JFLA ~~2005~~ 2014

ReactiveML : un langage pour la programmation réactive en ML

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~~9 mars 2005~~
11 janvier 2014

Historique

- 1998 : cours de programmation en Licence
  - programmation événementielle

Programmation événementielle

```
class generate_new_plateforme = object(self)
  val mutable state = 0
  val mutable last_clock = (0, 0)

  method on_click pos =
    match state with
    | 0 -> last_click <- pos;
           state <- 1
    | 1 -> emit new_plateforme (last_click, pos);
           state <- 0

  method on_key_down k =
    match k with
    | Key_ESC -> state <- 0
    | _ -> ()
end
```

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  - Inspiration en particulier de Junior par L. Hazard

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- 2002 - 2003 : Implantations de SugarCubes (Junior)
  - Inspiration en particulier de Junior par L. Hazard
- Fin 2003 : passage de Java à ML
  - lien entre la partie réactive et langage hôte
  - simplification de l'implantation

Approche langages

- fournir des constructions de haut niveau pour composer/décrire des systèmes interactifs
- alternative aux approches classiques :
  impérative, programmation événementielle, concurrente (à base de thread), ...
- la question de l'efficacité est centrale, il n'y a pas de threads à l'exécution
- mécanismes de sûreté (e.g., typage)
- parallélisme déterministe
- s'intégrer a un langage existant (OCAML) sans réduire son pouvoir expressif

On fonde ce langage sur le modèle réactif introduit par F. Boussinot

Retour sur l'exemple

```
let process generate_new_plateforme click key new_plateforme =
  loop
    await click (p1) in
    do
      await click (p2) in
      emit new_plateforme (p1, p2)
  until key(Key_ESC) done
end
```

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Analyse de réactivité

Boucle instantanée

```
let process instantaneous_loop =
  loop () end
```

Récursion instantanée

```
let rec process instantaneous_rec =
  run instantaneous_rec
```

Approche langages

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Programming Mixed Music in ReactiveML

- Collaboration entre
  - l'équipe Mutant de l'IRCAM
  - l'équipe Parkas de l'ENS

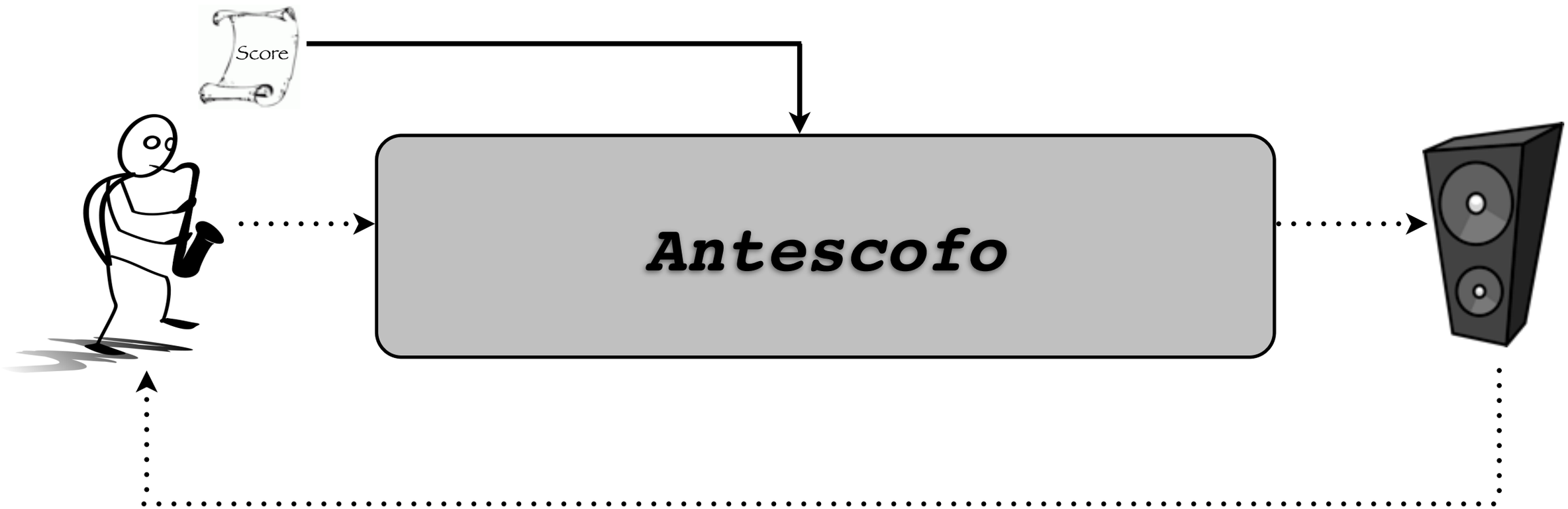
Guillaume Baudart, Florent Jacquemard, Louis Mandel, Marc Pouzet

Mixed Music and Antescofo

[Cont 2008]

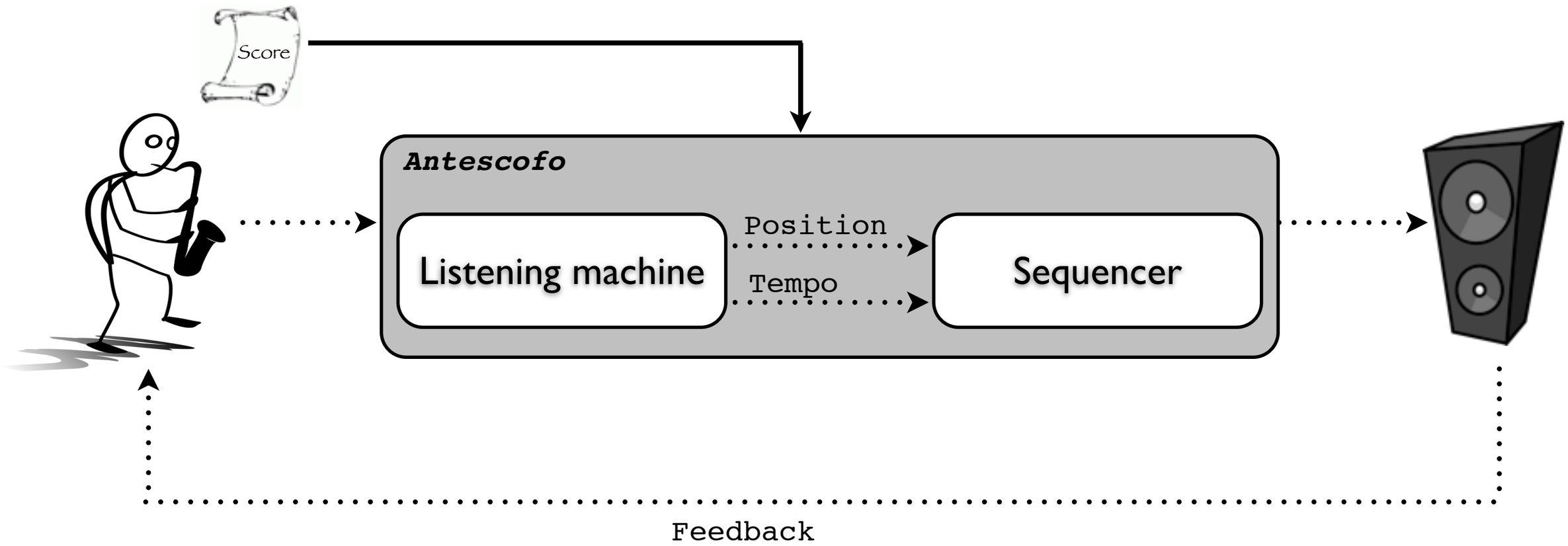
Mixed Music and Antescofo

[Cont 2008]



Antescofo Architecture

[Cont 2008]



