

# Programmation et représentation musicale interactive en composition assistée par ordinateur

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EFFICAC(e) — ANR-13-JS02-0004-01



*Extended Frameworks for "In-time" Computer-Aided Composition*

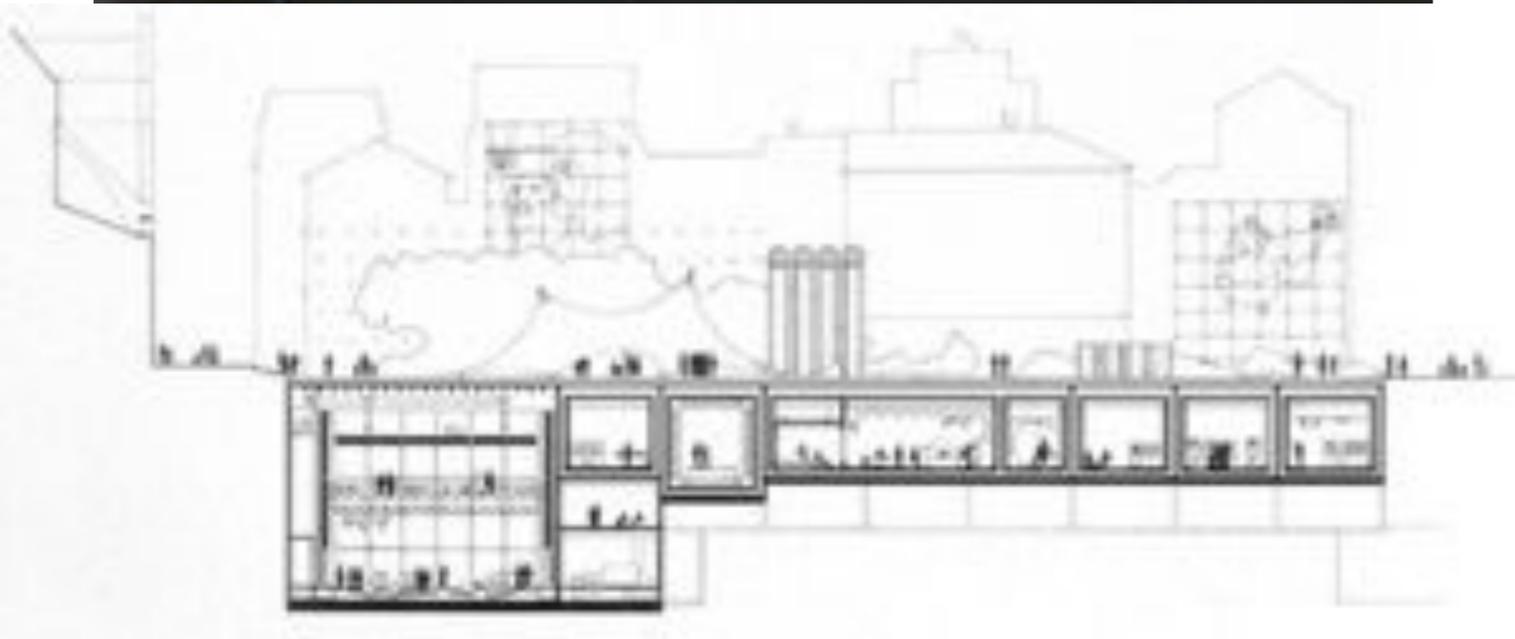
Séminaire SFR Agorantic  
Université d'Avignon, 12-13/06/2014

