– Euterpea –
From Signals to Symphonies
Using Haskell

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CREATIVE CONSILIENCE
of Computing and the Arts

Euterpea

- Haskell library for computer music.
- Support for both "note level" and "signal level."
- Named after *Euterpe*, one of nine Greek *muses*, or goddesses of the arts, specifically the muse of *music.*
- Basis for textbook: *The Haskell School of Music* (available on-line, almost 400 pages).
- Used to teach two-term computer music sequence in Computing and the Arts major at Yale.
- Goal: Teach FP and Computer Music in symbiosis.
- Free download from haskell.cs.yale.edu.

Demo

- Basics

- (Musical) Performance

- Algorithmic Composition

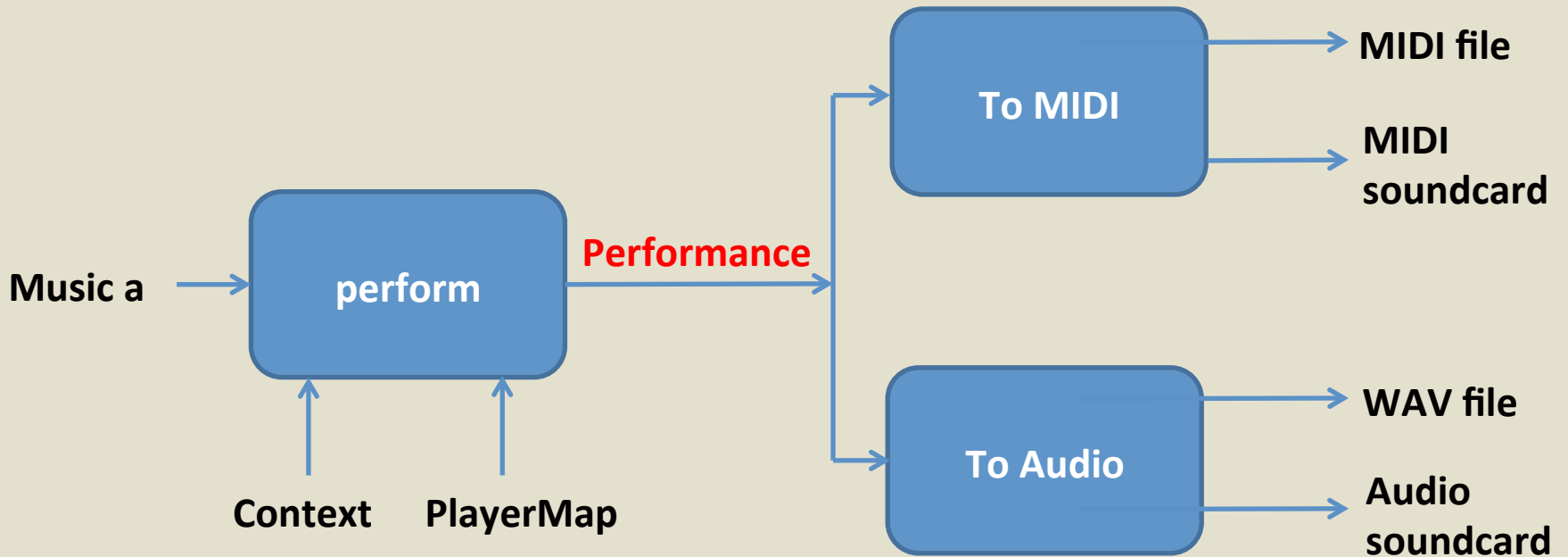- Musical User Interface (MUI)

- Sound Synthesis

(to demo)