Antescofo Architecture

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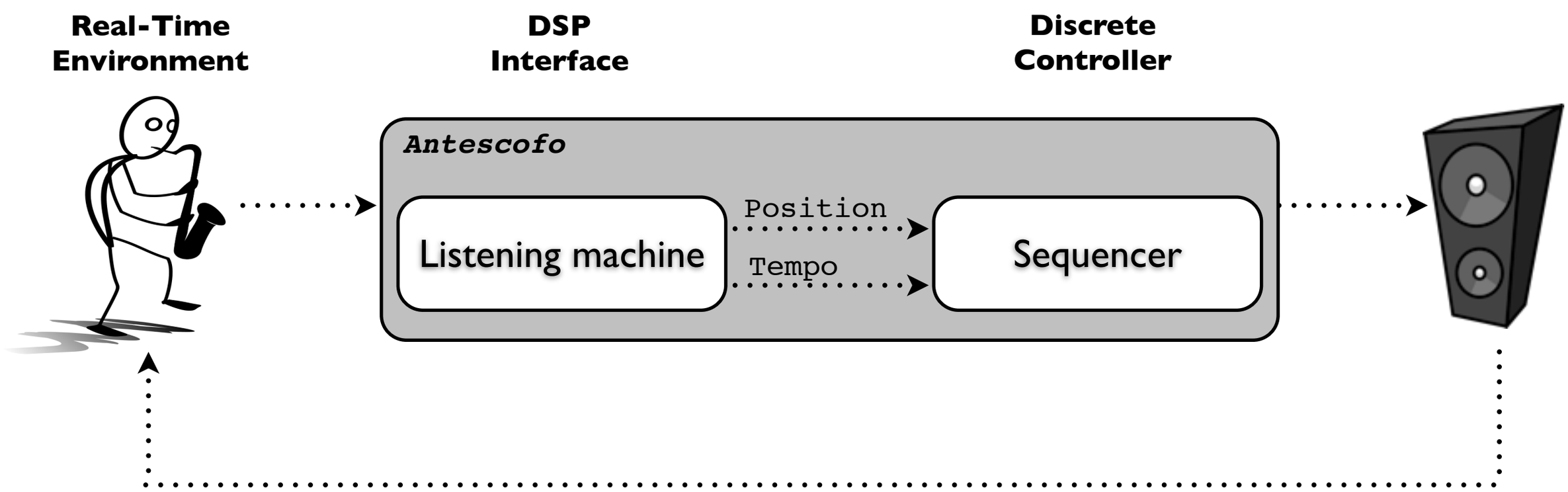
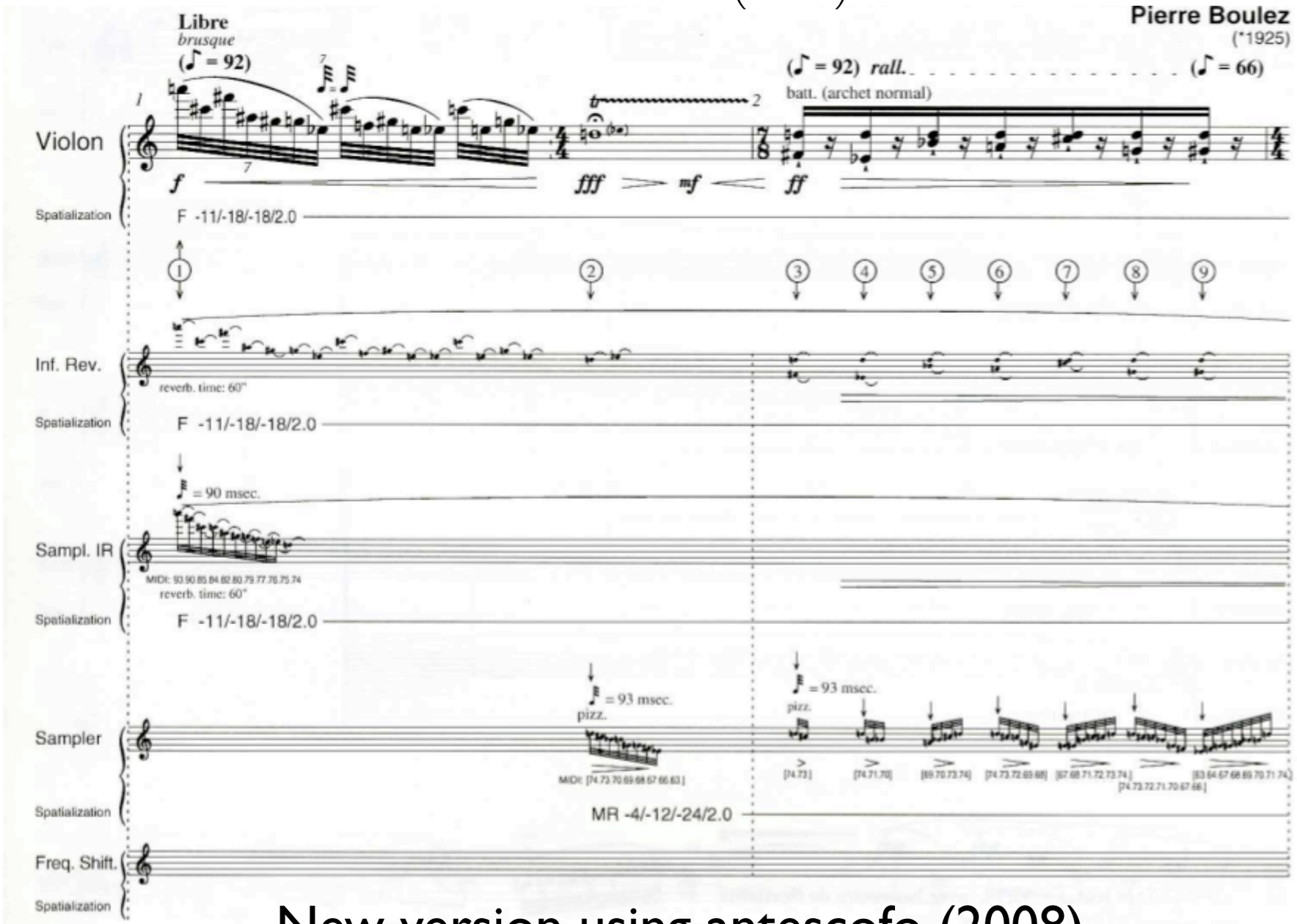


The Antescofo Language

Goal: Jointly specify electronic and instrumental parts

Anthèmes II (1994)

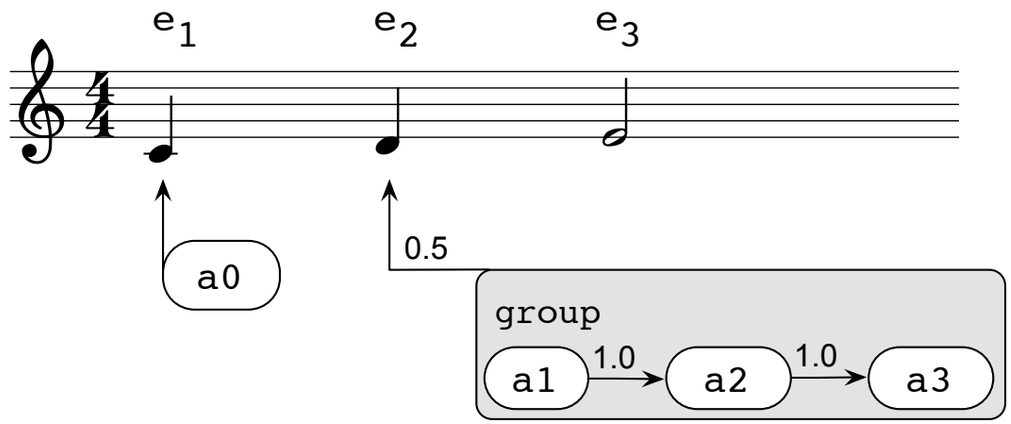


New version using antescofo (2008)

The Antescofo Language

Goal: Jointly specify electronic and instrumental parts

[Echeveste et al. 2012]




```
NOTE  60  1.0
0.0  'a_0'

NOTE  62  1.0
0.5  GROUP  loose  causal
     { 0.0  'a_1'
       1.0  'a_2'
       1.0  'a_3' }

NOTE  64  2.0
```

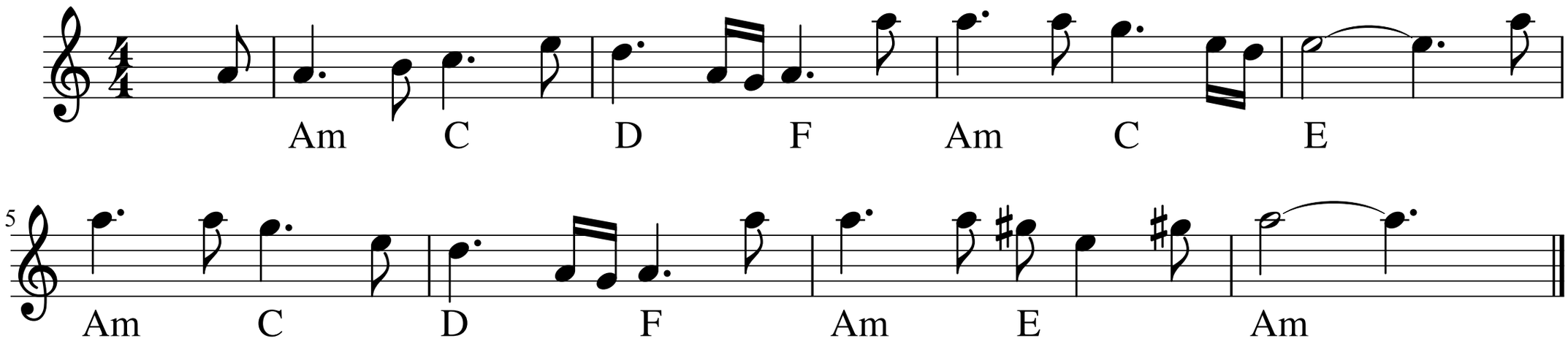
- Time is relative to the tempo
- Electronic actions are characterized by a delay
- Hierarchical structure: *groups and nested groups*
- Synchronization with the musician : *tight, loose*
- Error handling strategies : *partial, causal*

Live Coding

Modify, correct and interact with the score during the performance

Automatic Accompaniment

The house of the rising sun



- **Functional programming**
  modular definition of the accompaniment
- **Reactive programming**
  interaction with the score during the performance

