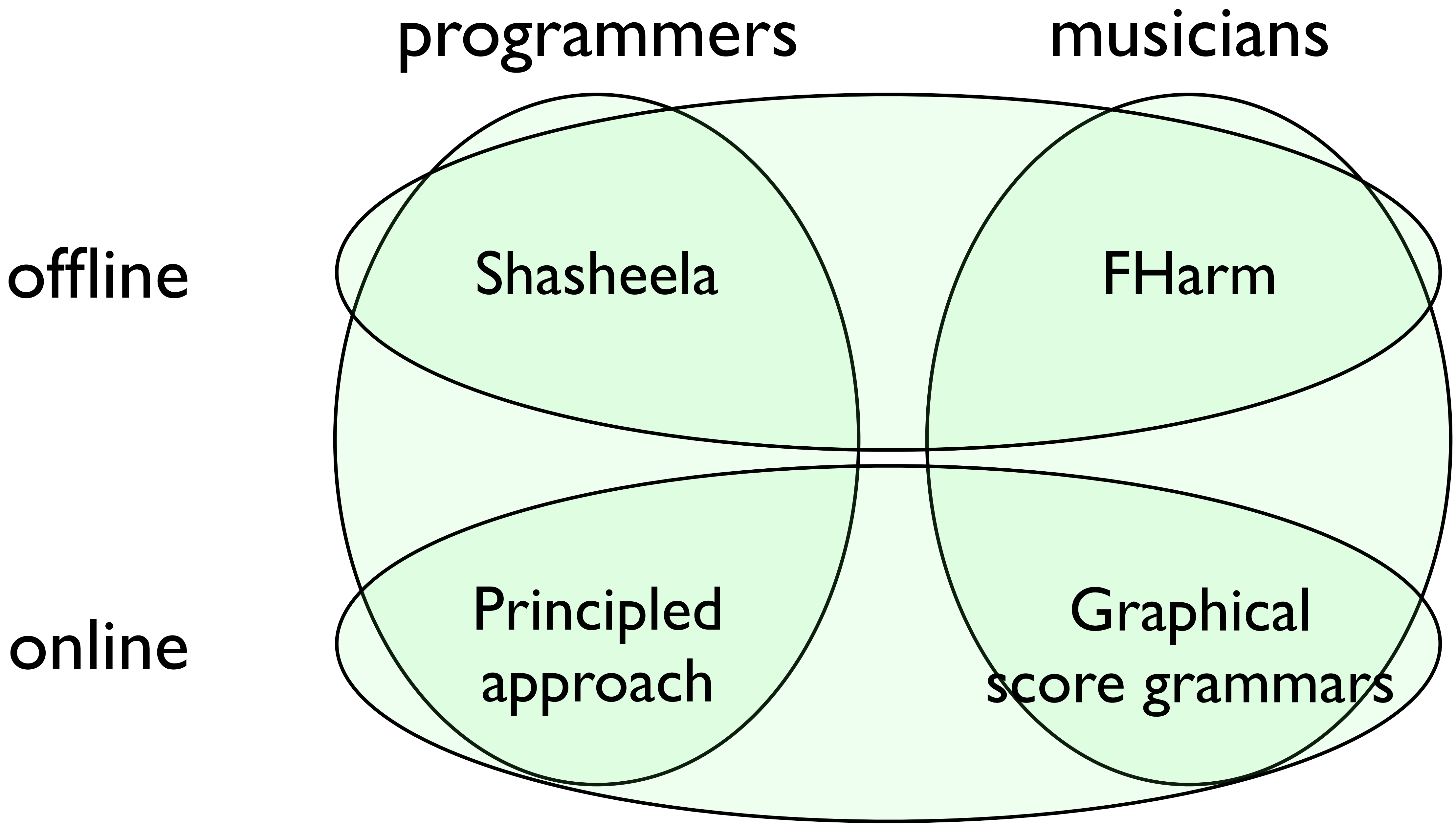
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