# IRCAM (quick intro)

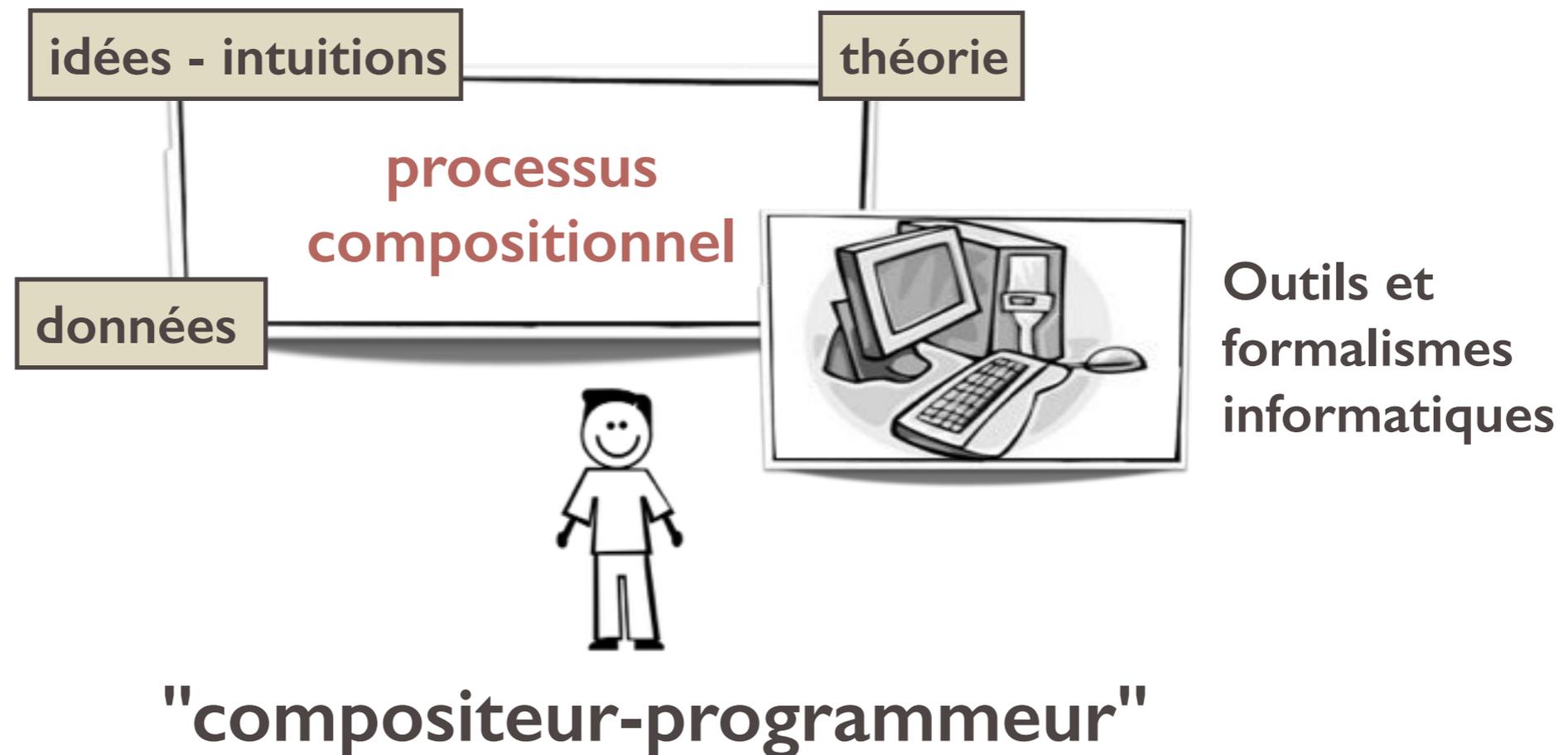


- Institut (statut asso 1901) sous tutelle du Centre Georges Pompidou
- Fondé en 1977 par Pierre Boulez
- Département R&D / UMR 9912 STMS associé au CNRS et à L'UPMC

➡ Recherches dans les domaines du son (analyse/synthèse), de l'acoustique, de la **composition**, de la perception, de l'analyse musicale.



