

# Antescofo

Synchronous Interpretations of a Language  
for Mixed Music

## Supervisors

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# Objectives

- Study and formalization of a language for mixed music: the language of Antescofo
- Link with synchronous languages

# Antescofo

[Cont 2010]

- Score Follower: Position, Tempo
- Reactive Sequencer:  
Automatic accompaniment



# Mixed Music



Performance/Real Time



Composition/Program

Voice 1: sampler  
Voice 2: player  
Voice 3: sampler

OTEMO (1st section)

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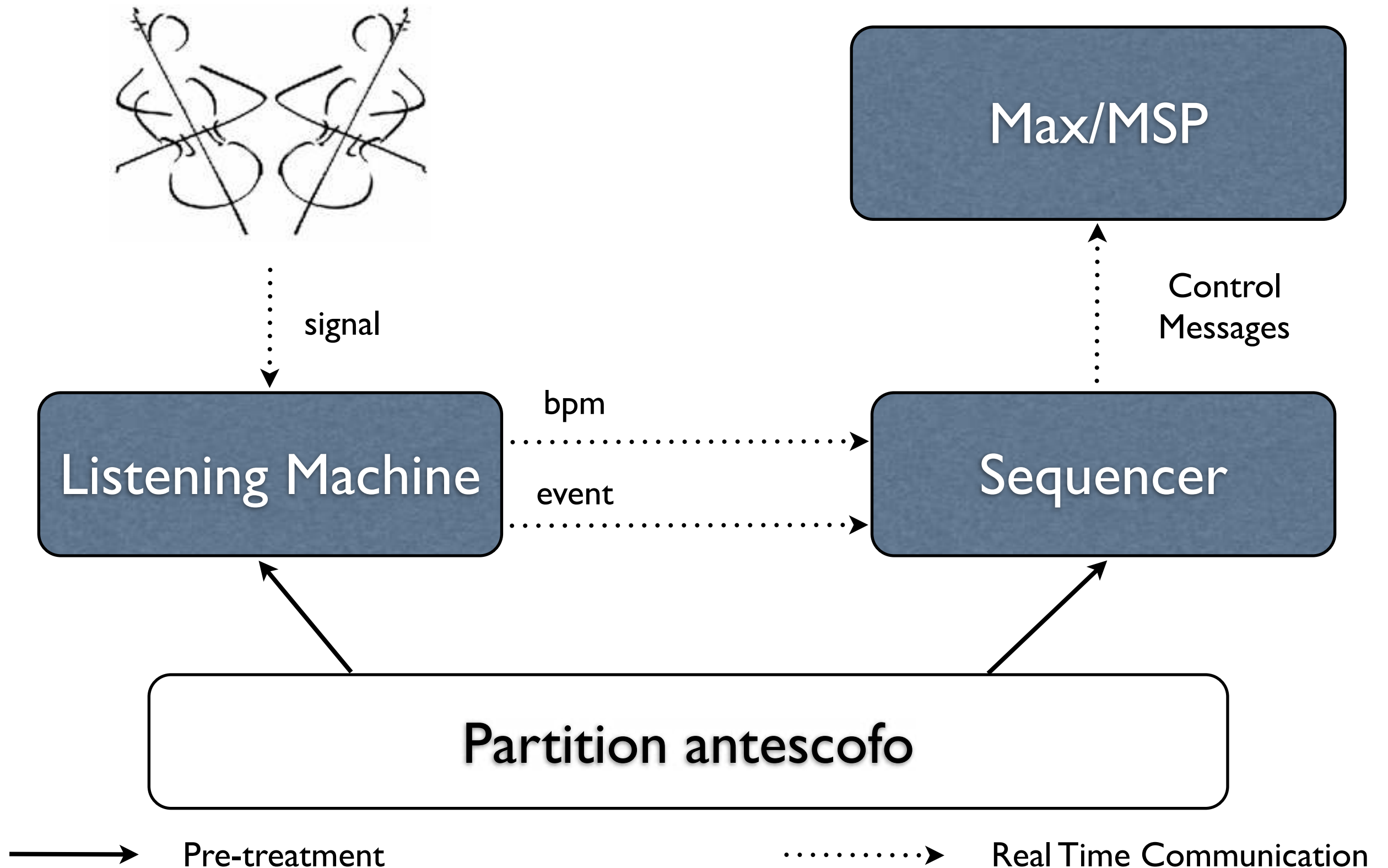
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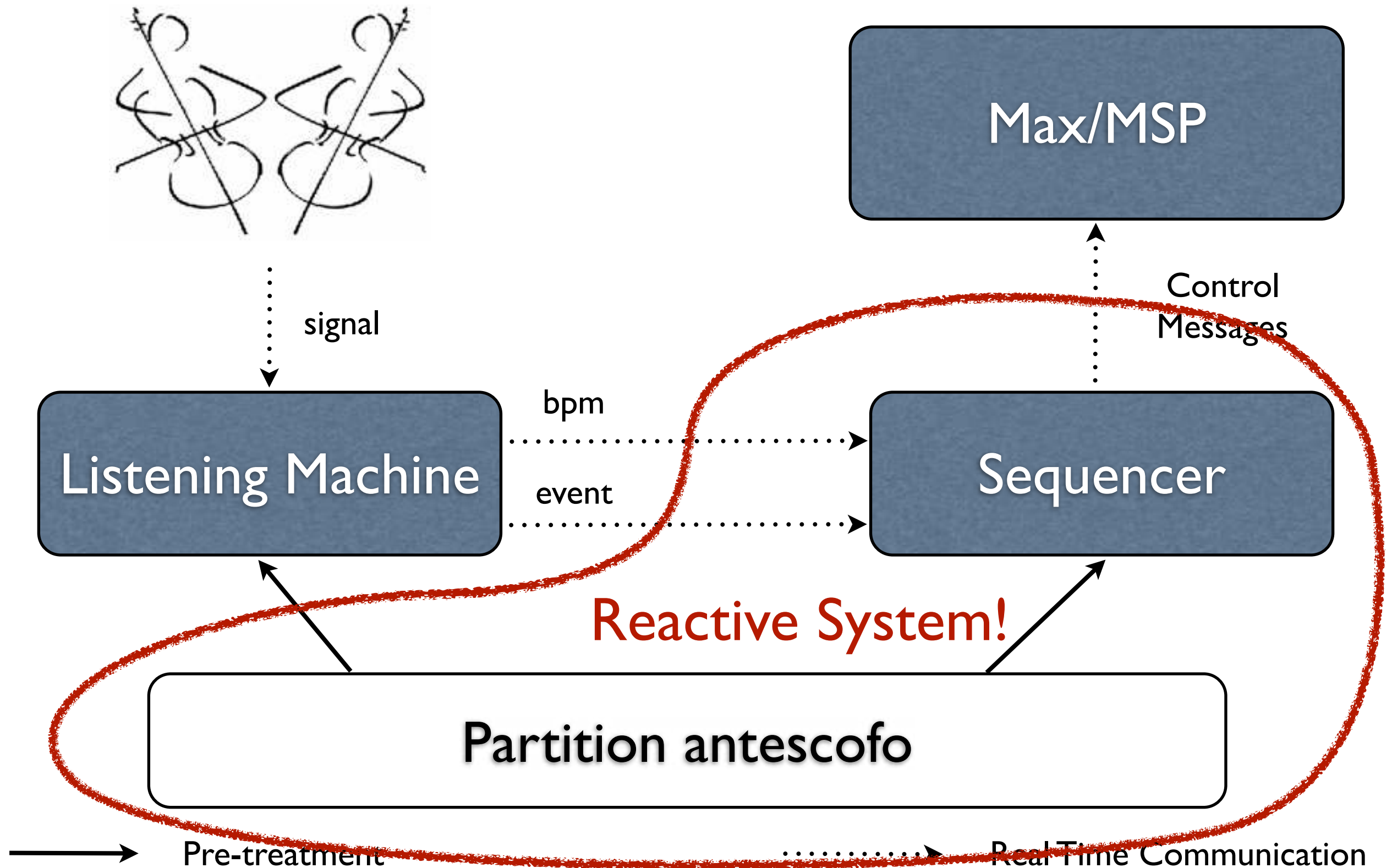
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# Antescofo Architecture





# Antescofo Architecture



# The Language of Antescofo

Goal: Jointly specify electronic and instrumental parts

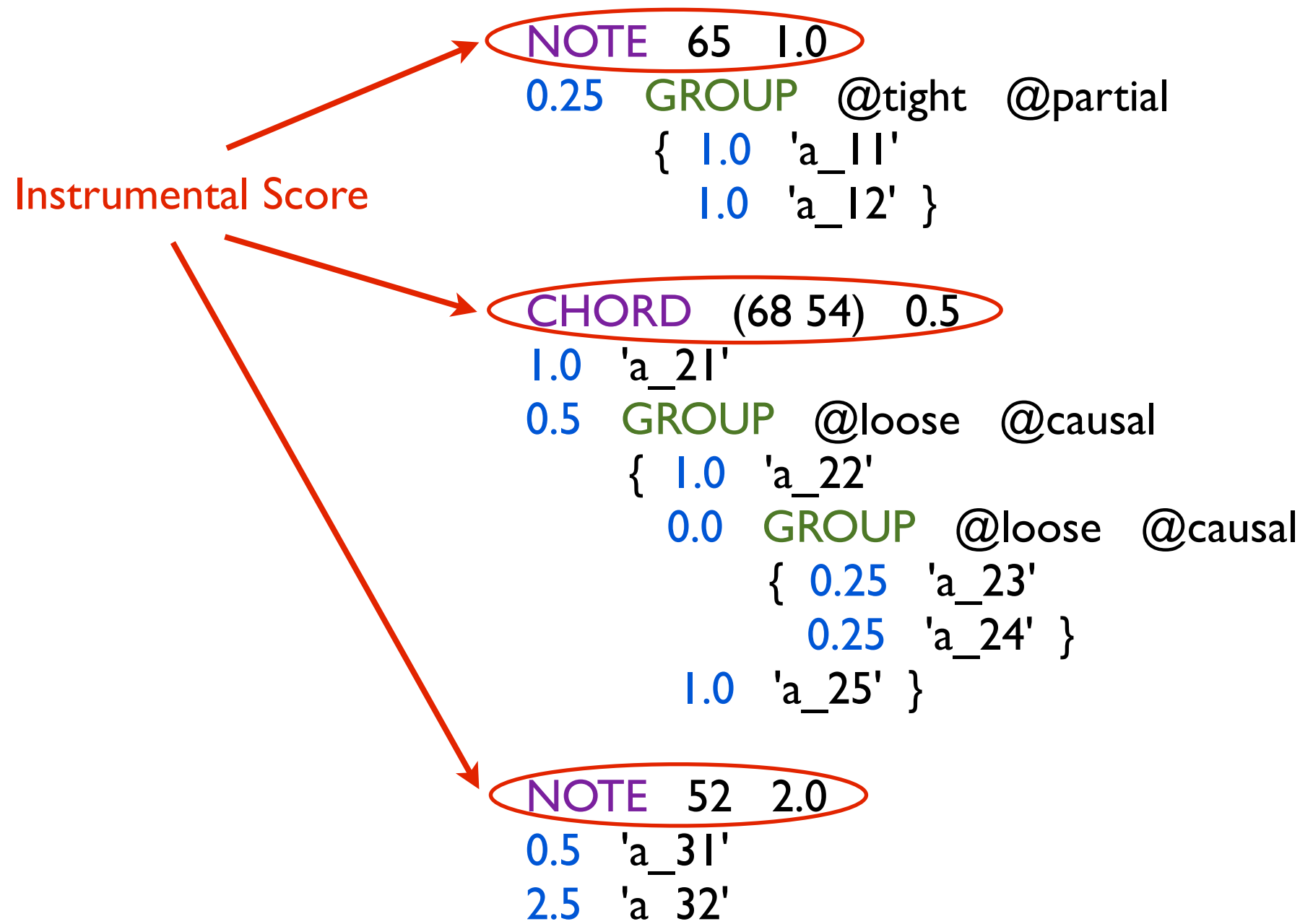
```
NOTE 65 1.0
0.25 GROUP @tight @partial
      { 1.0 'a_11'
        1.0 'a_12' }
```

```
CHORD (68 54) 0.5
1.0 'a_21'
0.5 GROUP @loose @causal
      { 1.0 'a_22'
        0.0 GROUP @loose @causal
          { 0.25 'a_23'
            0.25 'a_24' }
        1.0 'a_25' }
```

```
NOTE 52 2.0
0.5 'a_31'
2.5 'a_32'
```