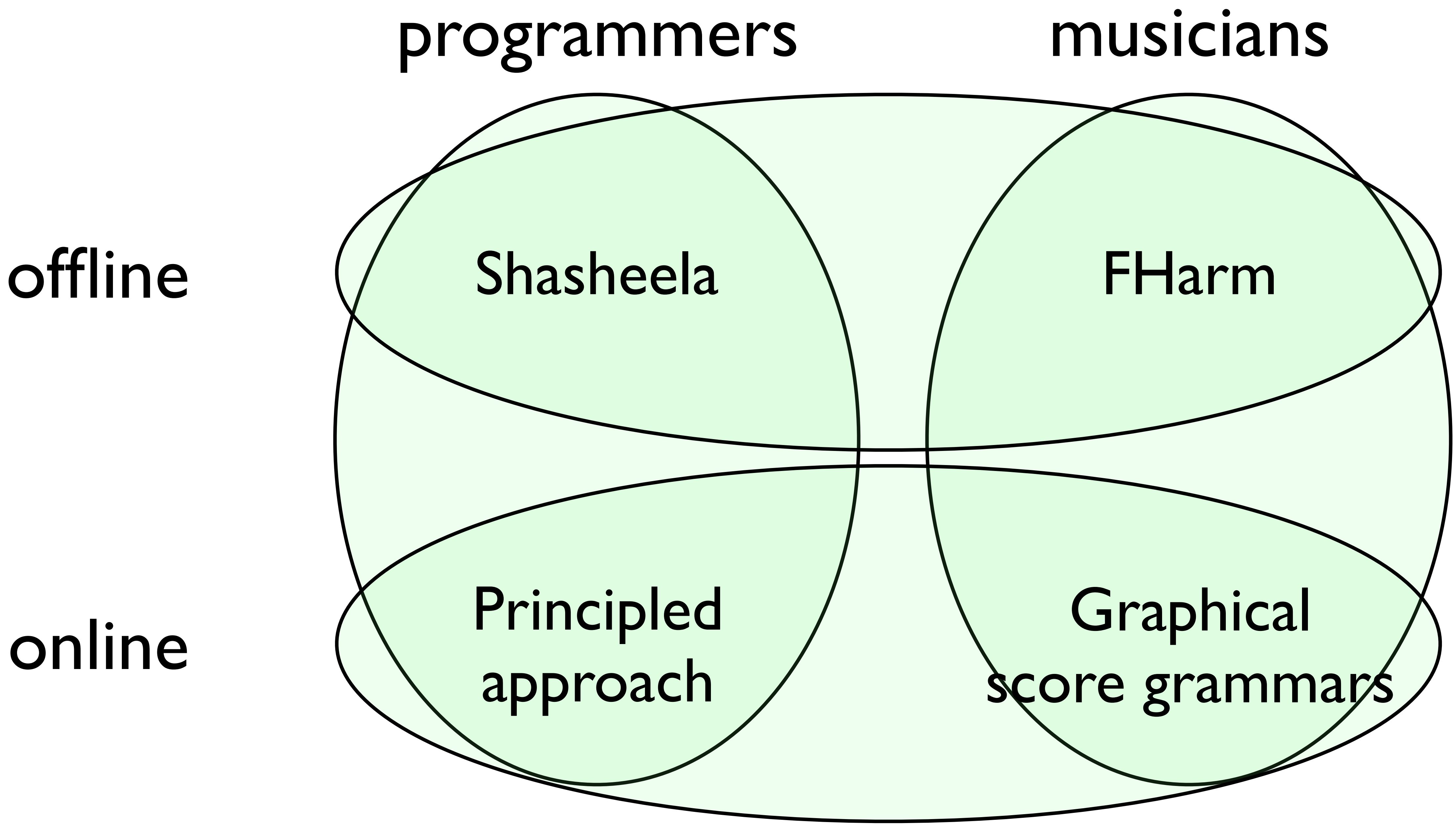
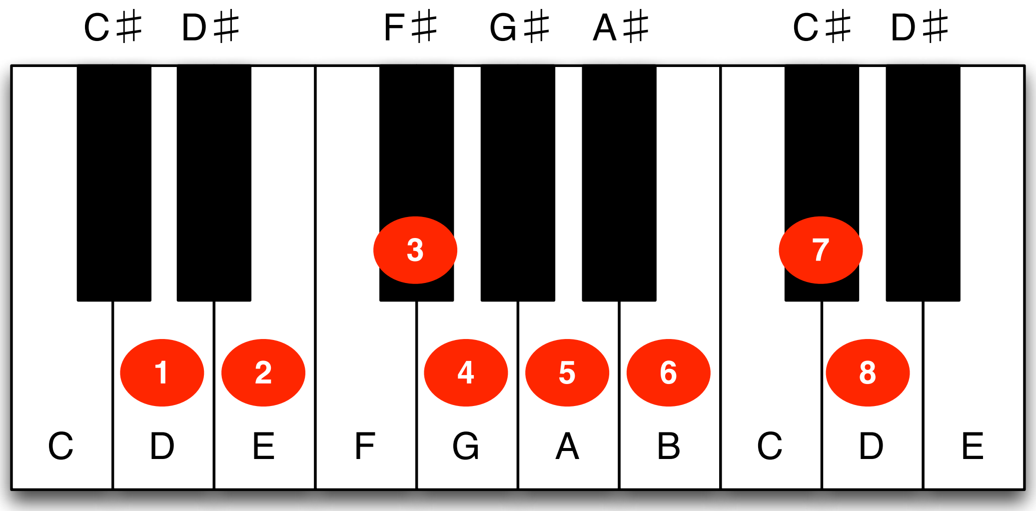