Definitions

1. Define the bass line

```
let bass = [0.0, (A, Min); 2.0, (C, Maj); ...]
val bass: (delay * chord) list
```

2. Define the accompaniment style

```
let arpeggio chord =
  ...
  group Loose Local
    [0.0, action_note (fond);
     1.0, action_note (third);
     2.0, action_note (fifth);}]
val arpeggio: chord -> asco_event
```

3. Link with the performance

```
let process basic_accomp =
  run (link asco 2 roots)
val basic_accomp: unit process
```

Kill a Process

Example of a higher-order process

```
let process killable k p =
  do
    run p
  until k done
val killable:
  (unit, unit) event -> unit process ->
    unit process
```

Kill a Process

Example of a higher-order process

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process

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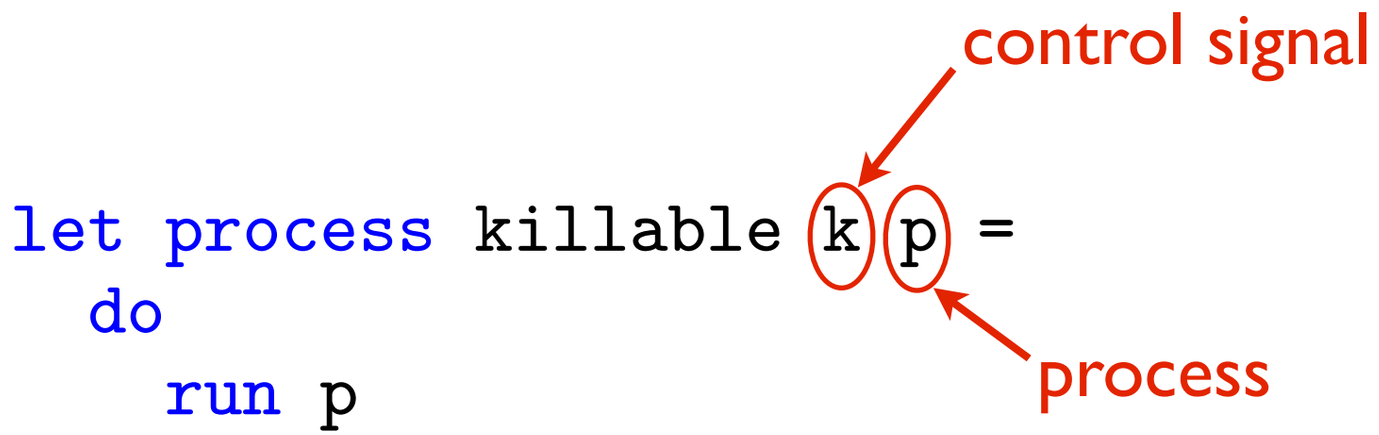


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```

Dynamic Changes

Example of a recursive higher-order process

```
let process rec replaceable replace p =
  do
    run p
  until replace (q) ->
    run (replaceable replace q)
  done
val replaceable:
  (unit process, unit process) event ->
    unit process -> unit process
```

Dynamic Changes

Example of a recursive higher-order process

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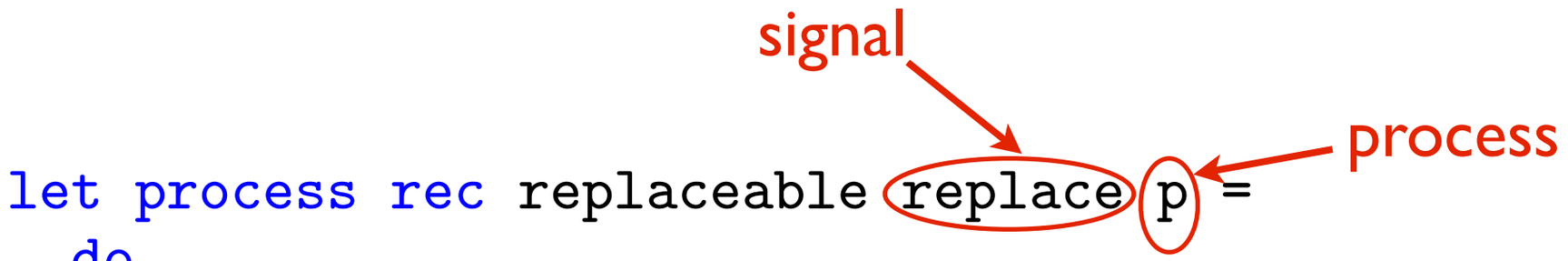