# The Language of Antescofo

Goal: Jointly specify electronic and instrumental parts





# The Language of Antescofo

Goal: Jointly specify electronic and instrumental parts

NOTE 65 1.0

0.25 GROUP @tight @partial  
{ 1.0 'a\_11'  
1.0 'a\_12' }

CHORD (68 54) 0.5

1.0 'a\_21'  
0.5 GROUP @loose @causal  
{ 1.0 'a\_22'  
0.0 GROUP @loose @causal  
{ 0.25 'a\_23'  
0.25 'a\_24' }  
1.0 'a\_25' }

NOTE 52 2.0

0.5 'a\_31'  
2.5 'a\_32'

Electronic Score

# The Language of Antescofo

Goal: Jointly specify electronic and instrumental parts

```
NOTE 65 1.0
0.25 GROUP @tight @partial
{ 1.0 'a_11'
  1.0 'a_12' }
```

```
CHORD (68 54) 0.5
1.0 'a_21'
0.5 GROUP @loose @causal
{ 1.0 'a_22'
  0.0 GROUP @loose @causal
    { 0.25 'a_23'
      0.25 'a_24' }
  1.0 'a_25' }
```

Delay relative to the tempo

```
NOTE 52 2.0
0.5 'a_31'
2.5 'a_32'
```

# The Language of Antescofo

Goal: Jointly specify electronic and instrumental parts

```
NOTE 65 1.0
0.25 GROUP @tight @partial
      { 1.0 'a_11'
        1.0 'a_12' }

CHORD (68 54) 0.5
1.0 'a_21'
0.5 GROUP @loose @causal
      { 1.0 'a_22'
        0.0 GROUP @loose @causal
              { 0.25 'a_23'
                0.25 'a_24' }
        1.0 'a_25' }

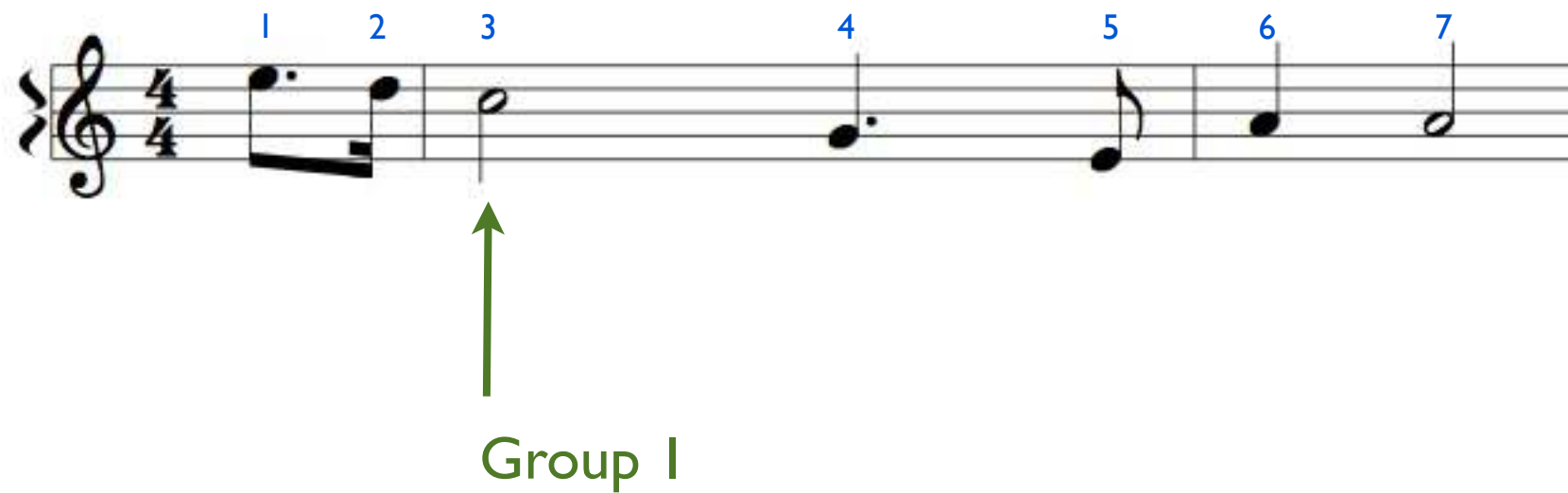
NOTE 52 2.0
0.5 'a_31'
2.5 'a_32'
```

Group Attributes

# Language Objectives

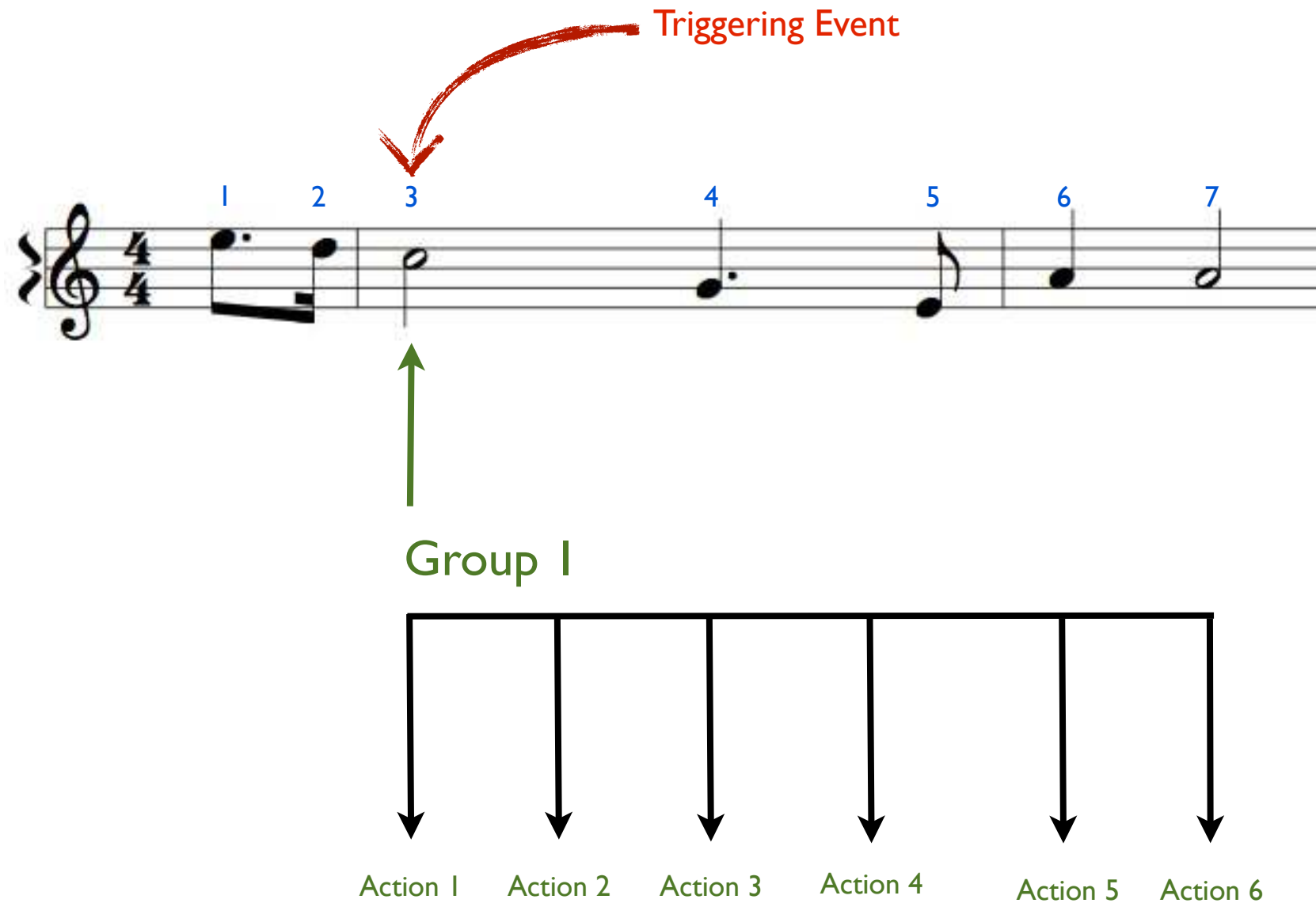
- Specify a ‘critical’ reactive system
- Time programming
- Real time synchronization
- Error handling strategies