- Anders: Composing music by composing rules (Ph.D. thesis)
- Koops, Magalhãe and de Haas: A functional approach to automatic melody harmonisation
- Aaron, Blackwell, Hoadley and Regan: A principled approach to developing new languages for live coding
- Stead, Blackwell and Aarong: Graphic score grammars for end-users

Melody rules

- Tonic note
- Mode
- Cadence



Melody rules

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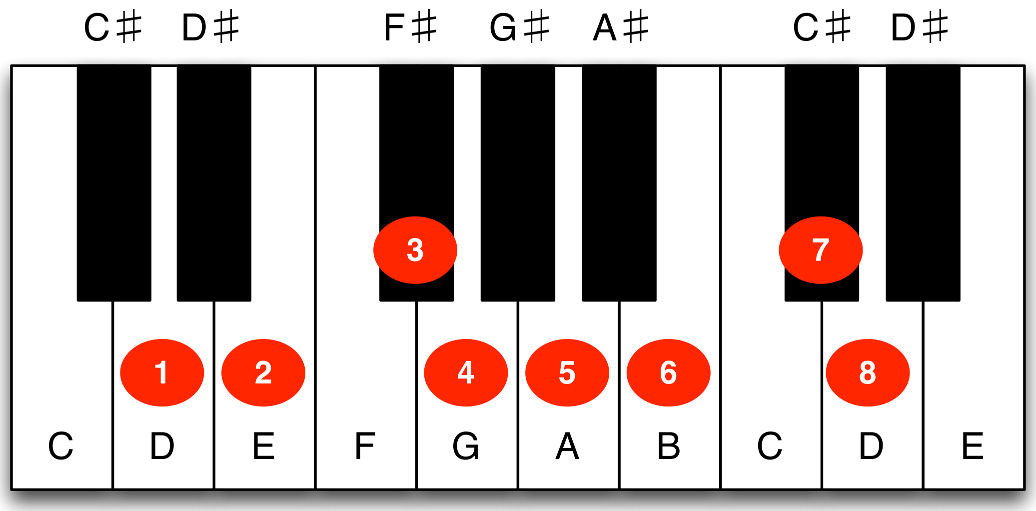
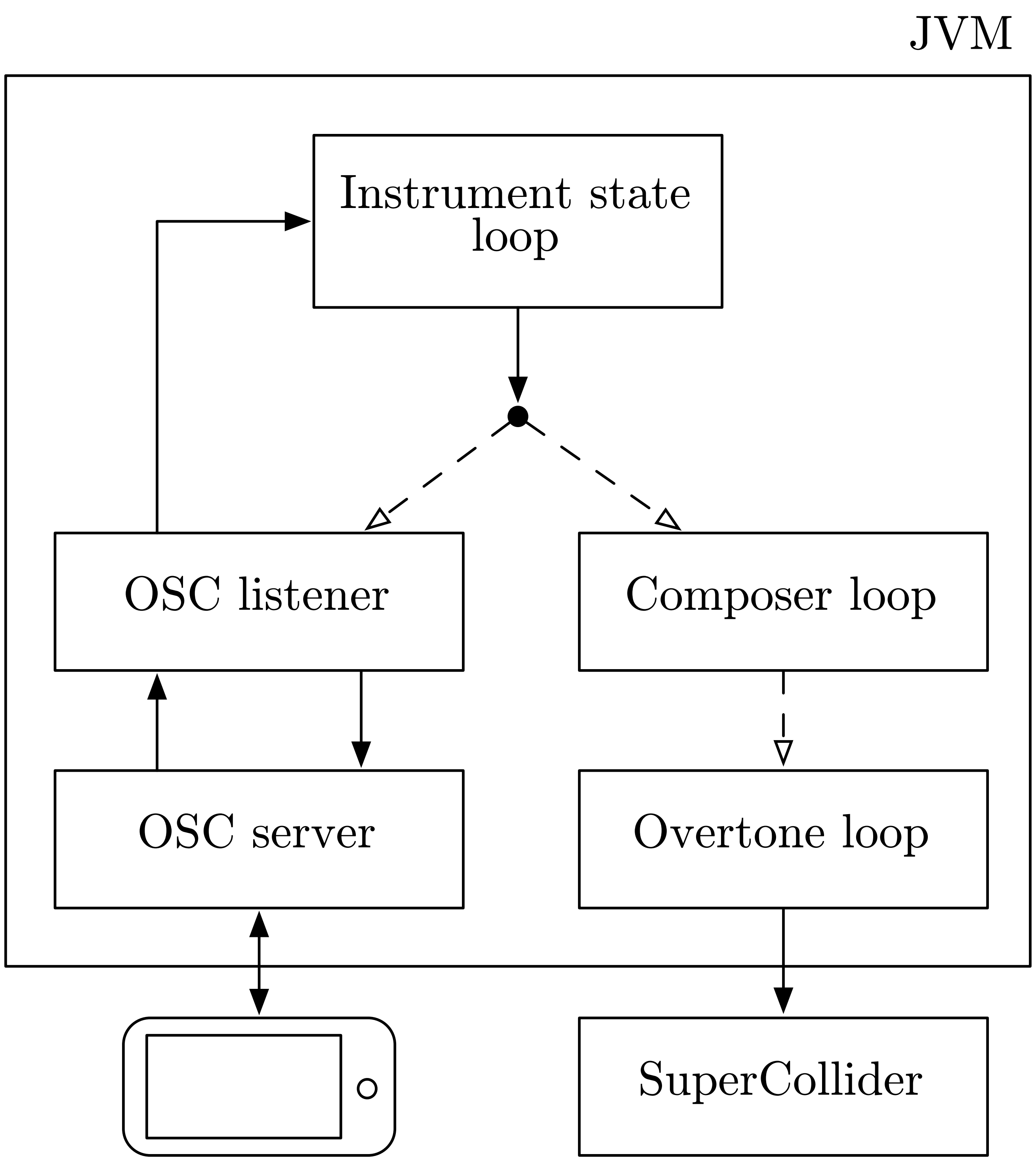