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signal

process

new behavior

signal can carry processes

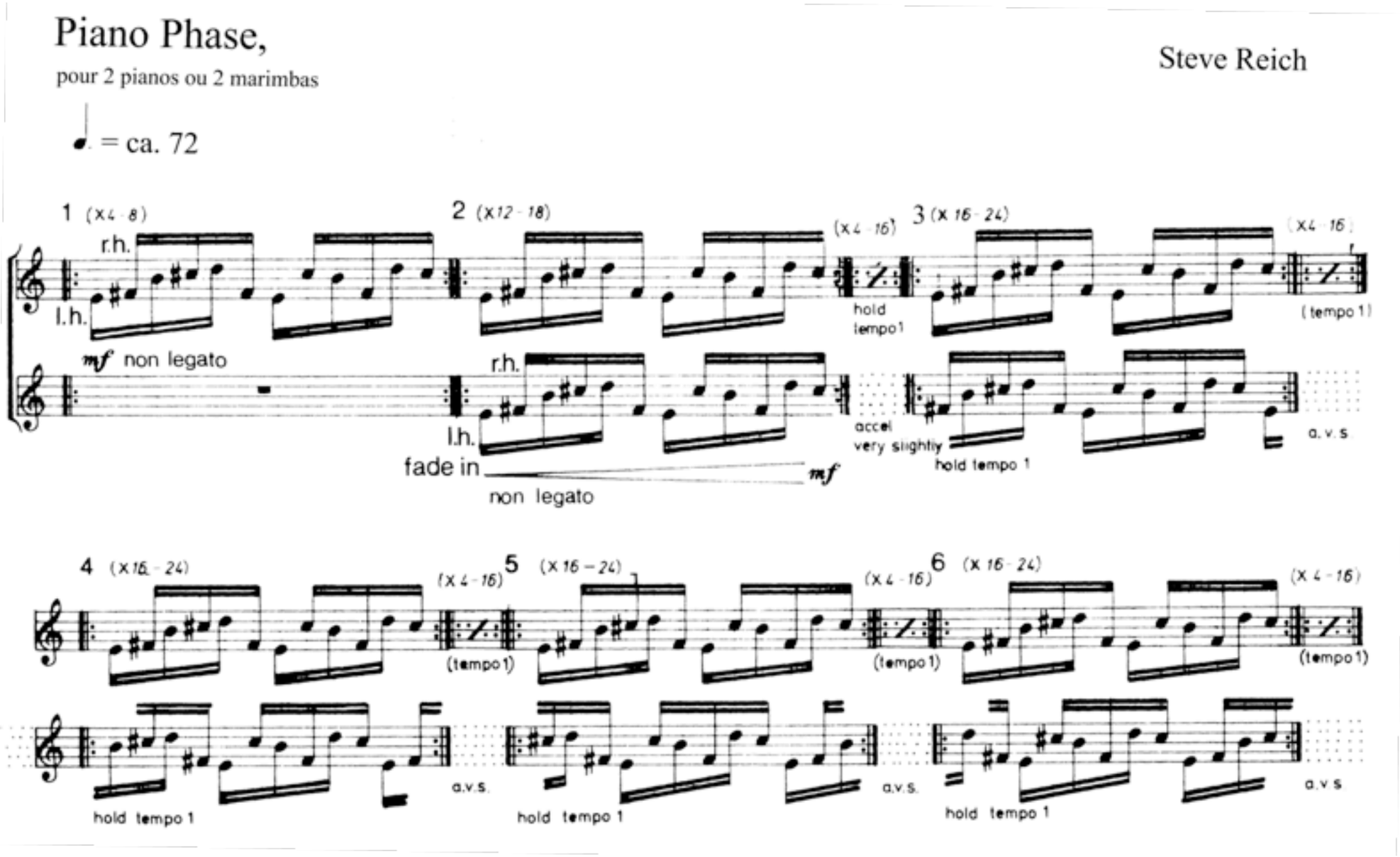
New Reactive Behaviors

Example: Steve Reich's Piano Phase

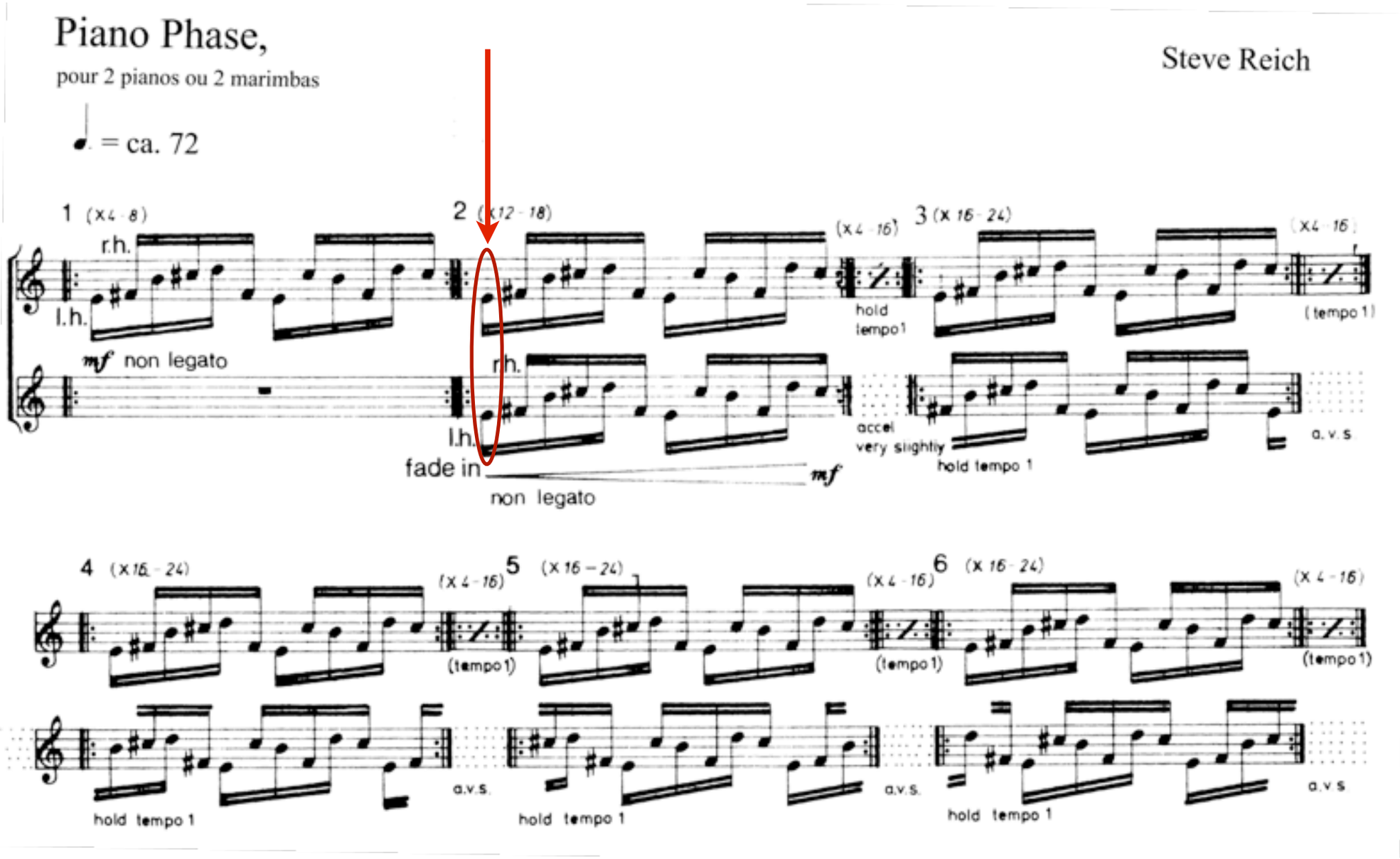
Piano Phase ...

Bob

Alice



Piano Phase ...



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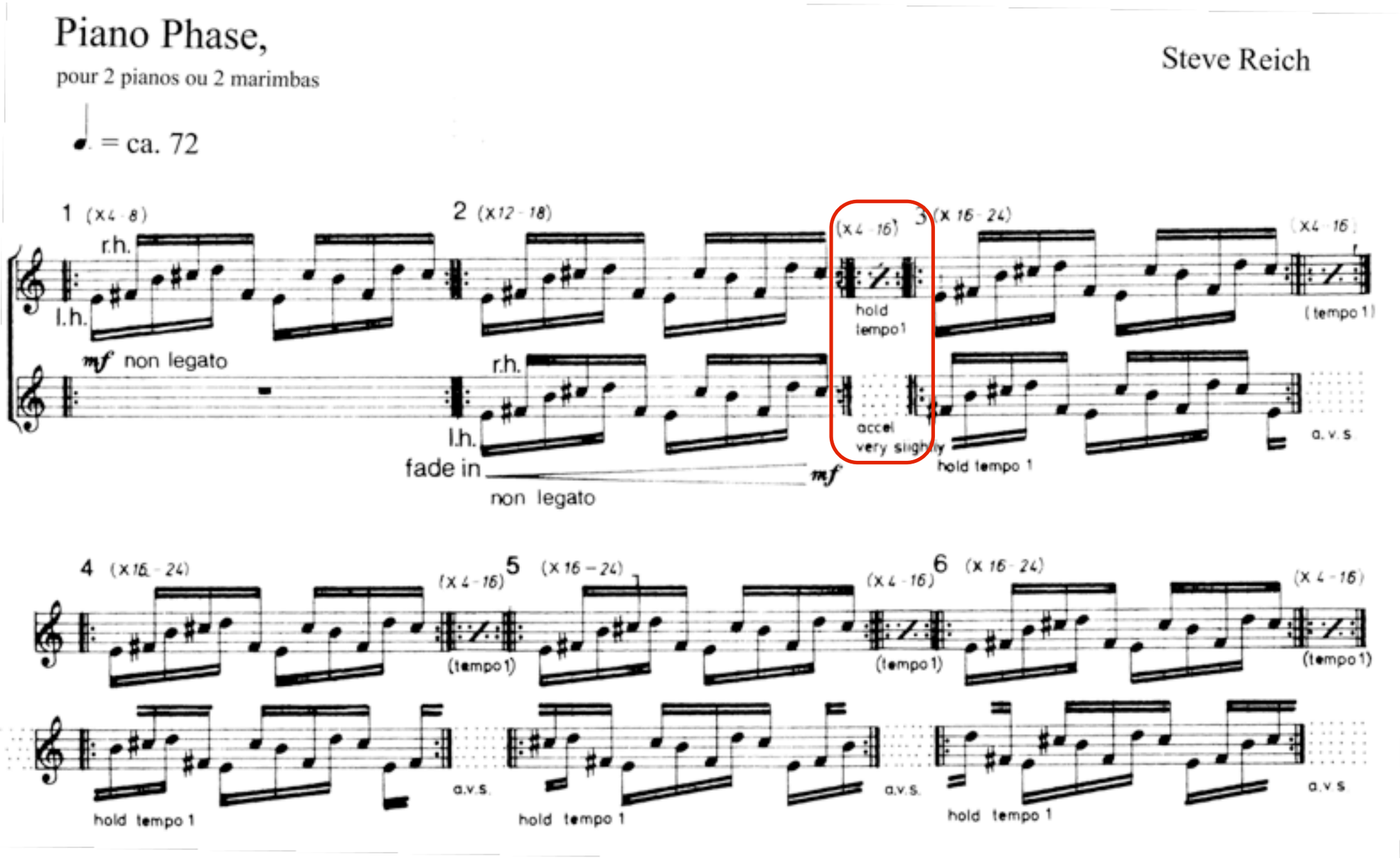
Synchronization

Piano Phase ...



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Desynchronization

Piano Phase ...

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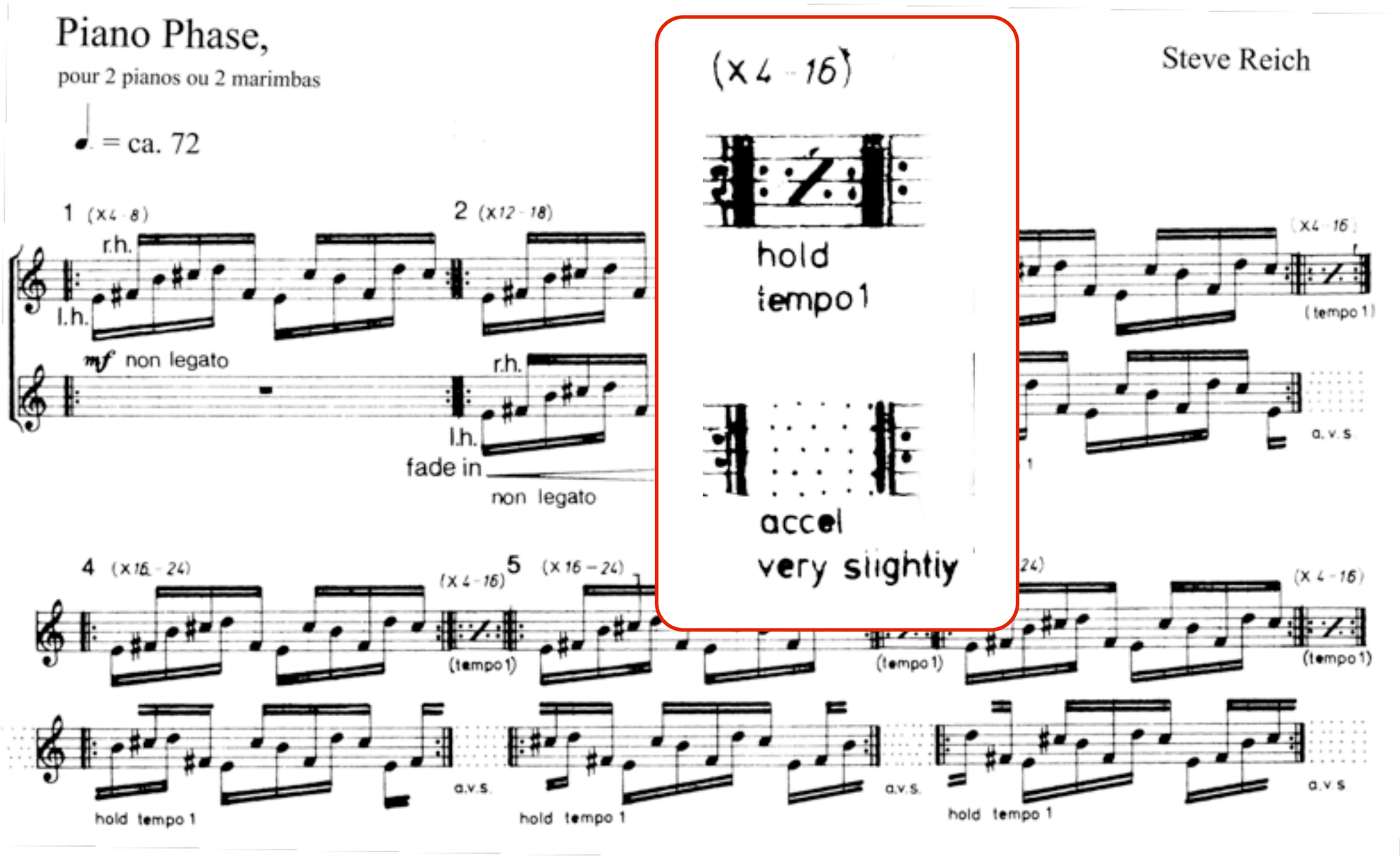