# Synchronization Strategies

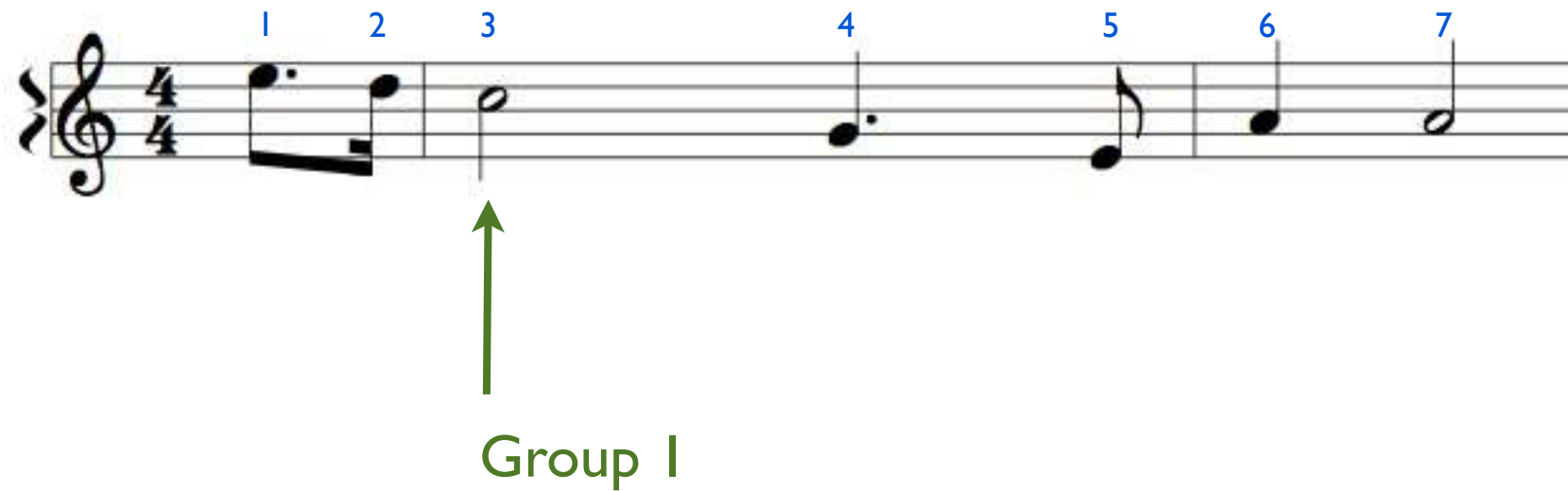


**Loose:** Synchronization  
with the tempo stream.

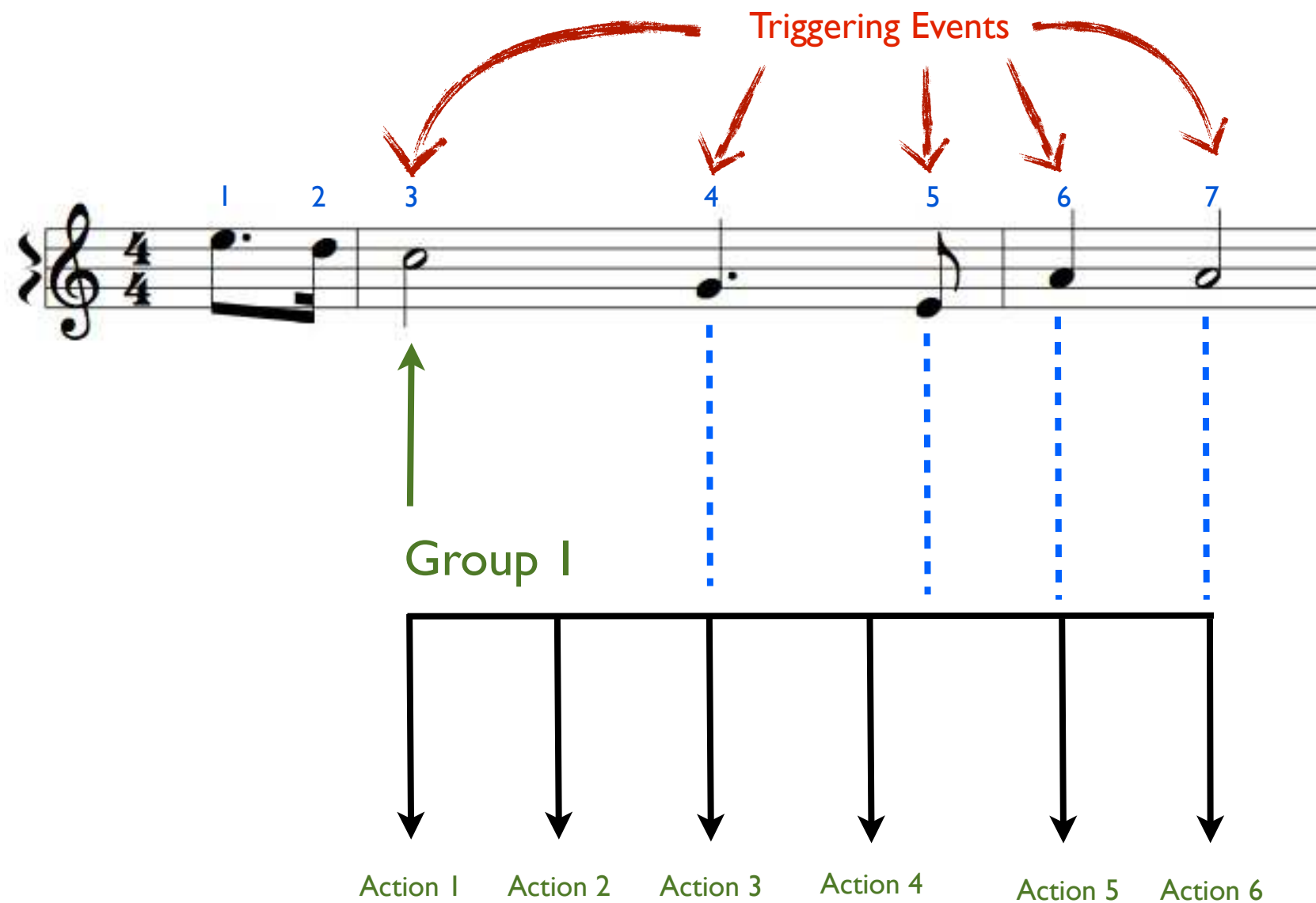




**Loose:** Synchronization  
with the tempo stream.

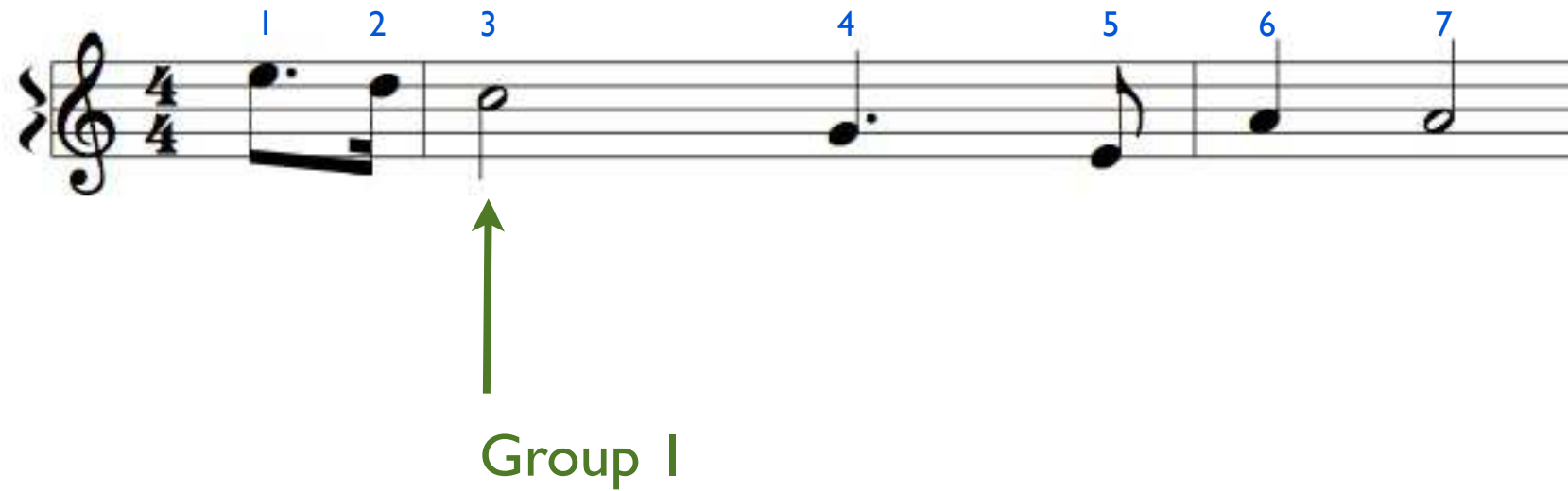


***Tight:*** Synchronization  
with tempo and events stream.

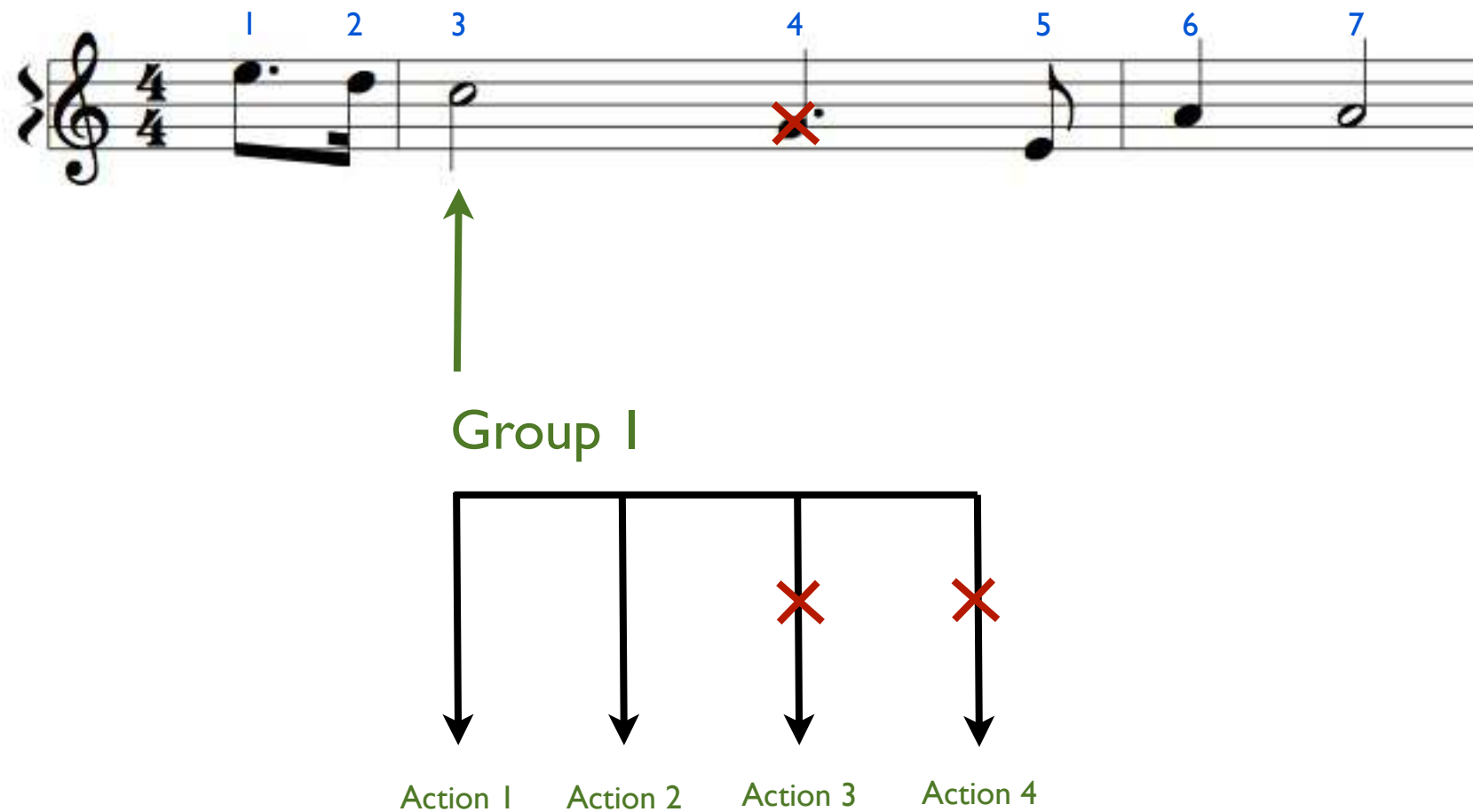


***Tight:*** Synchronization  
with tempo and events stream.

# Error Handling Strategies

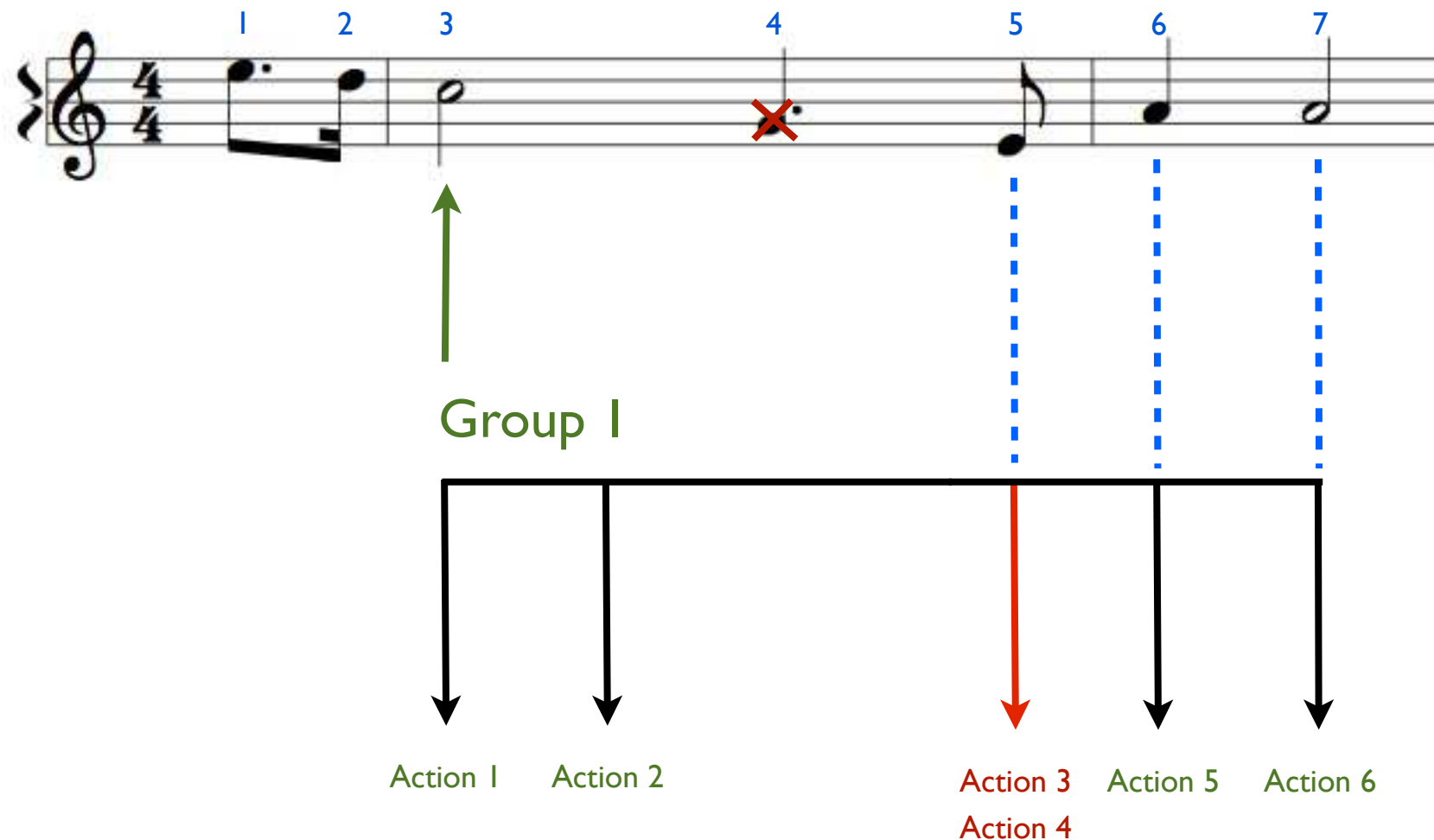


***Causal:*** Actions should be launch immediately when the system recognize the absence of the triggering event

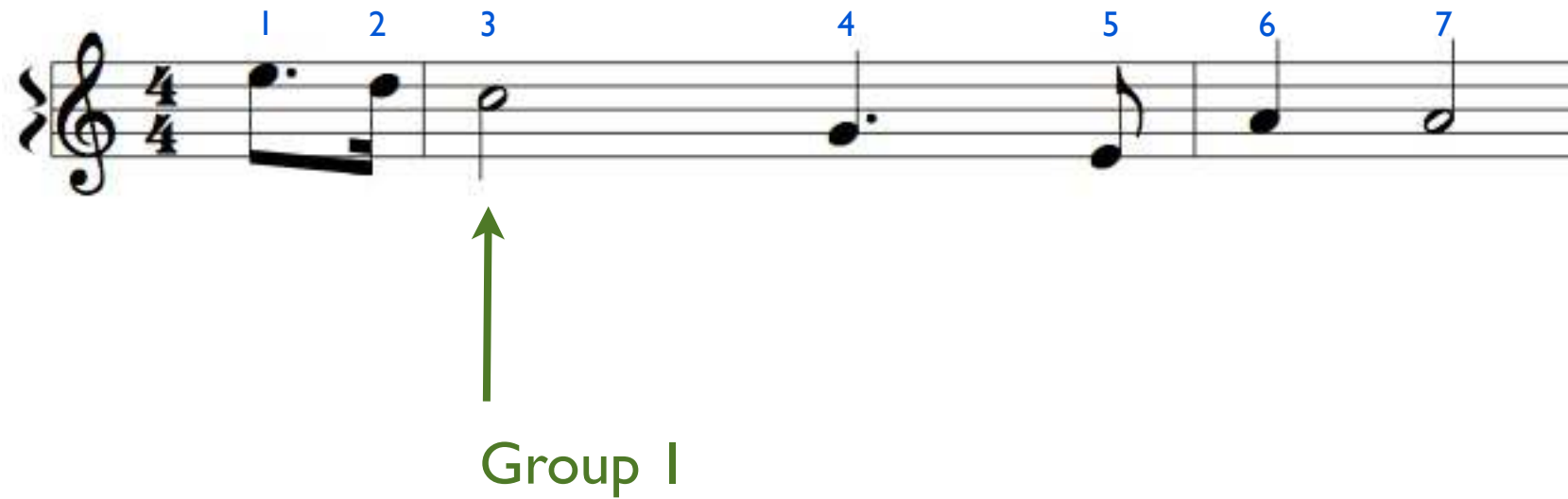


***Causal:*** Actions should be launch immediately when the system recognize the absence of the triggering event

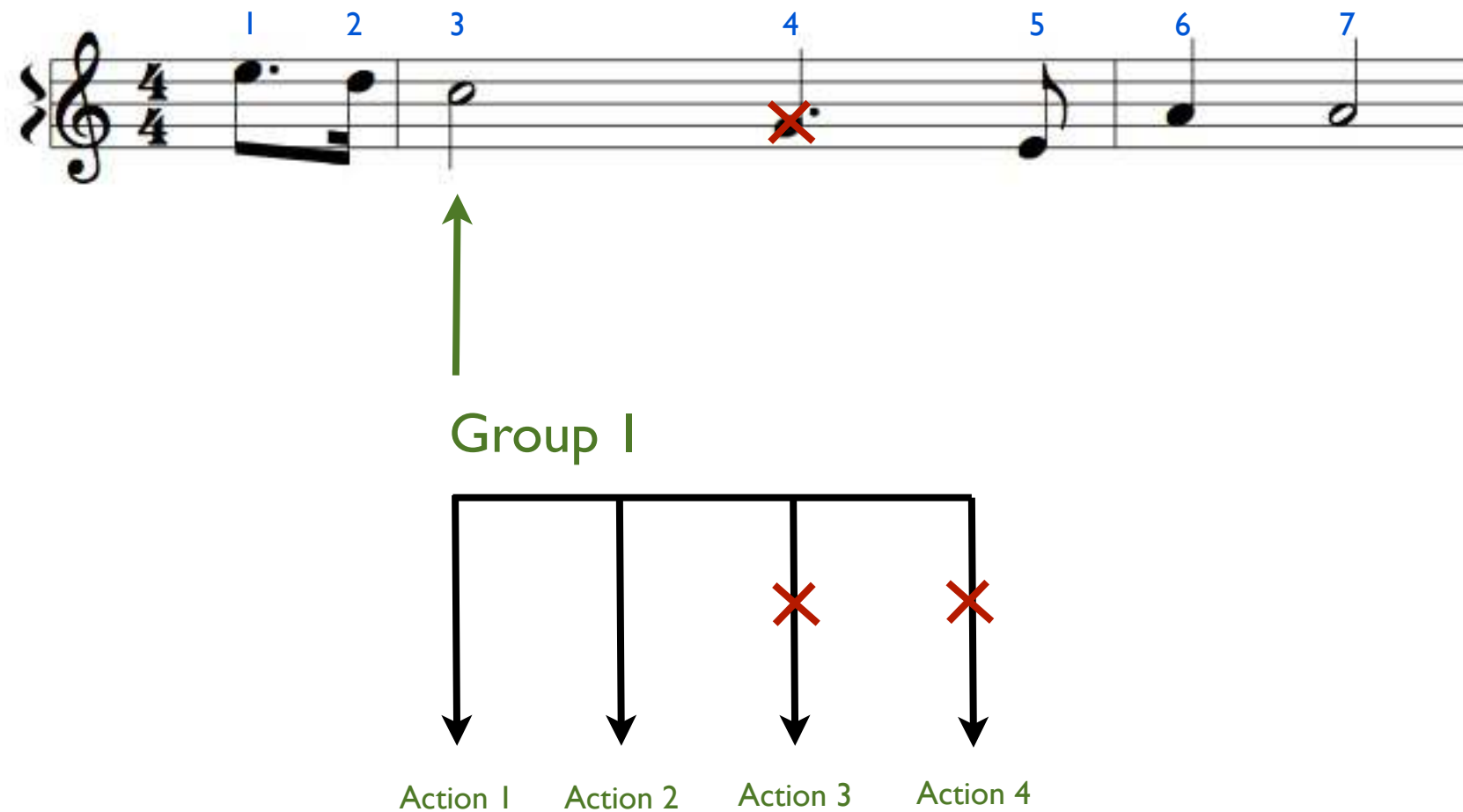




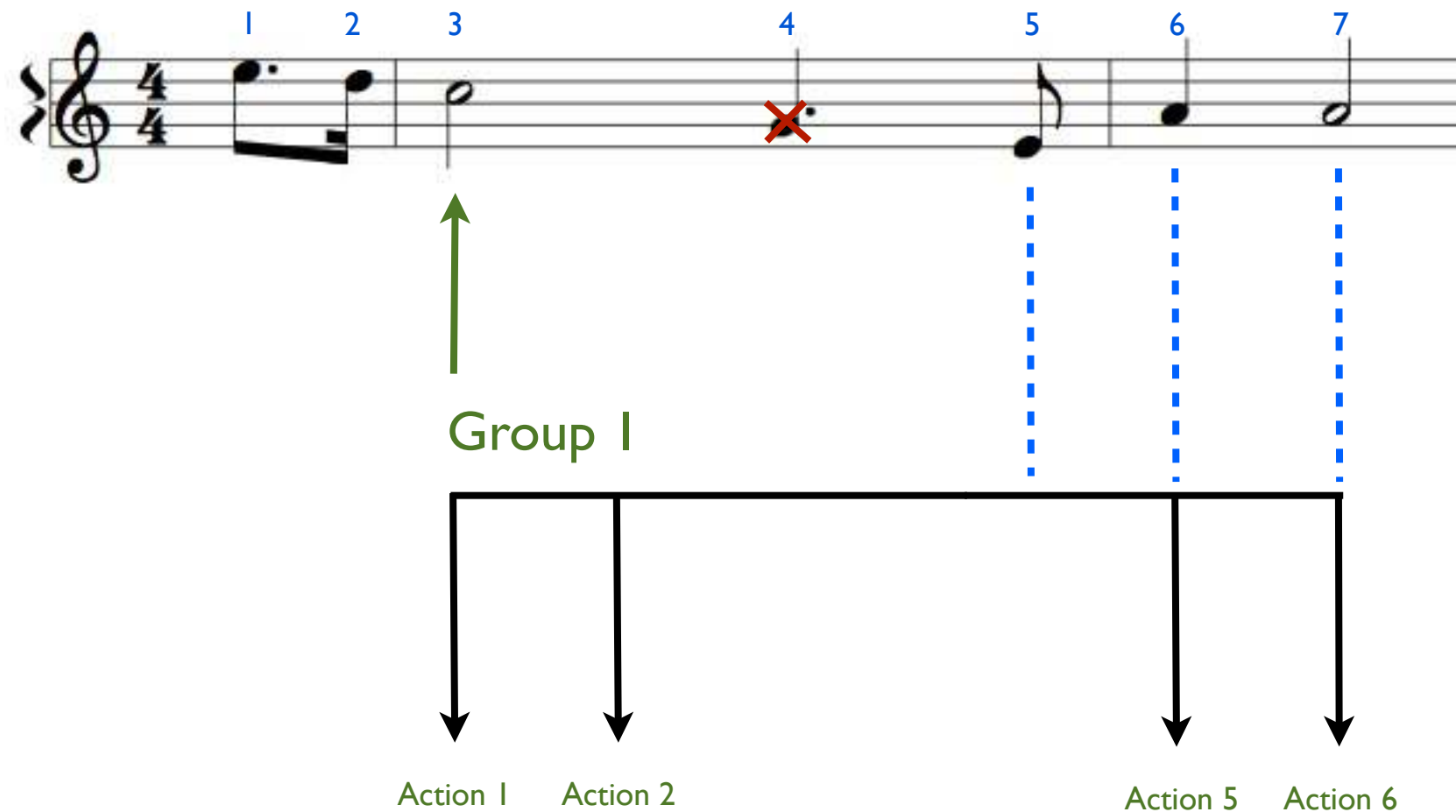
***Causal:*** Actions should be launch immediately when the system recognize the absence of the triggering event



***Partial:*** Actions should be dismissed in the absence of the triggering event



***Partial:*** Actions should be dismissed in the absence of the triggering event



***Partial:*** Actions should be dismissed in the absence of the triggering event

# Model

$a$	$::=$	$A(\delta, m)$
$g$	$::=$	$G(\delta, sync, err, ae^*)$
$ae$	$::=$	$a g$