Architecture



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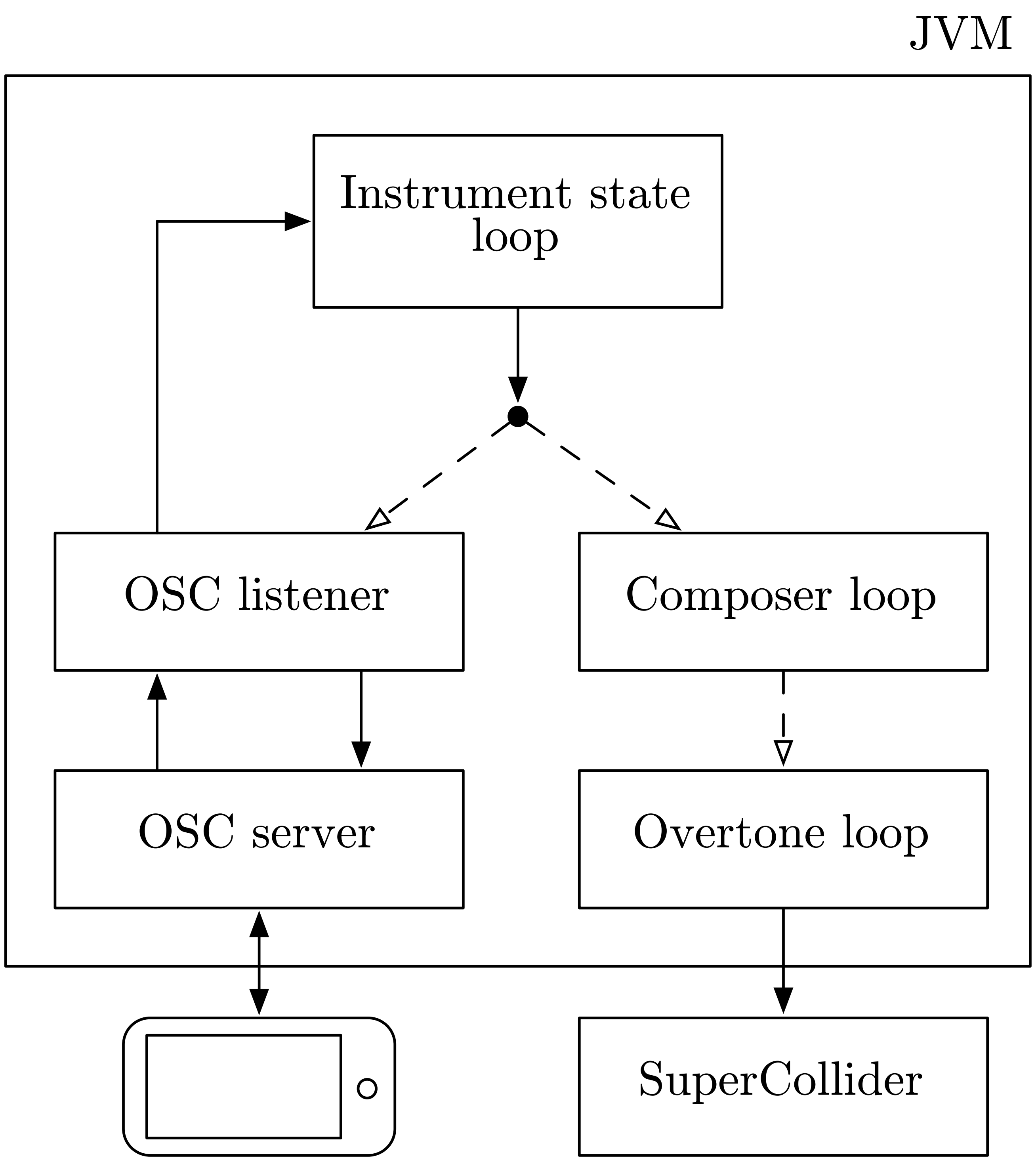