Handy Musical Functions

- delayM d m = rest d :+: m

- timesM 0 m = rest 0
  timesM n m = m :+: timesM (n – 1) m

- repeatM m   = m :+: repeatM m

- takeM d m   = …   -- truncates m's duration to d

- m1 (/=:) m2 = …   -- like (:=:), but stops after shortest

- line [ ]   = rest 0 -- turns list of notes into Music
  line (m:ms)   = m :+: line ms
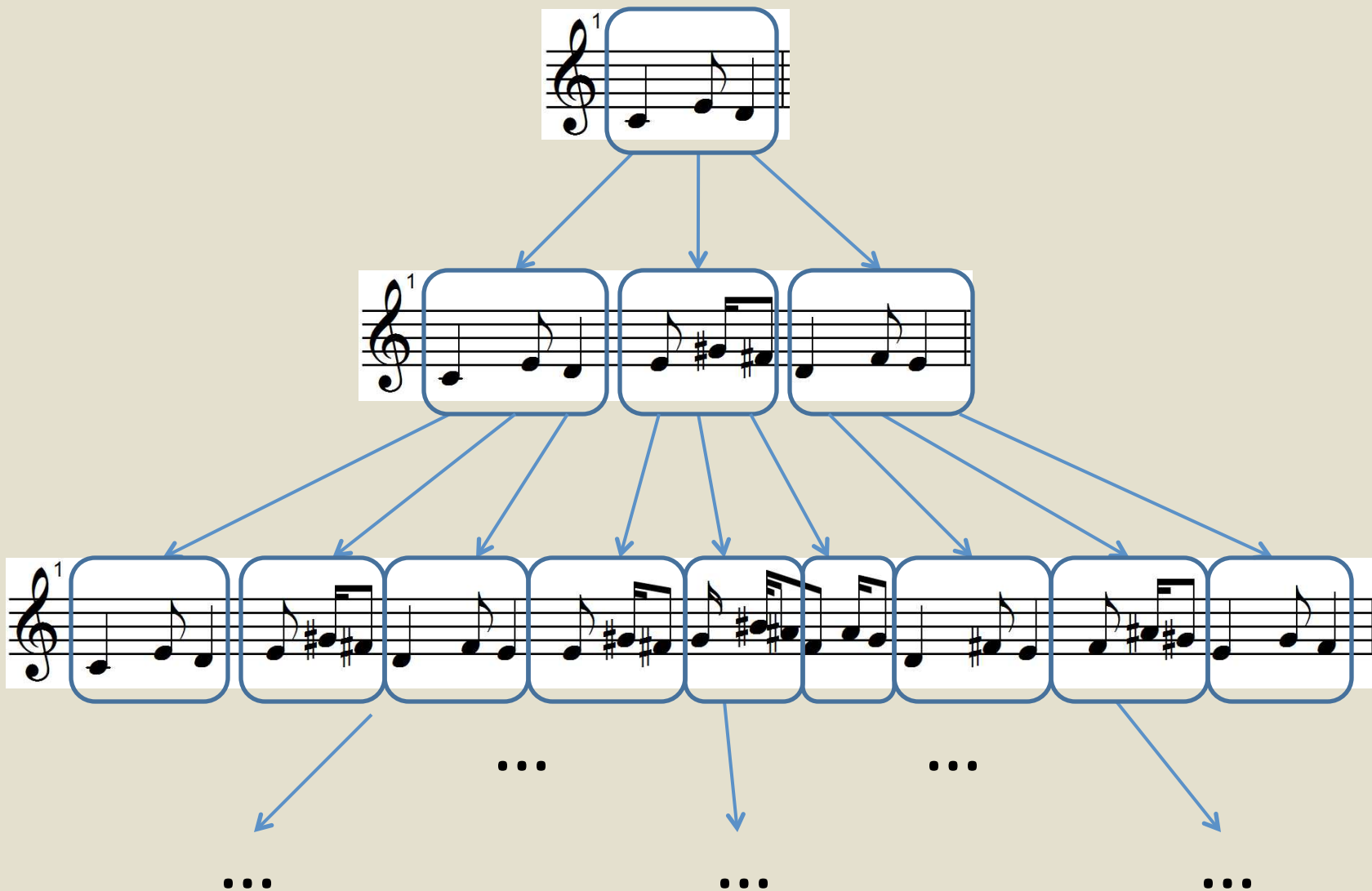 [better: line   = foldr (:+:) (rest 0)]

(to demo)

(Musical) Performance

Music a → **perform** → **Performance** →

Context ↑ **PlayerMap** ↑ (inputs to perform)

→ **To MIDI** → MIDI file
→ **To MIDI** → MIDI soundcard

→ **To Audio** → WAV file
→ **To Audio** → Audio soundcard

(to demo)

Example of Self-Similar Music

Example

- Use this 4-note motif as the seed:

- Traverse 4 levels in the tree.

- Play together with itself in reverse and transposed up a perfect fourth:

```
m  :=: transpose 5 (revM m)
```

(to demo)

Bifurcate Me, Baby!

- Consider the recurrence equation:

  $$x_{n+1} = r * x_n * (1 - x_n)$$

  Start with an initial population x_0 and iteratively apply the growth function to it, where r is the growth rate. For certain values of r, the population stabilizes, but as r increases, the period doubles, quadruples, and eventually leads to chaos. It is one of the classic examples in chaos theory.