$sync$	$::=$	$T L$
$err$	$::=$	$P C$
$\delta$	$::=$	$delay$
$m$	$::=$	$message$
$i$	$::=$	$int$
$se$	$::=$	$(i : ae)$
$sc$	$::=$	$se^*$
$p$	$::=$	$(i, \delta, m)^*$

# Model

$a$	$::=$	$A(\delta, m)$		
$g$	$::=$	$G(\delta, sync, err, ae^*)$		
$ae$	$::=$	$a g$		
$sync$	$::=$	$T L$		
$err$	$::=$	$P C$	Dating	$\mathcal{E} : int \rightarrow delay$
$\delta$	$::=$	$delay$	Detections	$D : int^*$
$m$	$::=$	$message$	Errors	$M : int \rightarrow int$
$i$	$::=$	$int$		
$se$	$::=$	$(i : ae)$		
$sc$	$::=$	$se^*$		
$p$	$::=$	$(i, \delta, m)^*$		



# Model

$a$	$::=$	$A(\delta, m)$	
$g$	$::=$	$G(\delta, sync, err, ae^*)$	
$ae$	$::=$	$a g$	
$sync$	$::=$	$T L$	
$err$	$::=$	$P C$	Dating $\mathcal{E} : int \rightarrow delay$
$\delta$	$::=$	$delay$	Detections $D : int^*$
$m$	$::=$	$message$	Errors $M : int \rightarrow int$
$i$	$::=$	$int$	
$se$	$::=$	$(i : ae)$	
$sc$	$::=$	$se^*$	
$p$	$::=$	$(i, \delta, m)^*$	

## Objective

$$D, M, sc \mid_{\text{exec}} p$$

# Execution Rules

$$D, M, sc \mid \frac{\text{exec}}{} p$$

Execute a score

$$D, M, sc \mid \frac{\text{detect}}{\delta, i} a \rightarrow p$$

Execute an action  $a$   
attached to a detected event  $i$   
with a delay  $\delta$

$$D, M, sc \mid \frac{\text{missed}}{\delta, i} a \rightarrow p$$

Execute an action  $a$   
attached to a missed event  $i$   
with a delay  $\delta$