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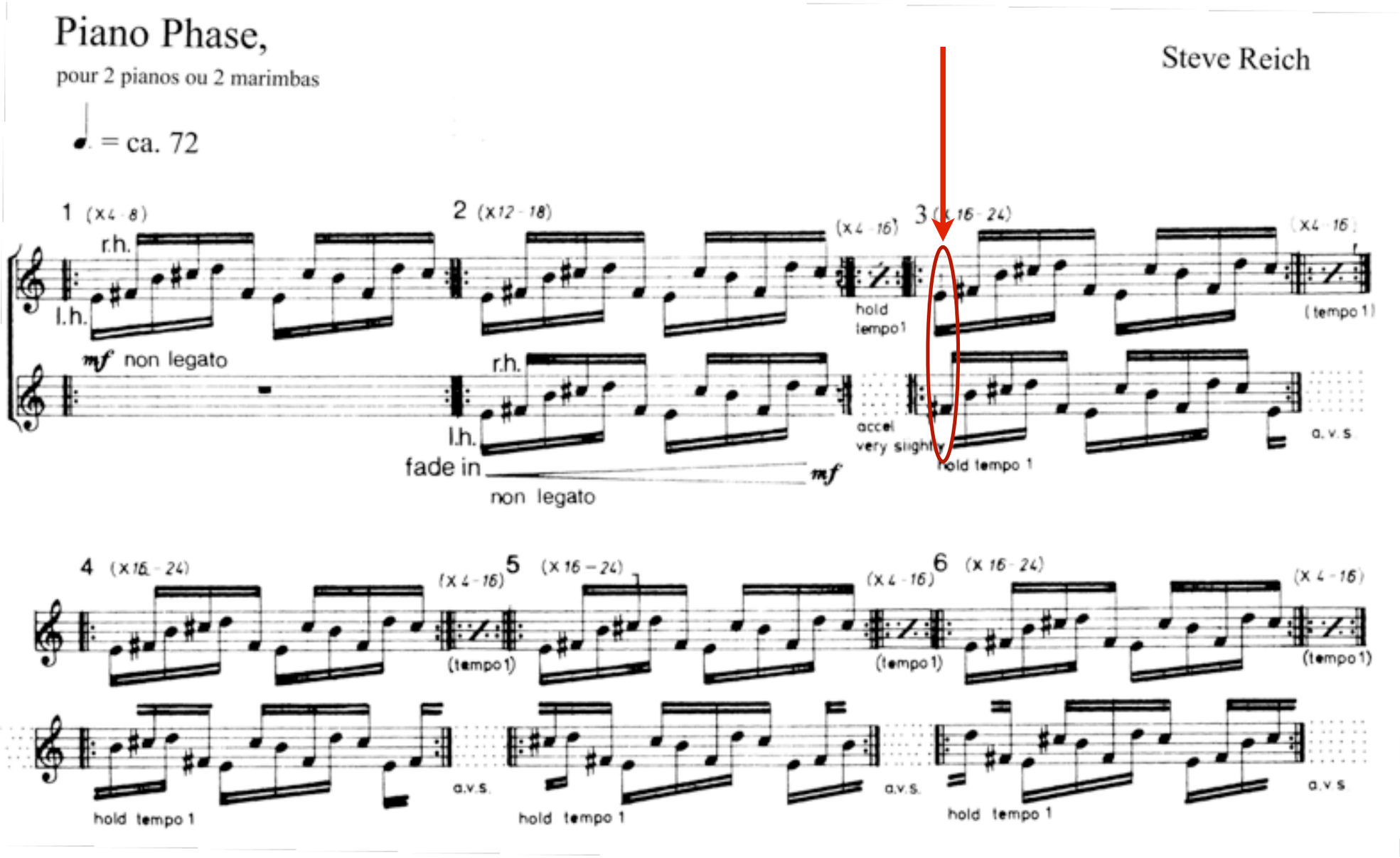

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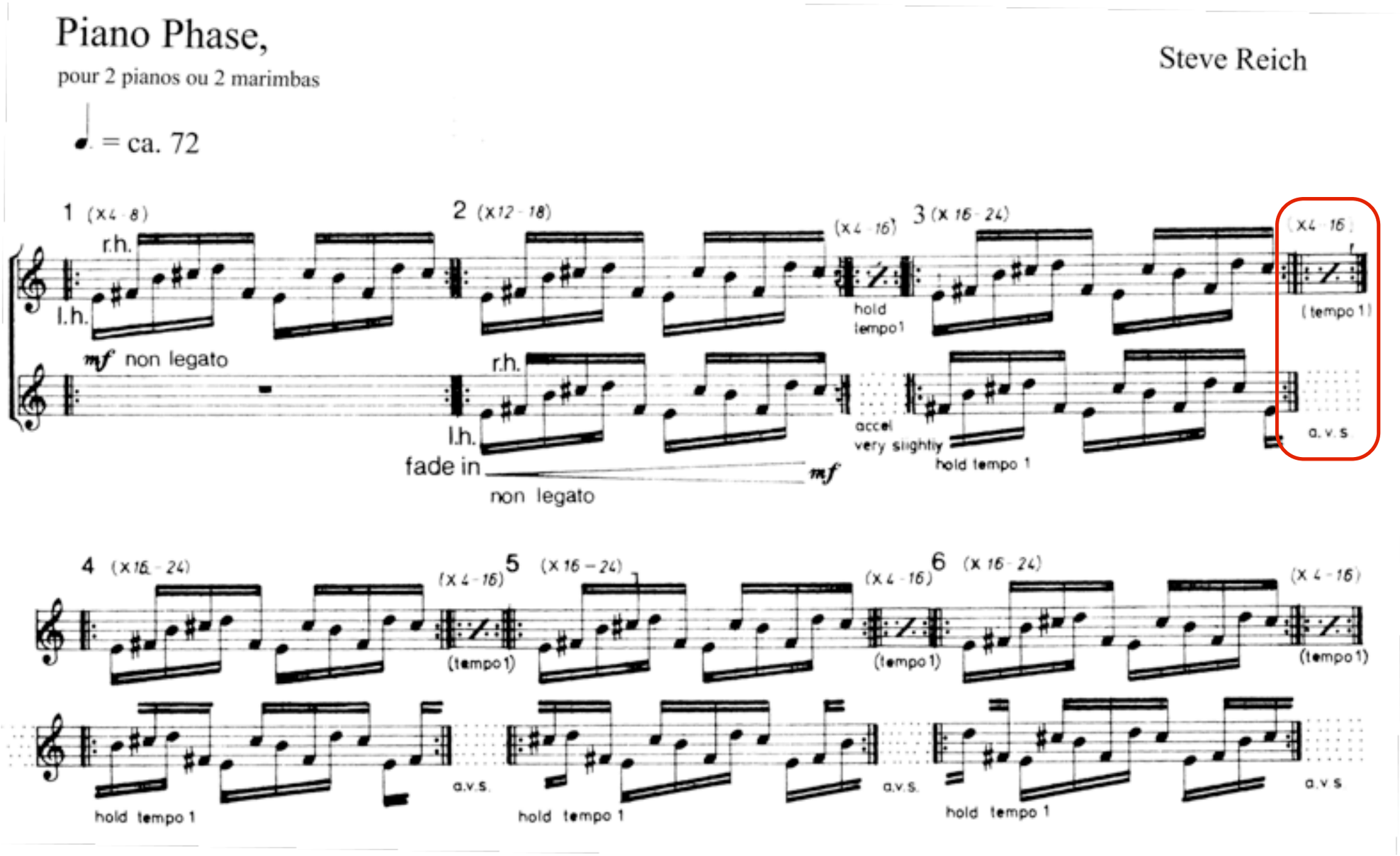