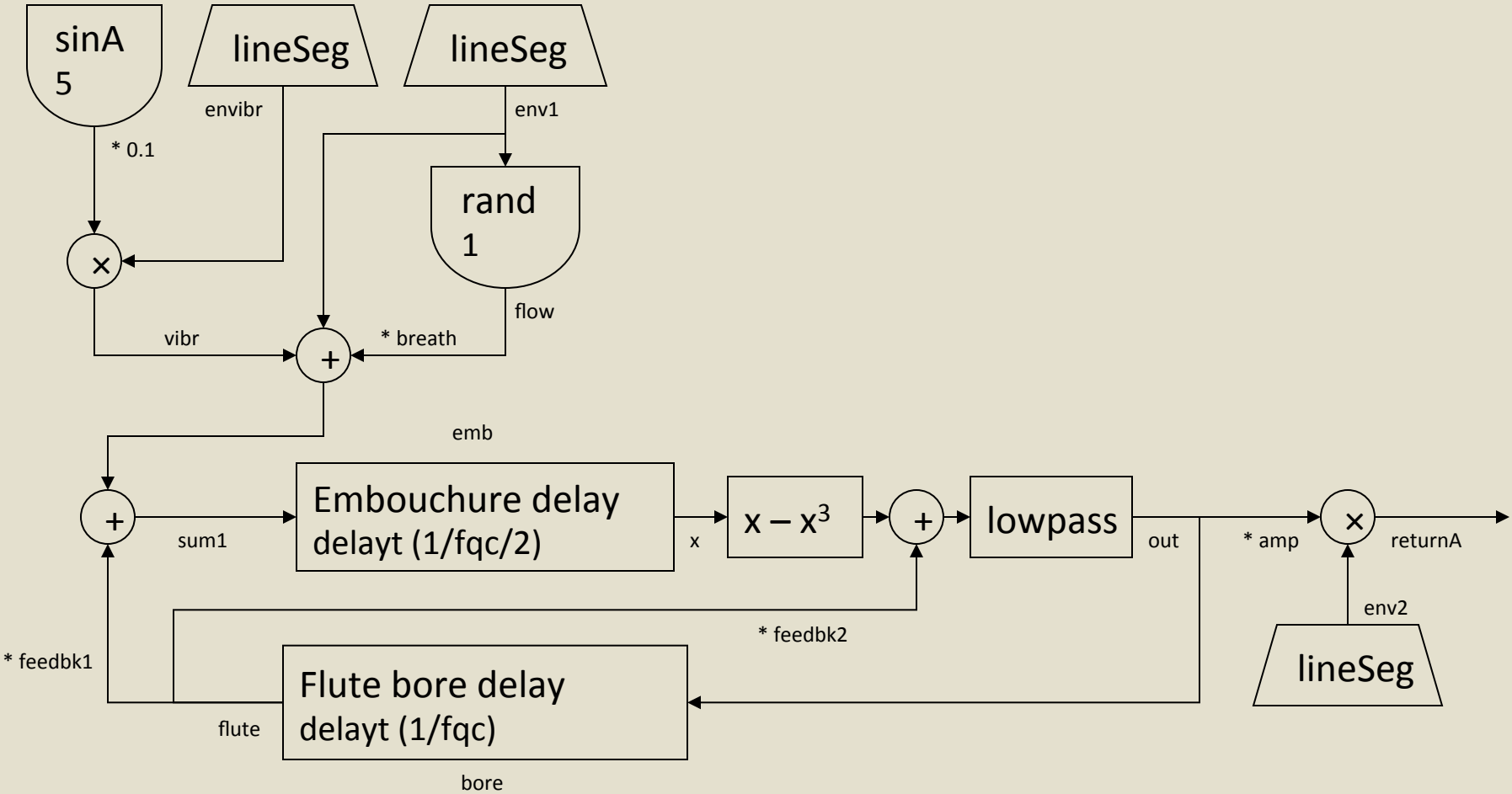- In Euterpea:

*grow r x = r * x * (1-x)*

Bifurcate Me, Baby!

Gary Lee Nelson

1995

(to demo)

Physical Model of a Flute

Flute Model in Euterpea

```
flute dur freq amp vfreq =
    in proc () -> do
        amp1  <- linseg …       -< ()
        amp2  <- linseg …       -< ()
        ampv  <- linseg …       -< ()
        flow   <- rand 1        -< amp1
        vibr   <- oscils vfreq  -< 0.1 * ampv
        rec
            let feedbk = body * 0.4
            body <- delay (1/freq)     -< out
            x      <- delay (1/freq/2) -< breath*flow
                                          + amp1 + vibr + feedbk
            out   <- tone              -< (x - x*x*x + feedbk, 2000)
        returnA -< out*amp*amp2
```

Flute Demo

- f0 and f1 demonstrate the change in the breath parameter.

  f0 = flute 3 0.35 440 0.93 0.02
  f1 = flute 3 0.35 440 0.83 0.05

- f2 has a weak pressure input so only plays the blowing noise.

  f2 = flute 3 0.35 440 0.53 0.04

- f3 takes in a gradually increasing pressure signal.

  f3 = flute 4 0.35 440
        (lineSeg [0.53, 0.93, 0.93] [2, 2])
        0.03

- Sequence of notes:

Thank You!!

(any questions?)

For more information about Euterpea, see:

haskell.cs.yale.edu