# Execution

EMPTY SCORE

$$\overline{D, M, \emptyset \mid \text{exec} \quad \emptyset}$$

DETECTED

$$\frac{i \in D \quad D, M, sc \mid \frac{\text{detect}}{0, i} ae \rightarrow p_1 \quad D, M, sc \vdash p_2}{D, M, sc \cup (i : ae) \mid \text{exec} \quad p_1 \cup p_2}$$

MISSED

$$\frac{i \notin D \quad D, M, sc \mid \frac{\text{missed}}{0, i} ae \rightarrow p_1 \quad D, M, sc \vdash p_2}{D, M, sc \cup (i : ae) \mid \text{exec} \quad p_1 \cup p_2}$$

# Execution

DETECTED ACTION

$$\overline{D, M, sc \mid \frac{\text{detect}}{\delta, i} A(\delta_a, m) \rightarrow \{(i, \delta + \delta_a, m)\}}$$

MISSED ACTION

$$M(i) = j$$

$$\overline{D, M, sc \mid \frac{\text{missed}}{\delta, i} A(\delta_a, m) \rightarrow \{j, \max(0, \delta + \delta_a + \mathcal{E}(i) - \mathcal{E}(j)), m\}}$$

# An Interpret in Reactive ML

# Reactive ML

[Mandel 2005]

- A Reactive extension to OCaml
- Synchronous constructs (`|| ;`)
- Communication between processus via signals



# Logical Time

```
let process wait_abs dur =  
  let d = int_of_float (dur /. clock_step) in  
  for i=d downto 1 do pause;
```

- Wait a duration in millisecond
- Compilation in sampling mode  
(clock\_step : argument for the compiler)

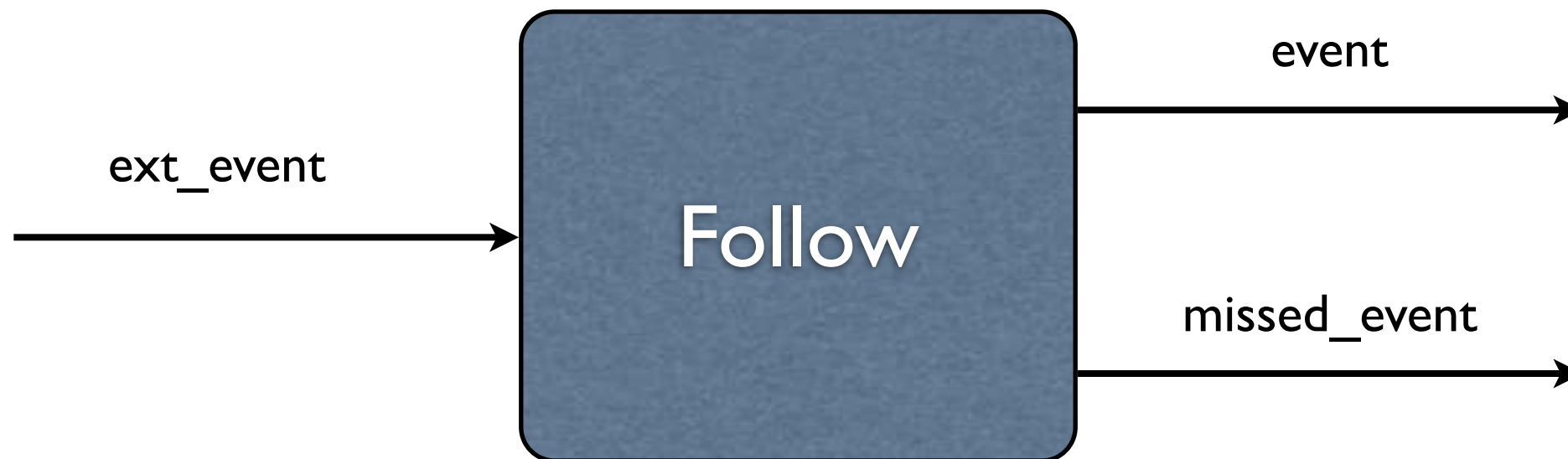
# Logical Time

```
let process wait_abs dur =  
  let d = int_of_float (dur /. clock_step) in  
  for i=d downto 1 do pause;
```

```
let process ab d1 d2 =  
  (run (wait_abs d1); print a)  
  ||  
  (run (wait_abs d2); print b)
```

# Signals

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```



# Signals

```
signal ext_event default 0 gather fun x y -> x;;
signal event default 0 gather fun x y -> x;;
signal missed_event default [] gather fun x y -> x;;

let process follow ext_event event missed_event =
  loop
    await ext_event (ev) in
    let pre_event = last ?event in
    emit event ev;
    emit missed_event (nat (p_event+1) (event-1));
  end
```



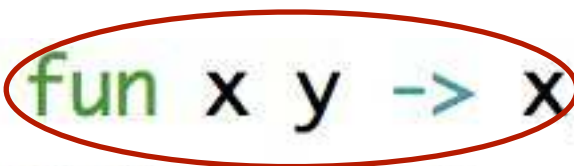
# Signals

Default value

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```

```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```

# Signals

signal ext\_event default 0 gather  fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed\_event default [] gather fun x y -> x;;

```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```



# Signals

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```

```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```

Await a  
reception



# Signals

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```

```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```

Emit on a signal

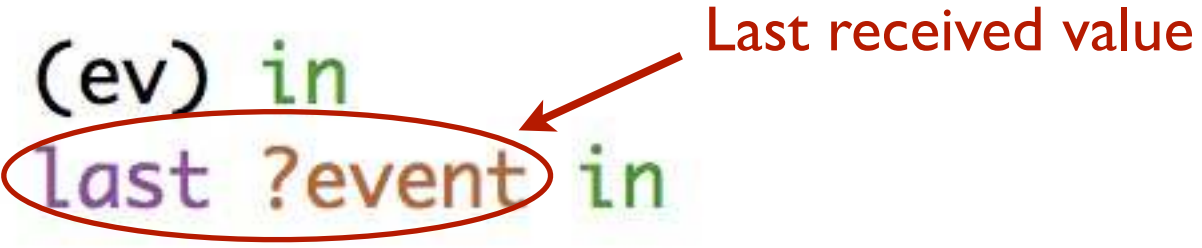




# Signals

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```

```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```



# Signals

```
signal ext_event default 0 gather fun x y -> x;;  
signal event default 0 gather fun x y -> x;;  
signal missed_event default [] gather fun x y -> x;;
```

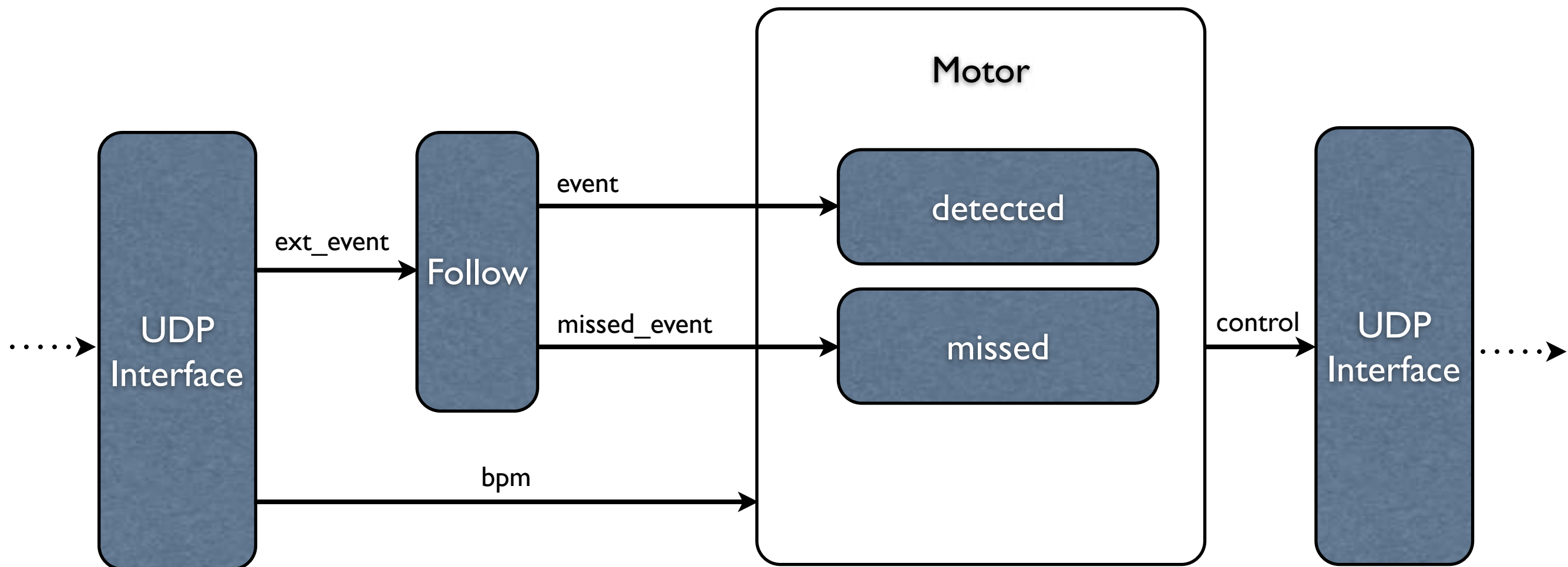
```
let process follow ext_event event missed_event =  
  loop  
    await ext_event (ev) in  
    let pre_event = last ?event in  
    emit event ev;  
    emit missed_event (nat (p_event+1) (event-1));  
  end
```

For each emission

# Why Reactive ML ?

- Time programming expressivity
- High level programming
- Recursivity: Hierarchical structure
- Lazy waiting: tempo changes

# Architecture





# Types

```
(** Basic action *)
type action =
  { action_delay : delay;
    action_body : message; }

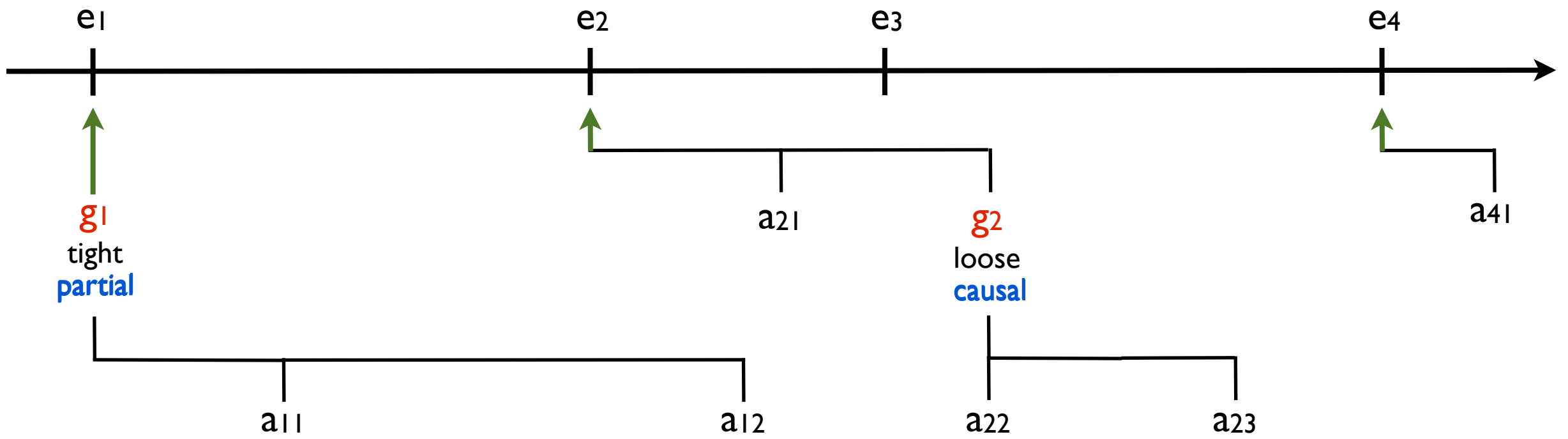
(** Asco group *)
type group =
  { group_delay : delay;
    group_synchro : sync;
    group_error : err;
    group_body : asco_event list; }