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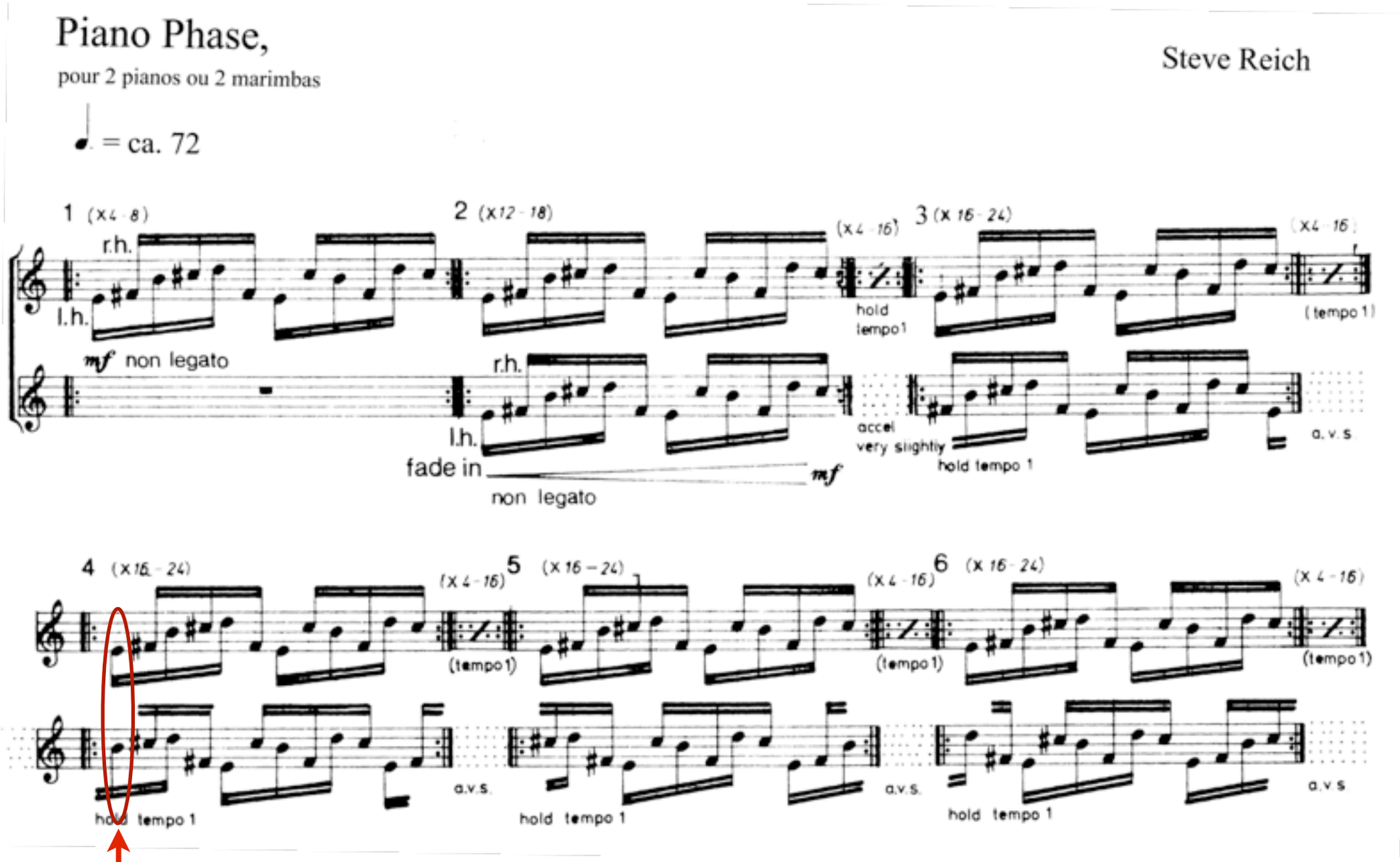

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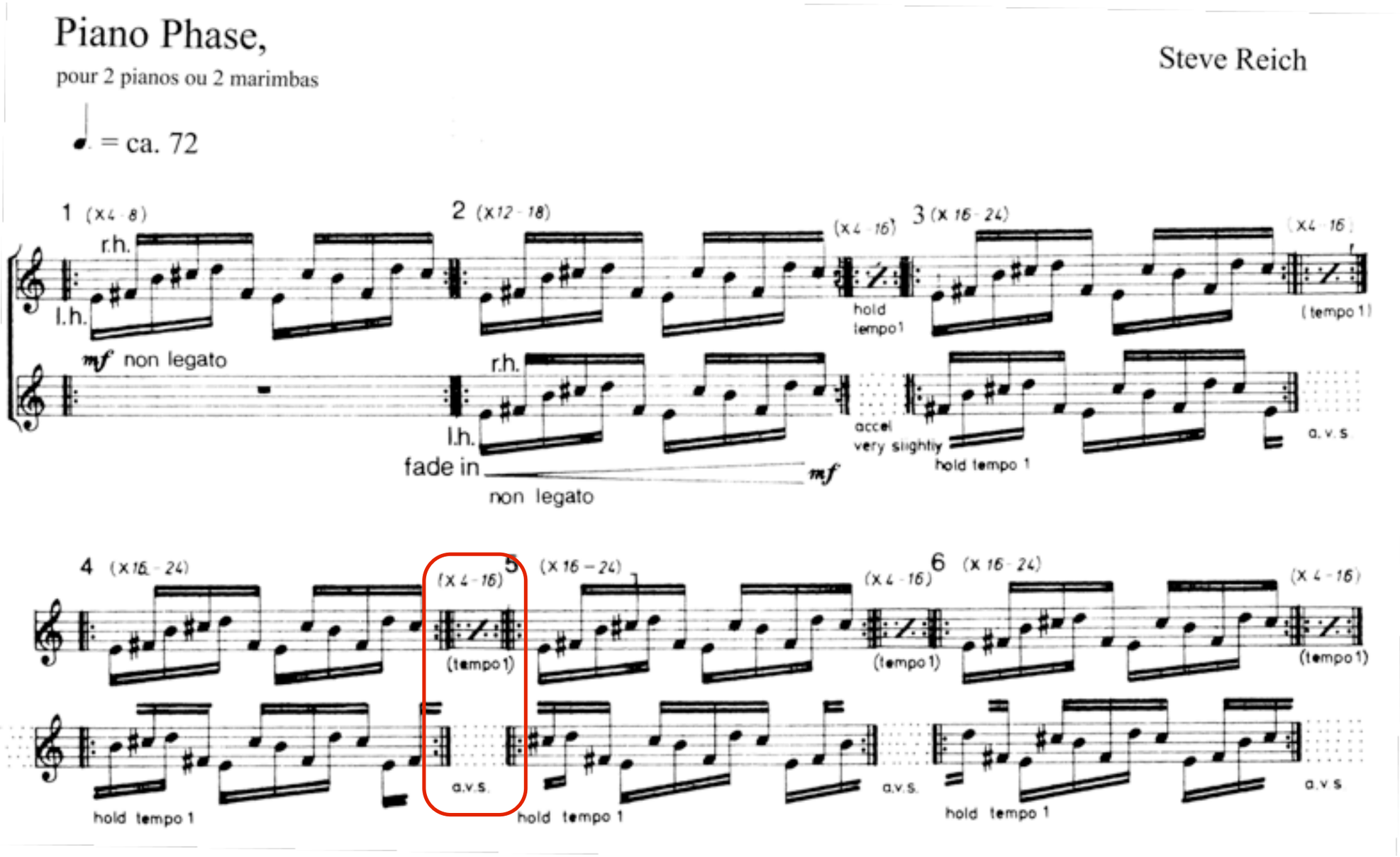