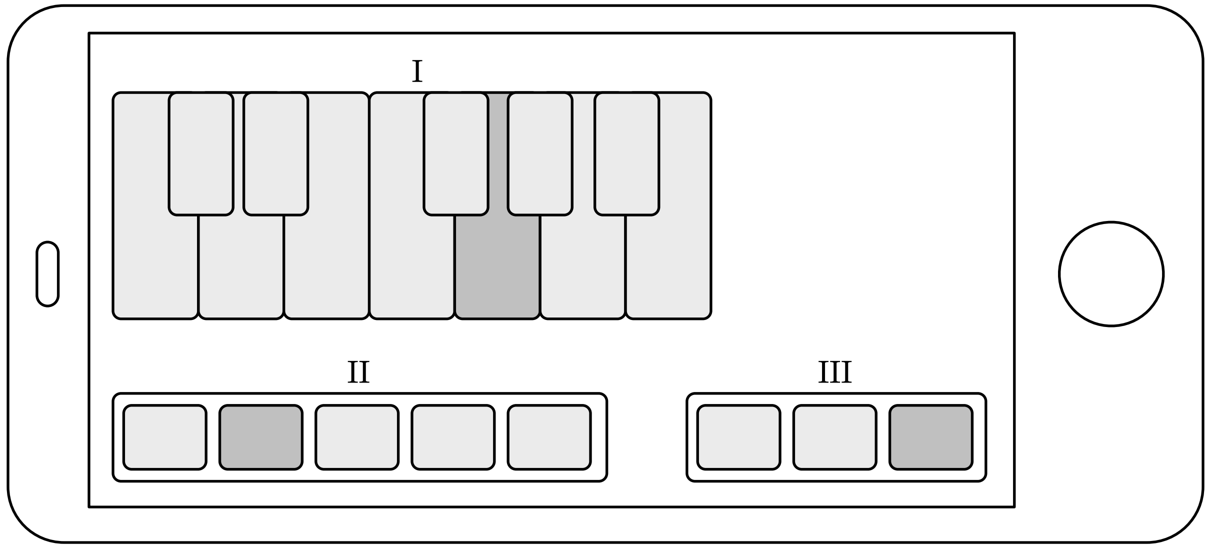

Logic programming

Logic programming

```
(run* [notes]
      (scaleo :C3 major-scale notes)
      (counto notes 8))
;; => ([:C3 :D3 :E3 :F3 :G3 :A3 :B3 :C4])
```

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;; => ([:C3 :D3 :E3 :F3 :G3 :A3 :B3 :C4])
```

```
(run 3 [m1 m2 m3 m4 m5 m6 m7 m8]
     (fresh [n1 n2 n3 n4 n5 n6 n7 n8]
            (scaleo :C3 major-scale
                    [n1 n2 n3 n4 n5 n6 n7 n8])
            (permuteo [m1 m2 m3 m4 m5 m6 m7 m8]
                      [n1 n2 n3 n4 n5 n6 n7 n8])
            (== m1 :C3)
            (== m8 :C4)))
;; => ([:C3 :D3 :E3 :F3 :G3 :A3 :B3 :C4]
;;     [:C3 :E3 :D3 :F3 :G3 :A3 :B3 :C4]
;;     [:C3 :F3 :D3 :E3 :G3 :A3 :B3 :C4])
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;;     [:C3 :E3 :D3 :F3 :G3 :A3 :B3 :C4]
;;     [:C3 :F3 :D3 :E3 :G3 :A3 :B3 :C4])
```