(** Generic asco event *)
and asco_event =
  Group of group
  | Action of action
```

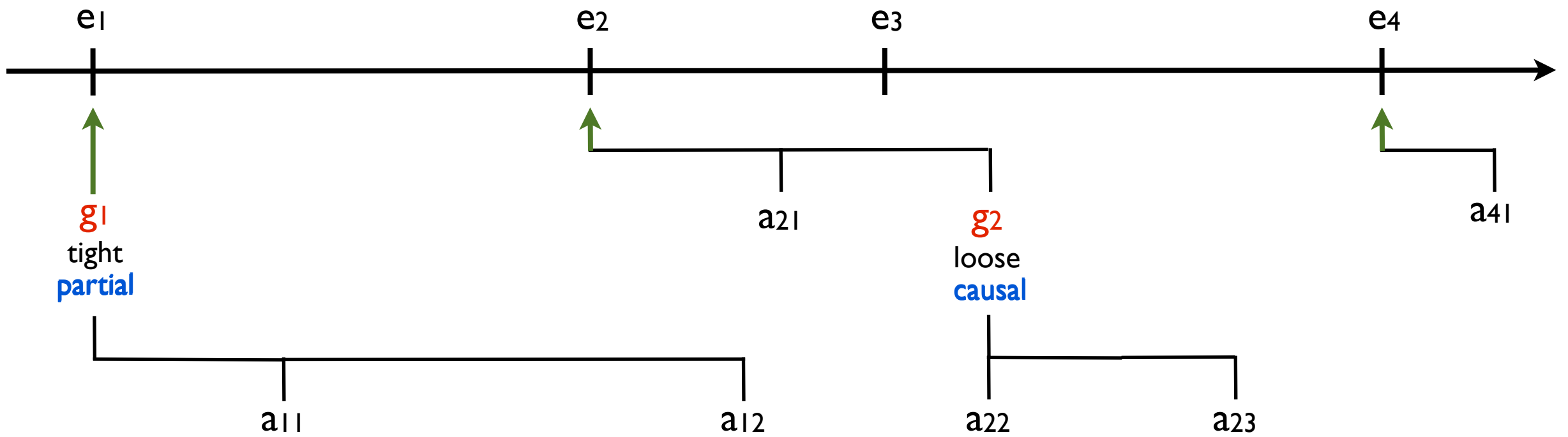
# Execution

```
let rec process exec ae ev =  
  (await event (e) when (ev = e) in  
  run detect ae)  
  ||  
  (await missed_event (me) when (List.mem ev me) in  
  run missed ae)  
  
and process detect ae = ...  
  