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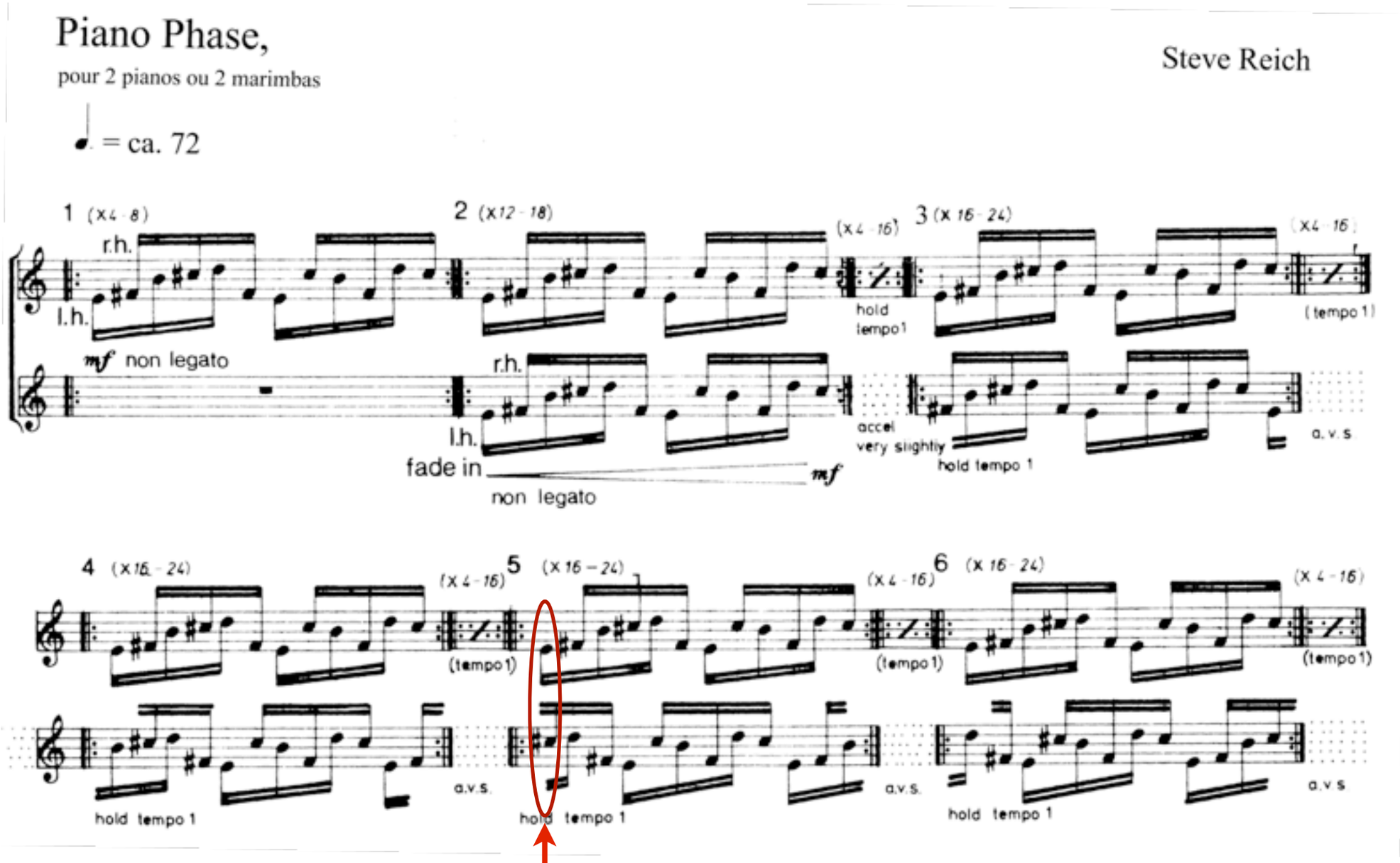

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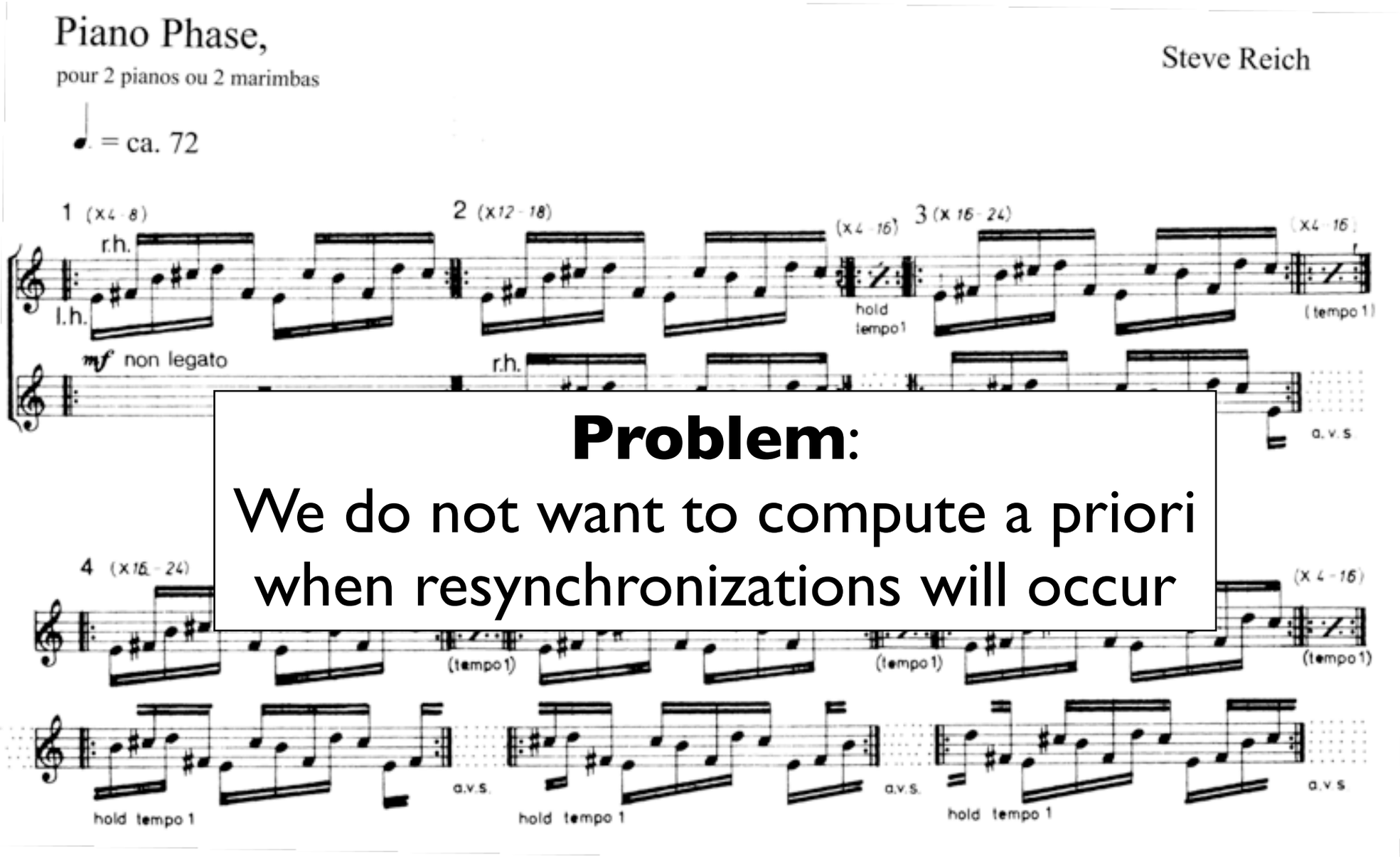

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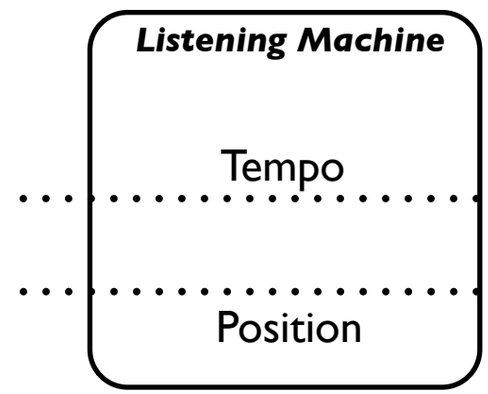
Alice

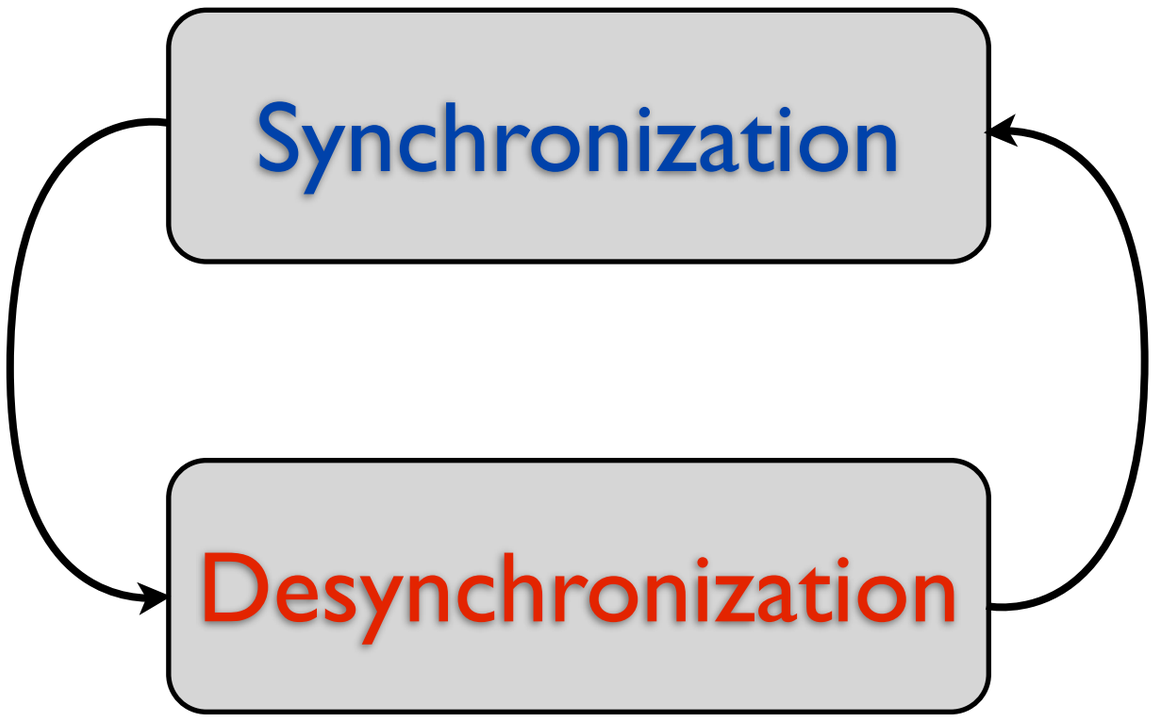
Problem:
We do not want to compute a priori when resynchronizations will occur