```
(run* [tonic-note pattern]
      (scaleo tonic-note pattern
              [:C3 :D3 :E3 :F3 :G3 :A3 :B3 :C4]))
;; => ([:C3 (1 0 1 0 1 1 0 1 0 1 0 1 1 . _0)])
```

Logic programming

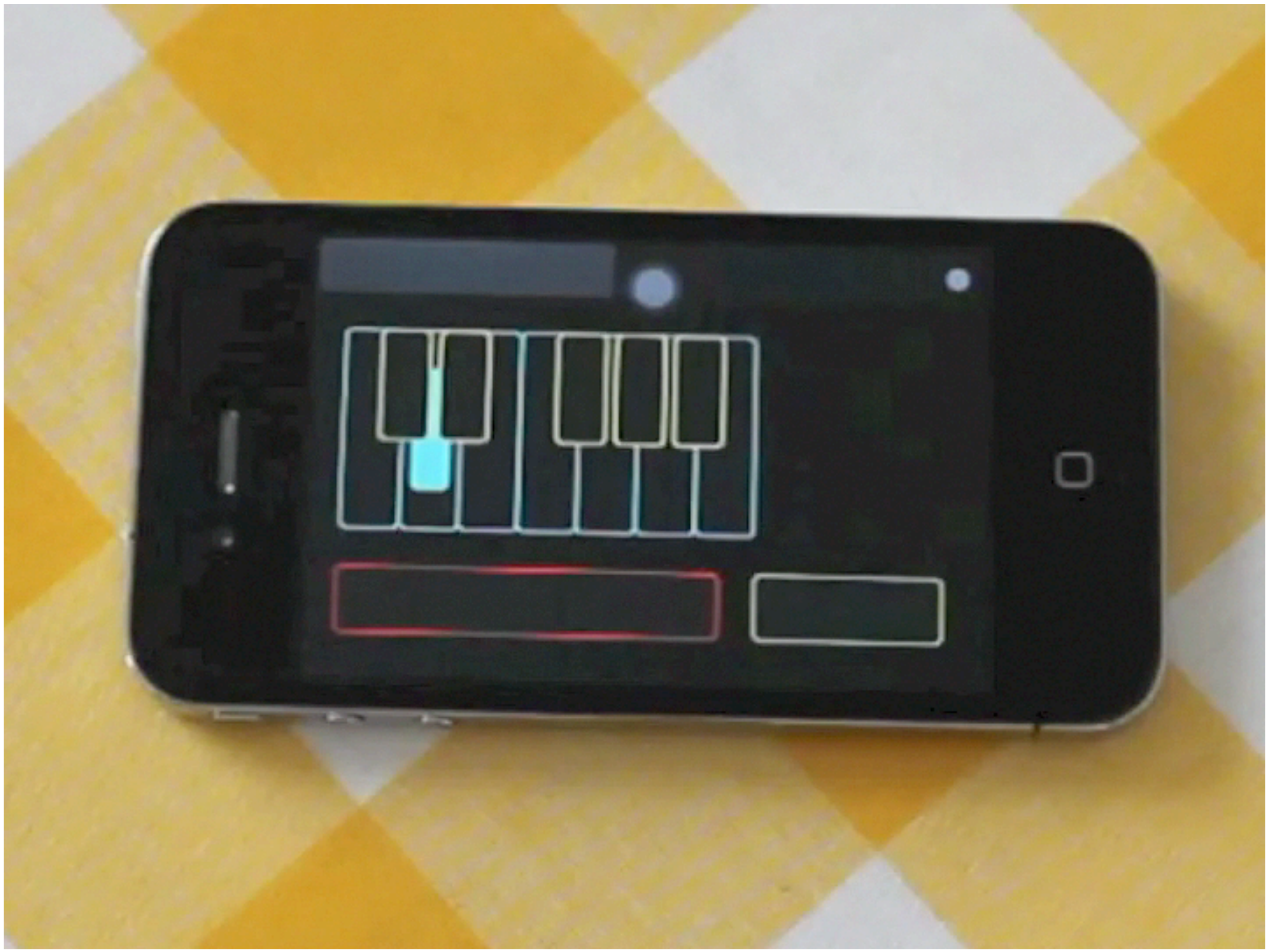
```clojure
(ns composer.composer
  (:refer-clojure :exclude [==])
  (:require [clojure.core.async :refer [go >! <!]]
            [clojure.core.logic :refer :all]
            [clojure.core.logic.pldb :refer :all]))

(defn scale-from-tones [tone-types]
  (take 25
        (->> tone-types
             (map {:semitone [1]
                   :tone [0 1]
                   :minor-third [0 0 1]})
             flatten
             butlast
             (cons 1)
             cycle)))