and process missed ae = ...
```

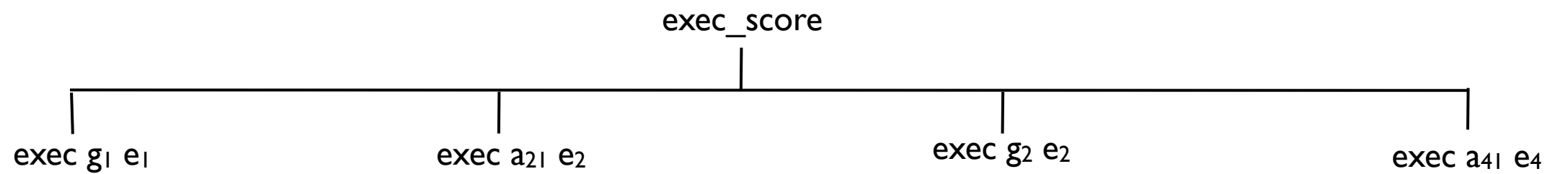
- Three mutually recursive processus
- Dynamical construction of the processus tree



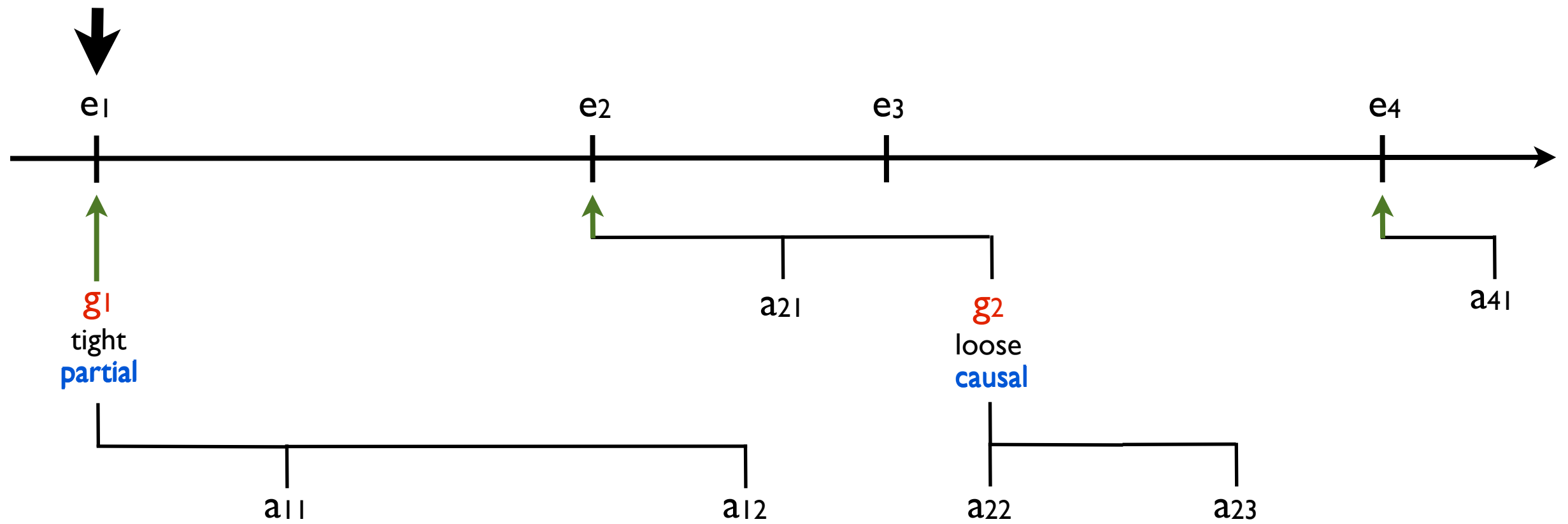
Score example



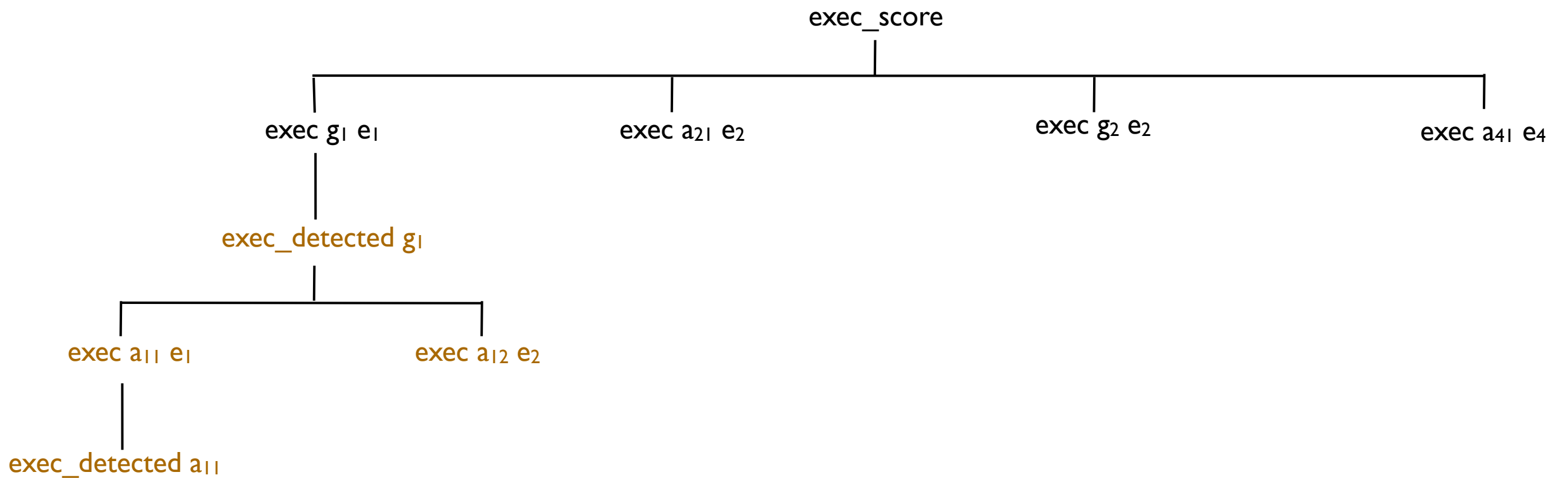
## Score example

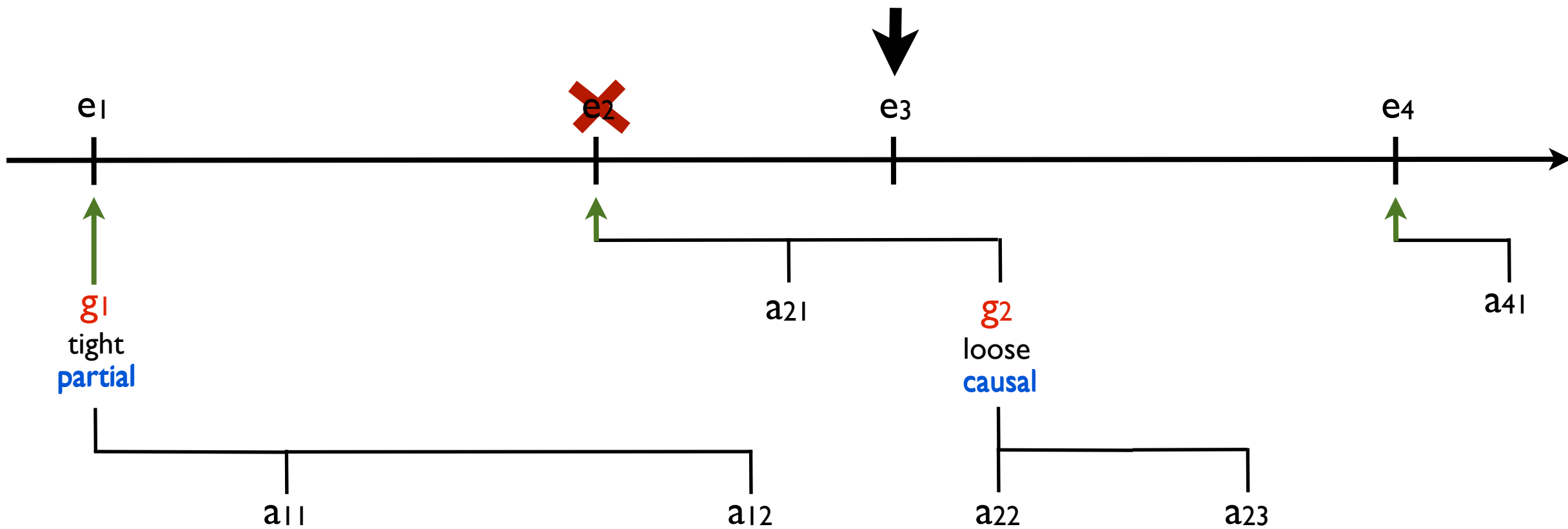




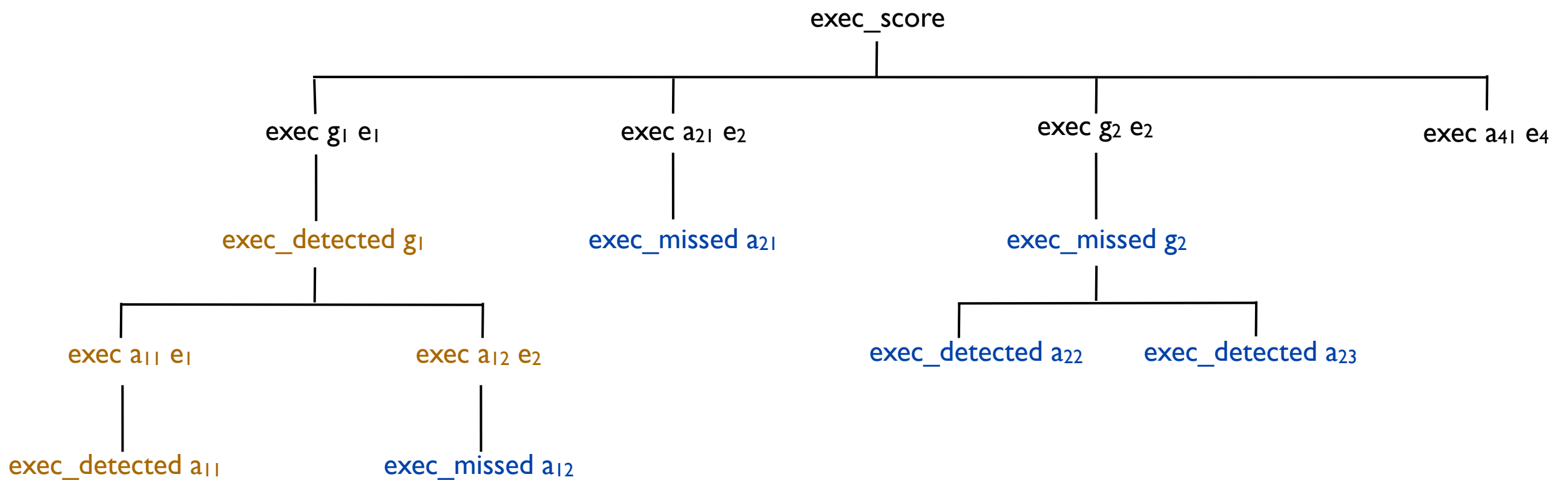


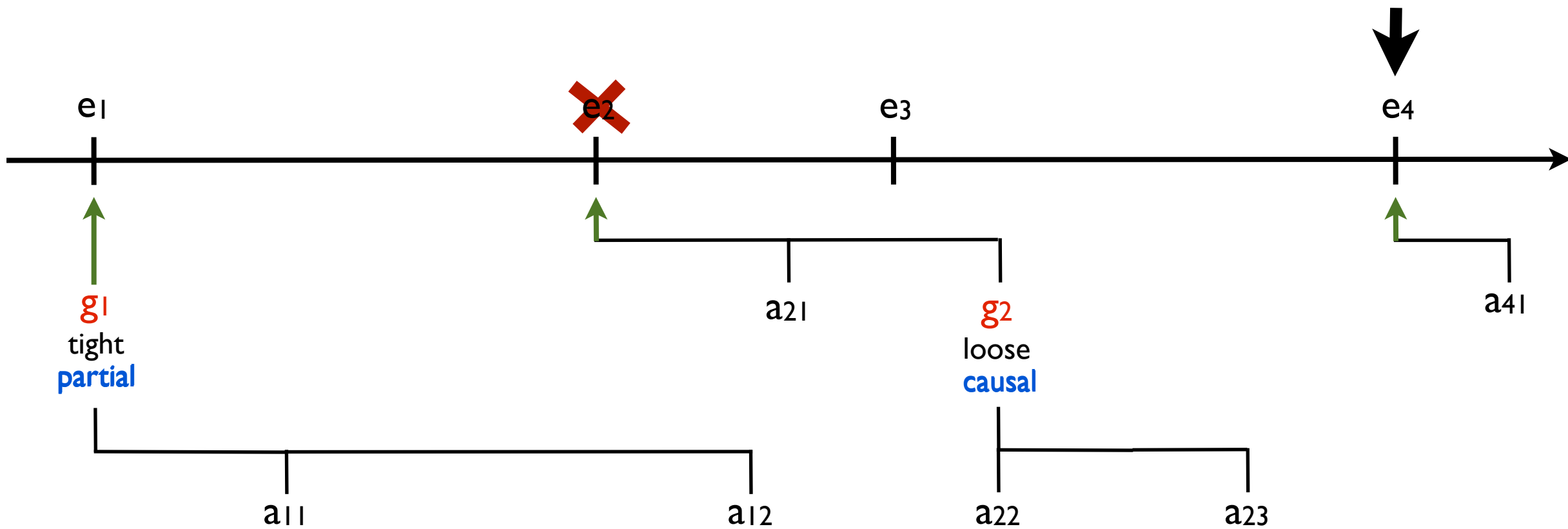
## Score example



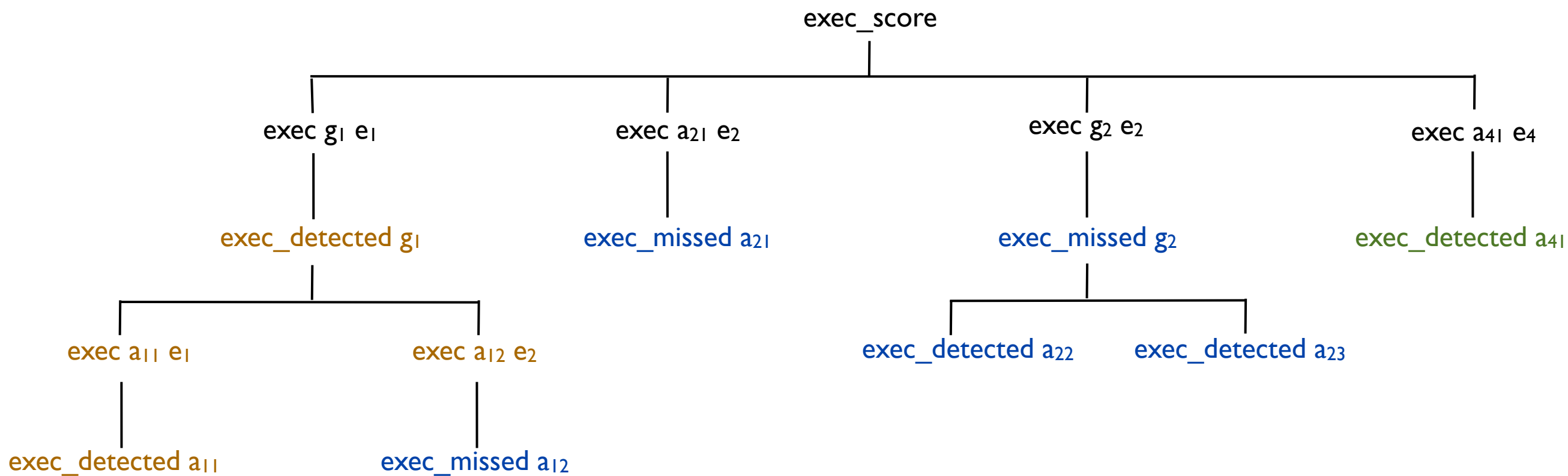


### Score example





### Score example



# Summary

- Direct translation of the model
- Implementation close to the specifications
- Powerful tool for prototyping

# An Interpret in Heptagon

# Heptagon

- A Lustre/Scade like language
- Clock inference
- With advanced constructions (automata...)

# Why Heptagon ?

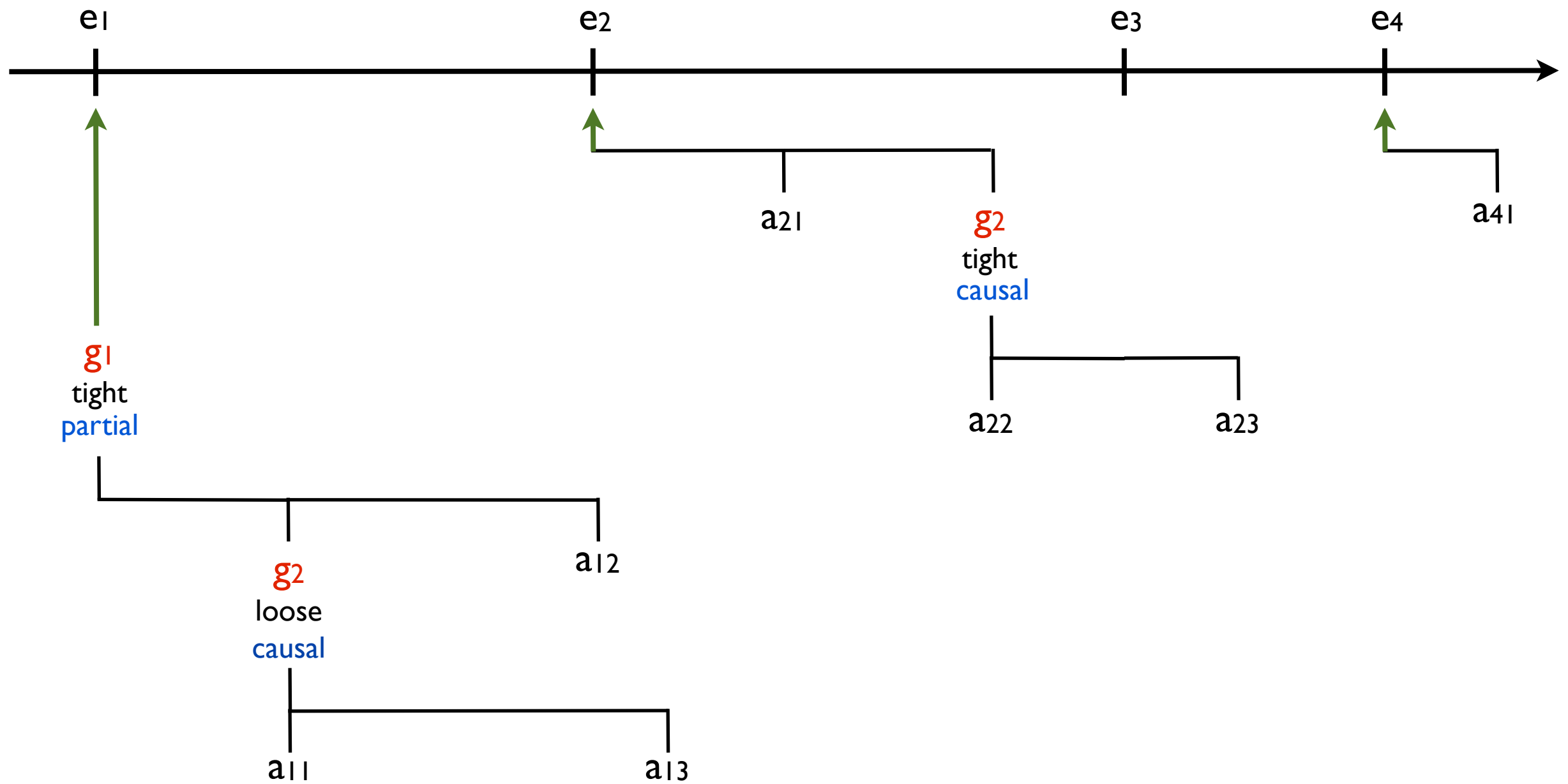
- Explore another point of view
- Generate C: Efficiency
- No dynamic allocation
- More guarantees on the runtime behavior  
(concert is a 'critical situation')

# Normalization

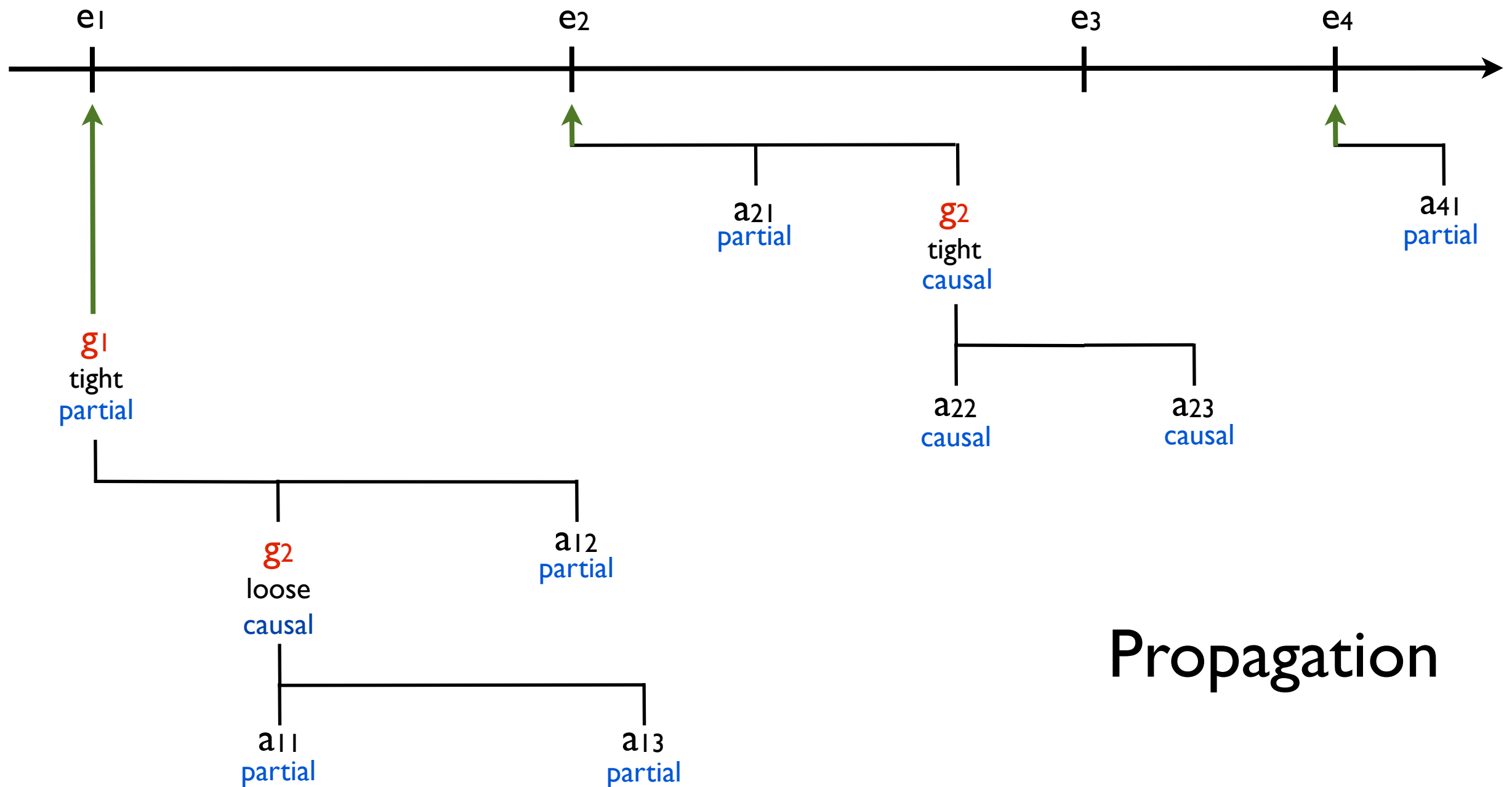
- Propagation of error handling attributes