... in Mixed Music

Live musician
Plays the constant speed part

Electronic
Handles the desynchronization





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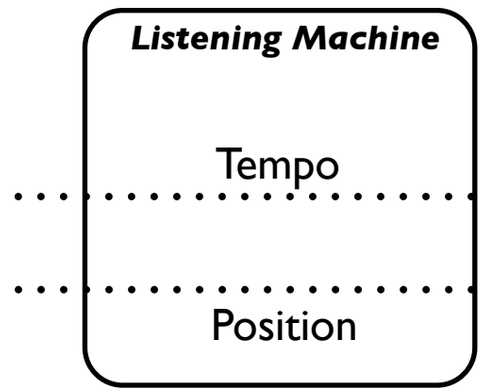

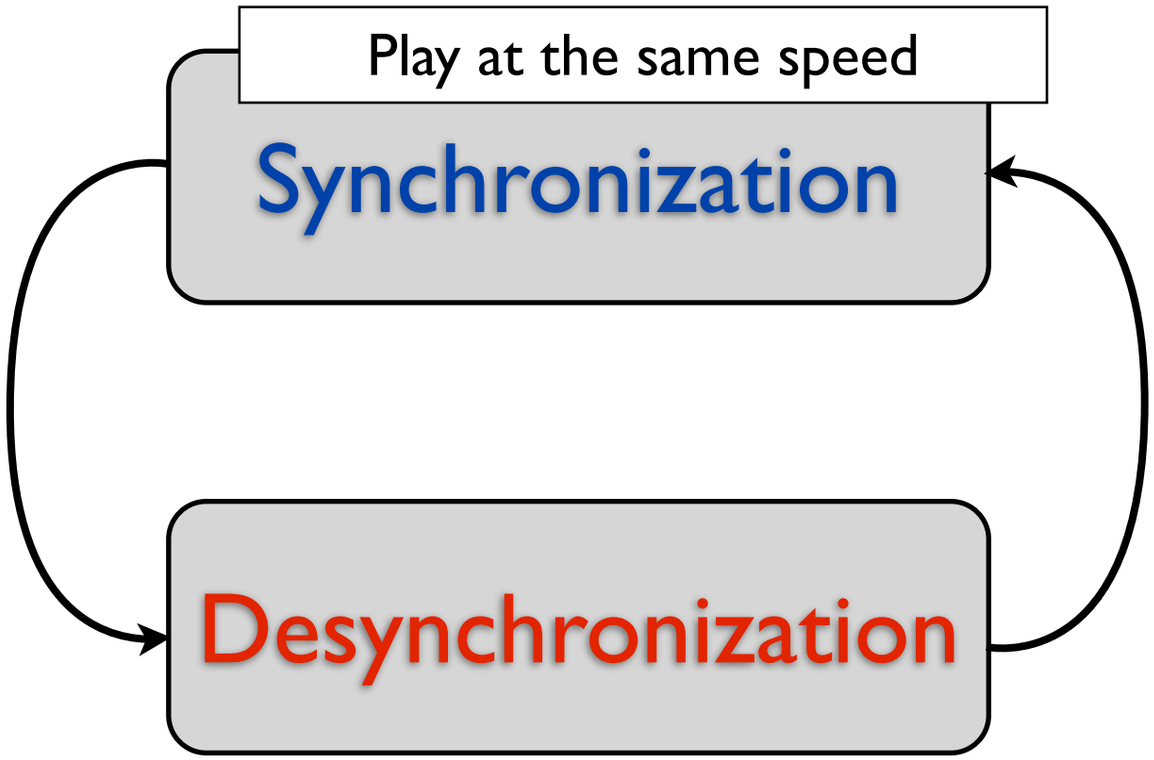

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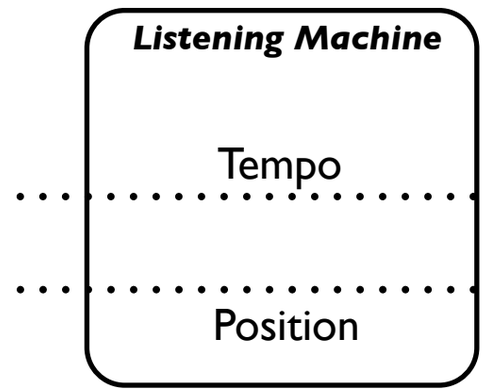

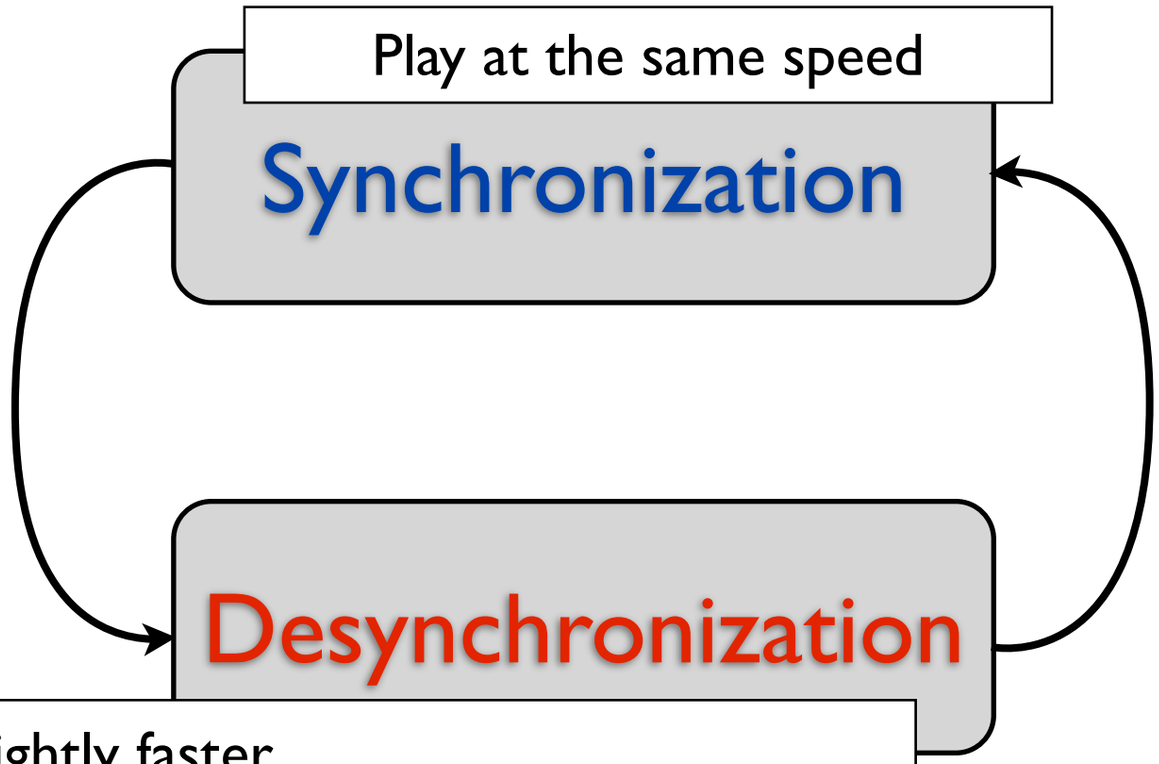

- Play slightly faster
- Track the first note of Bob
- Resynchronize when the k-th note of Alice is close enough of the first note of Bob

Implementation

Two phases:
Synchronization
Desynchronization

```
let piano_phase sync desync first_note kth_note =
  let rec process piano_phase k =
    let ev = last_event asco in
    run (melody ev 4 0.25 first_note);
    emit desync;
    do
      let ev = last_event asco in
      run (melody (ev+1) 16 0.2458 first_note) ||
      run (track asco k kth_note) ||
      run (compare asco first_note kth_note sync 0.05)
    until sync done;
    run (piano_phase ((k + 1) mod 12))
  in
  piano_phase 1
in
```

Implementation

Synchronization

Play the melody four times and follow the tempo

Emit the signal **`desync`** *after four iterations of the melody*

```
let piano_phase sync desync first_note kth_note =
  let rec process piano_phase k =
    let ev = last_event asco in
    run (melody ev 4 0.25 first_note);
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    until sync done;
    run (piano_phase ((k + 1) mod 12))
  in
  piano_phase 1
in
```

Implementation

Desynchronization

Play slightly faster
and emit the signal `first_note`
whenever the first note is played

Track the k-th note of the musician

Compare the emission of signals kth_note and first_note and emit **`sync`** *when they are close enough*

```
let piano_phase sync desync first_note kth_note =
  let rec process piano_phase k =
    let ev = last_event asco in
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    emit desync;
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    until sync done;
    run (piano_phase ((k + 1) mod 12))
  in
  piano_phase 1
in
```

Retour sur les choix

- Choix du langage hôte
- Choix du modèle de concurrence
- Choix de faire un langage

encore une démo

http://reactiveml.org