(def major-scale
  (scale-from-tones
   [:tone :tone :semitone :tone :tone :tone :semitone]))
(def harmonic-minor-scale
  (scale-from-tones
   [:tone :semitone :tone :tone :semitone :minor-third :semitone]))
(def natural-minor-scale
  (scale-from-tones
   [:tone :semitone :tone :tone :semitone :tone :tone]))
(def locrian-mode
  (scale-from-tones
   [:semitone :tone :tone :semitone :tone :tone :tone]))
(def mixolydian-mode
  (scale-from-tones
   [:tone :tone :semitone :tone :tone :semitone :tone]))

(def scale-modes
  [[:major-scale          major-scale]
   [:harmonic-minor-scale harmonic-minor-scale]
   [:natural-minor-scale  natural-minor-scale]
   [:locrian-mode         locrian-mode]
   [:mixolydian-mode      mixolydian-mode]])

(db-rel semitone note-1 note-2)

(def keys-from-c
  [:C3 :C#3 :D3 :D#3 :E3 :F3 :F#3 :G3 :G#3 :A3 :A#3 :B3
   :C4 :C#4 :D4 :D#4 :E4 :F4 :F#4 :G4 :G#4 :A4 :A#4 :B4
   :C5])

(def semitone-facts
  (reduce
   (fn [db [note-1 note-2]]
     (db-fact db semitone note-1 note-2))
   empty-db
   (partition 2 1 keys-from-c)))
```

```clojure
(defne scaleo [base-note scale notes]
  ([note [1 . scale-rest] [note . ()]])
  ([note [1 . scale-rest] [note . notes-rest]]
     (fresh [next-note]
            (semitone note next-note)
            (scaleo next-note scale-rest notes-rest)))
  ([note [0 . scale-rest] notes]
     (fresh [next-note]
            (semitone note next-note)
            (scaleo next-note scale-rest notes))))

(defn key-restriction
  [instrument-state s1]
  (if-let [key (:key instrument-state)]
    (all (== key s1))
    succeed))

(defn scale-restriction
  [instrument-state scale-type]
  (if (:scale instrument-state)
    (all (membero [(:scale instrument-state) scale-type] scale-modes))
    succeed))

(defn cadence-restriction
  [instrument-state m7 s2 s4 s5]
  (case (:cadence instrument-state)
    :perfect   (all (== m7 s5))
    :plagal    (all (== m7 s4))
    :just-nice (all (== m7 s2))
    nil        succeed))

(defn- logic-program
  [instrument-state melody2]
  (fresh [melody
          m1 m2 m3 m4 m5 m6 m7 m8
          scale
          s1 s2 s3 s4 s5 s6 s7 s8
          base-note scale-type]
         (key-restriction instrument-state s1)
         (== melody [m1 m2 m3 m4 m5 m6 m7 m8])
         (== scale [s1 s2 s3 s4 s5 s6 s7 s8])
         (== m1 s1)
         (== m8 s8)
         (cadence-restriction instrument-state m7 s2 s4 s5)
         (== melody2 [m1 m2 m3 m4 m5 m6 m7 m1])
         (scale-restriction instrument-state scale-type)
         (scaleo base-note scale-type scale)
         (permuteo scale melody)))
```

```clojure
(defn compositions
  [instrument-state & [n]]
  (with-db
    semitone-facts
    (if n
      (run n [melody2]
           (logic-program instrument-state melody2))
      (run* [melody2]
            (logic-program instrument-state melody2)))))

(defn- random-composition
  [instrument-state]
  (rand-nth
   (or (seq (compositions instrument-state 1024))
       [[]])))

;; Loop

(defn- same-melody-params?
  [instrument-state-1 instrument-state-2]
  (let [non-melody-keys [:speed :gaps]]
    (= (apply dissoc instrument-state-1 non-melody-keys)
       (apply dissoc instrument-state-2 non-melody-keys))))

(defn composer-loop
  "Listens for new instrument states on instrument-state-ch and emits a
  random melody to melody-ch. The loop terminates when
  instrument-state-ch closes.