- Actions repartition: triggering events
- Flattening: no more groups



# Example

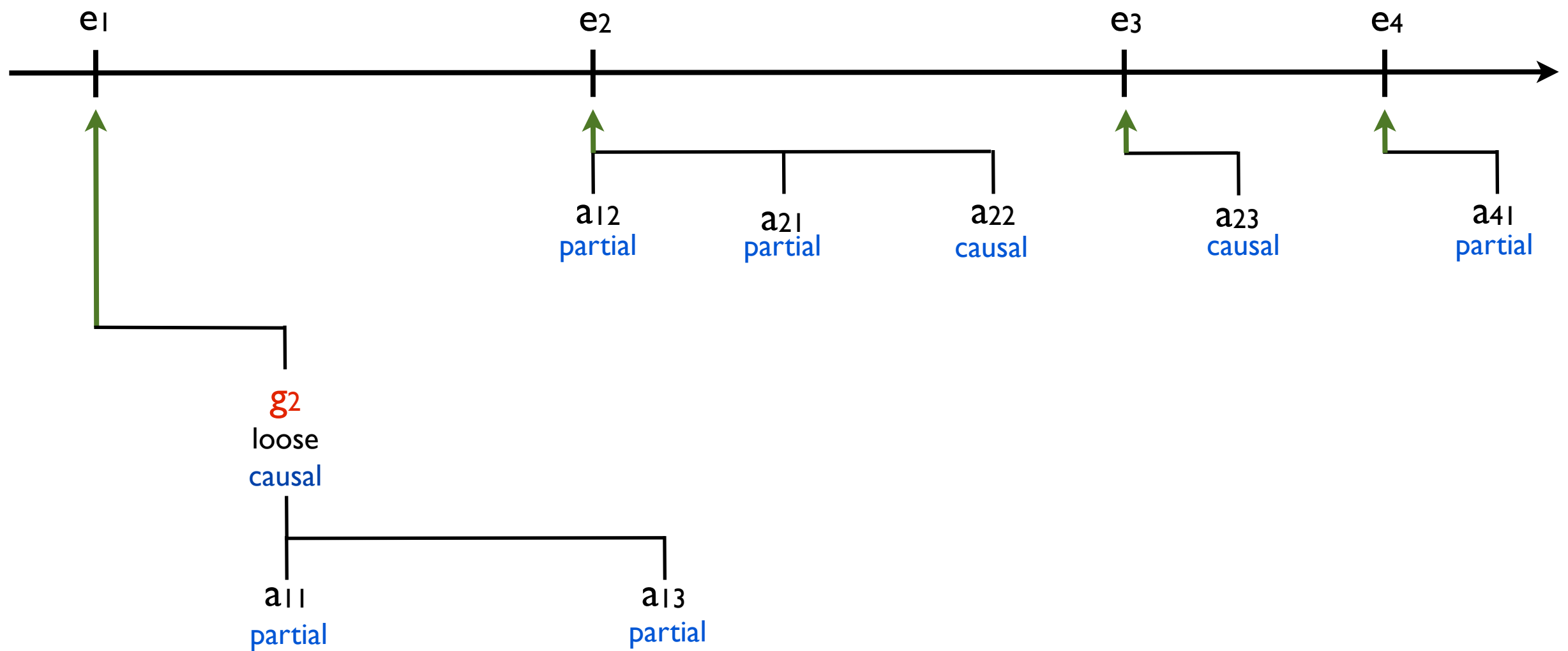


# Example



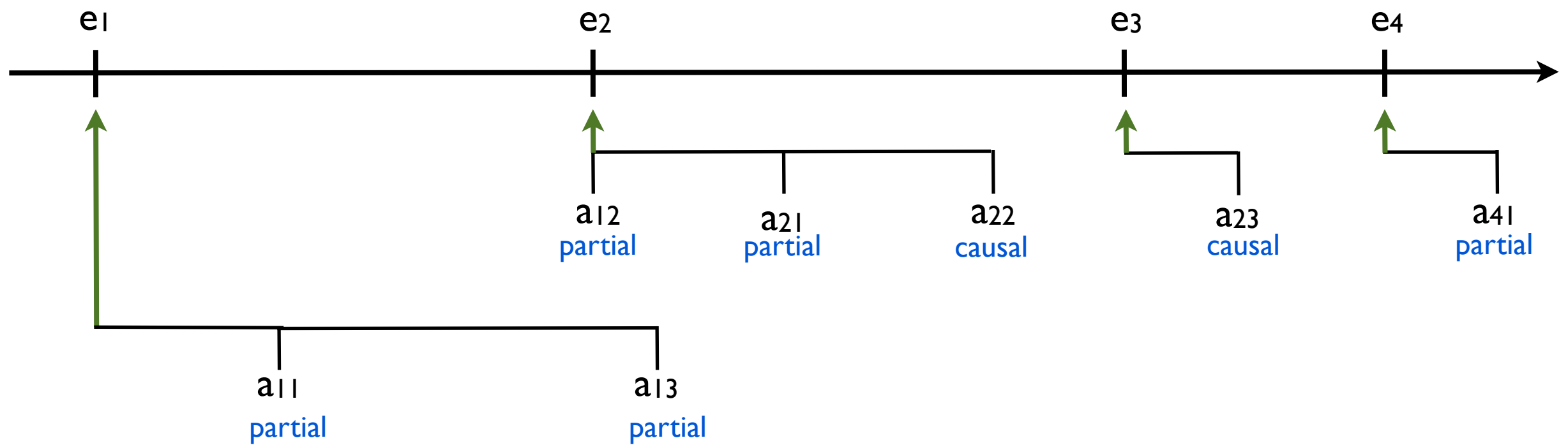
Propagation

# Example



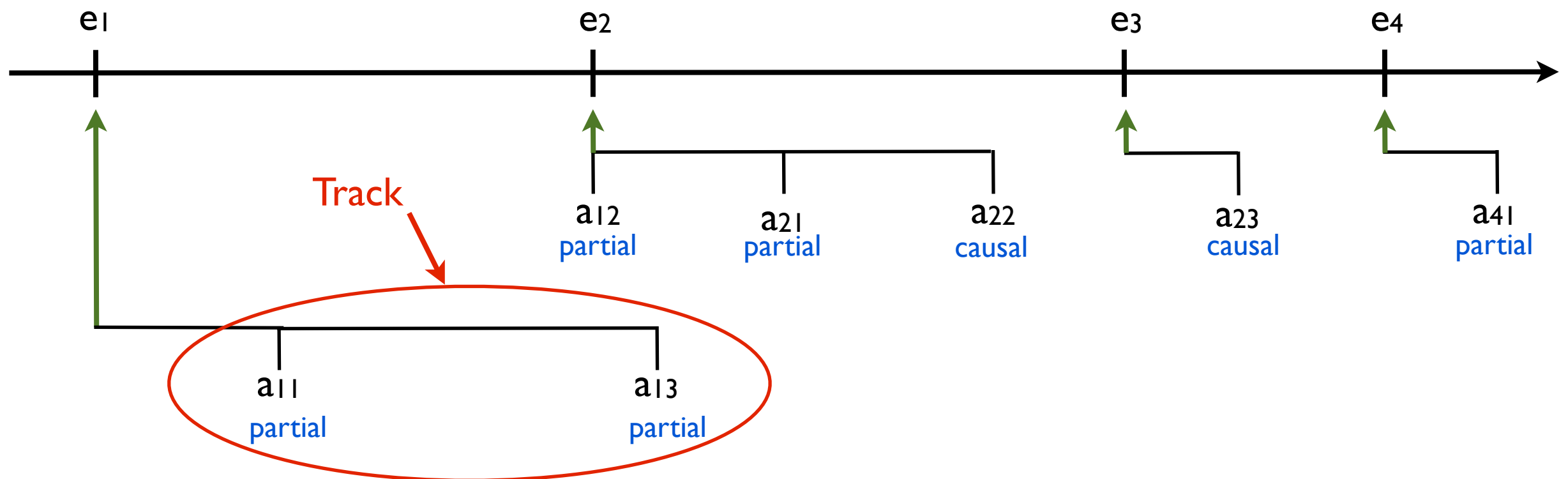
Repartition

# Example

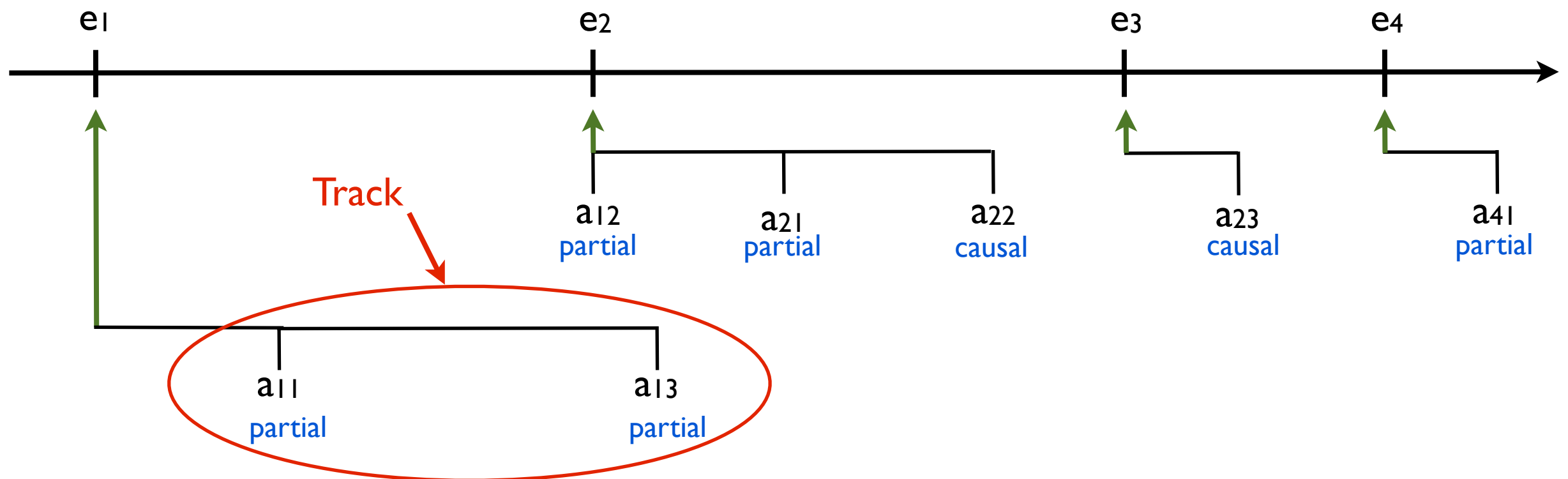


Flattening

# Example



# Example



Score: Normalized and stored in a static structure.

# Execution

```
node exec(tr:track) returns (o:bool)
var td,tm:bool;
let
  automaton
    state Wait
      do o = false;
      unless td then Detect
      unless tm then Missed
    state Detect
      do o = send(bpm,tr);
    state Missed
      do o = send(bpm,update(tr));
  end;
  td = testDetect(getEvent(tr),event);
  tm = testMissed(getEvent(tr),missed_event);
tel
```

# Conclusion

- A Semantics for Antescofo
- Two synchronous points of view
- Two Antescofo Interprets



# Perspectives

- Prototyping new features for Antescofo
  - New synchronization and error handling strategies
  - Variables, loops, etc...
- The Heptagon experiment
  - Prove some properties on the score
  - Performance could enable audio synthesis