# Composition assistée par ordinateur (CAO)

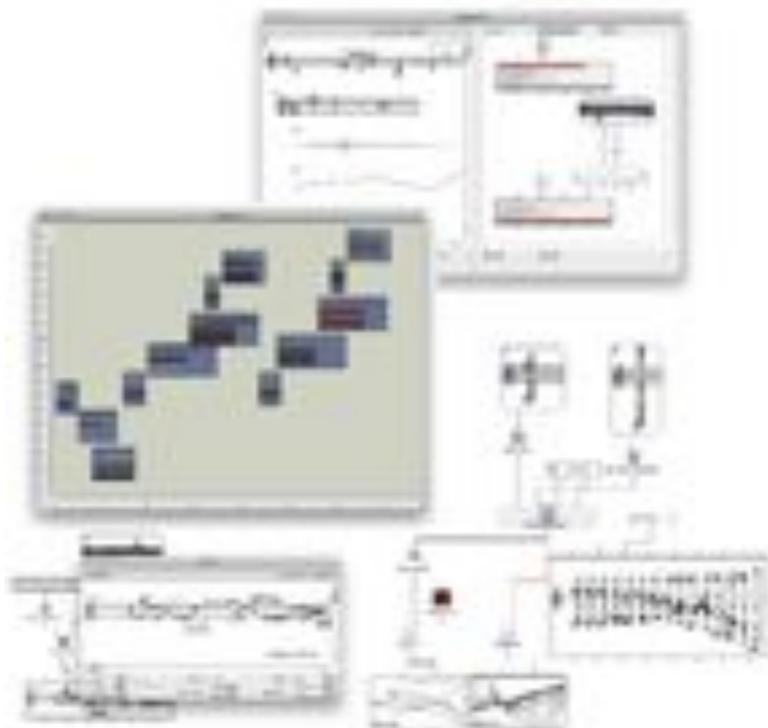