  Changes to :speed or :gaps does not compose a new melody, but alters
  the timing of the existing."
  [instrument-state-ch melody-ch]
  (go
   (loop [prev-instrument-state nil
          prev-composition      nil]
     (when-let [instrument-state (<! instrument-state-ch)]
       (let [gaps (for [i (range 8)] (get (:gaps instrument-state) i 0.5))
             speed (:speed instrument-state)
             new-melody (if (same-melody-params? prev-instrument-state
                                                 instrument-state)
                          (:melody prev-composition)
                          (random-composition instrument-state))
             new-composition {:gaps gaps
                              :speed speed
                              :melody new-melody}]
         (>! melody-ch new-composition)
         (recur instrument-state
                new-composition))))))
```

The system

The system



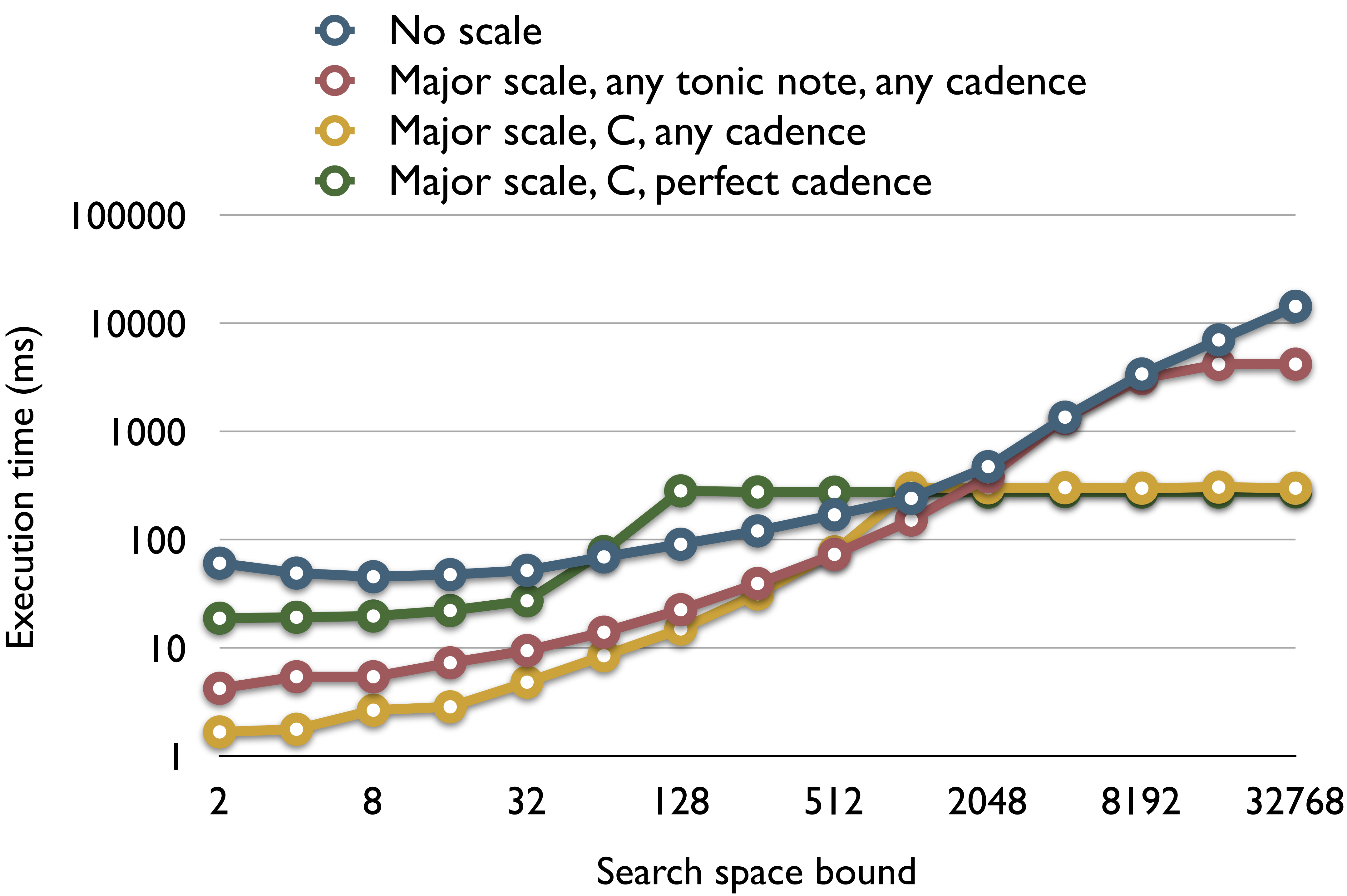
Experiments

- Goal: a reactive system
- Experiment 1: What is the size of the melody space and how long does it take to enumerate it?
- Experiment 2: What is a reasonable bound on the search space to achieve responsiveness?

Experiment 1

	No scale				Major scale			
	Any tonic note		C		Any tonic note		C	
	–	pc	–	pc	–	pc	–	pc
Melody space	25^8	25^8	25^8	25^8	$9,360$	$1,560$	720	120
Execution time (ms)	–	–	–	–	$4,299$	$3,852$	294	278
Melodies/second	–	–	–	–	$2,177$	404	$2,448$	431

Experiment 2



Conclusion

- Composer demonstrates it is possible to build a responsive interactive system with extremely small and succinct core
- The declarative nature of the core implementation makes it possible to extend the terminology to other types of music

Future work

- Proper sampling of search space
- Labeled interface
- Non-Western music
- User testing