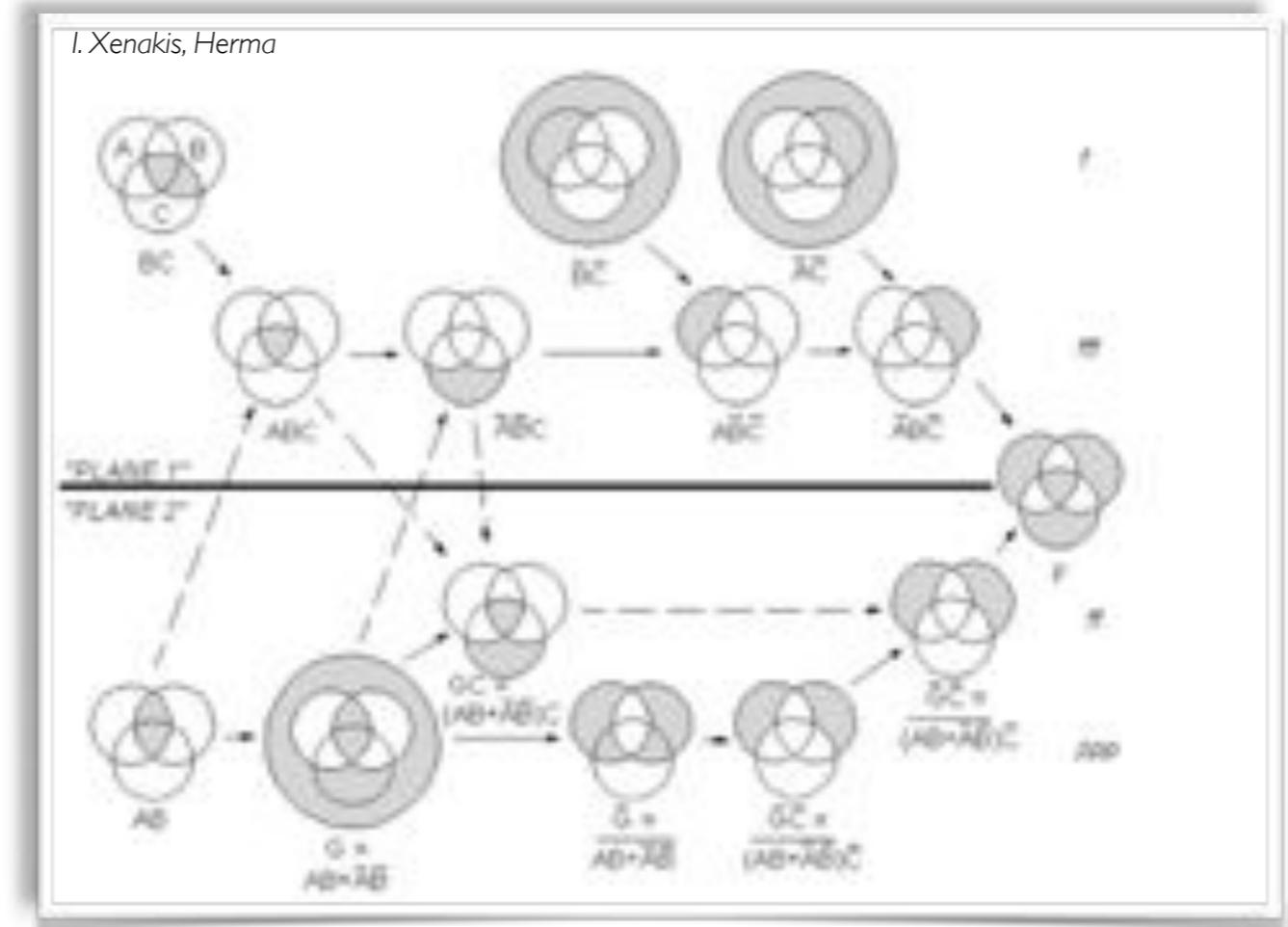
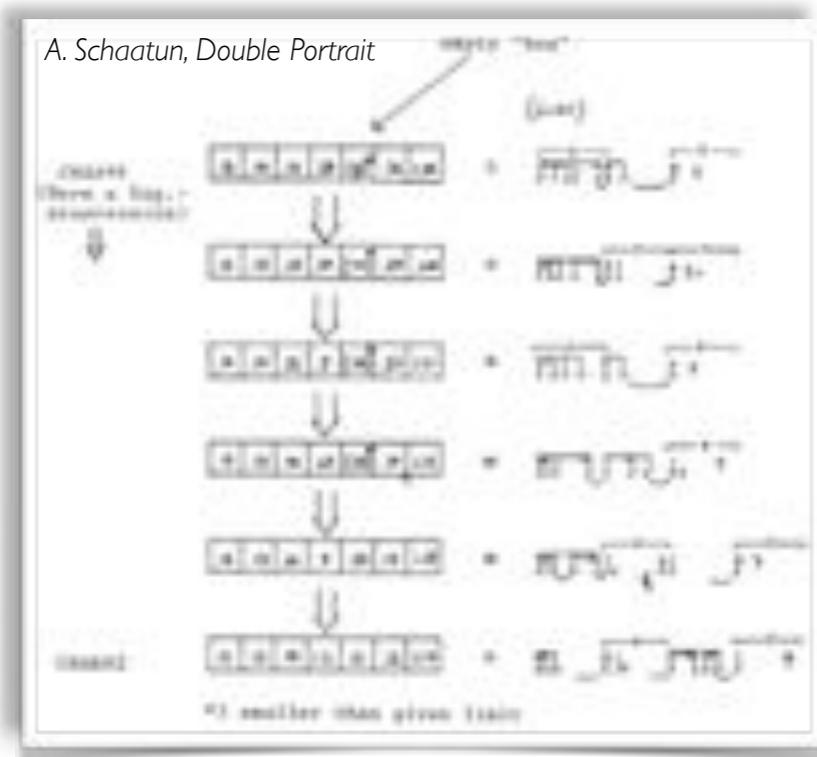


"We conceive such an environment [of computer-aided composition] as a **specialized computer language** that composers will use to build their own musical universe. [...] This leads us to reflect on the various existing programming models, as well as on the interfaces [...] which make it possible to control this programming, and on the representations of the musical structures, which will be built and transformed using this programming."

G.Assayag, *Computer Assisted Composition Today* (1998).

# Composition assistée par ordinateur (CAO)

une vision formelle des processus musicaux



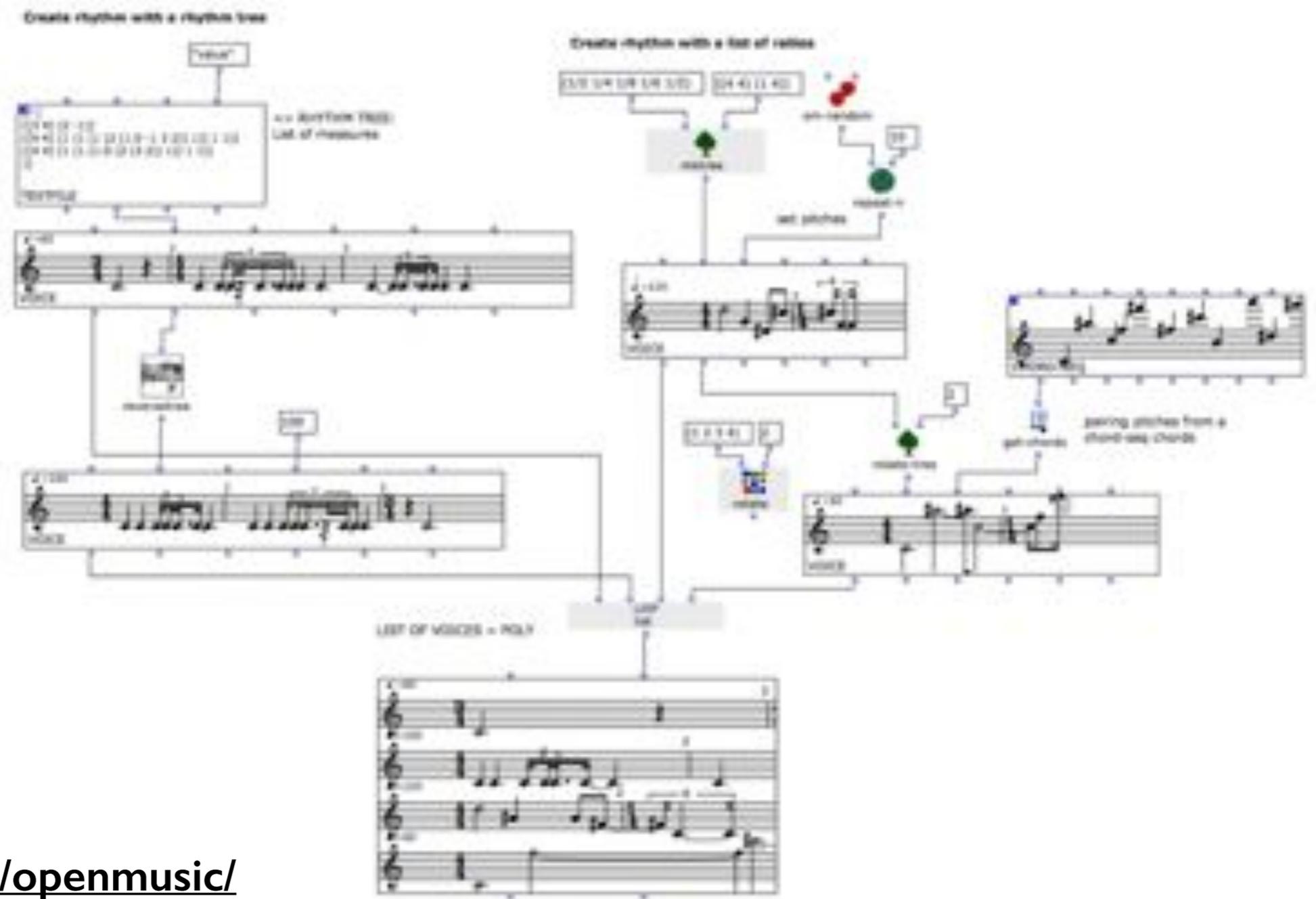
- Implémentation dans des langages de programmation
- Représentations / manipulations musicales grâce aux outils graphiques et à la programmation visuelle

# OpenMusic

Un langage de programmation visuelle pour la CAO

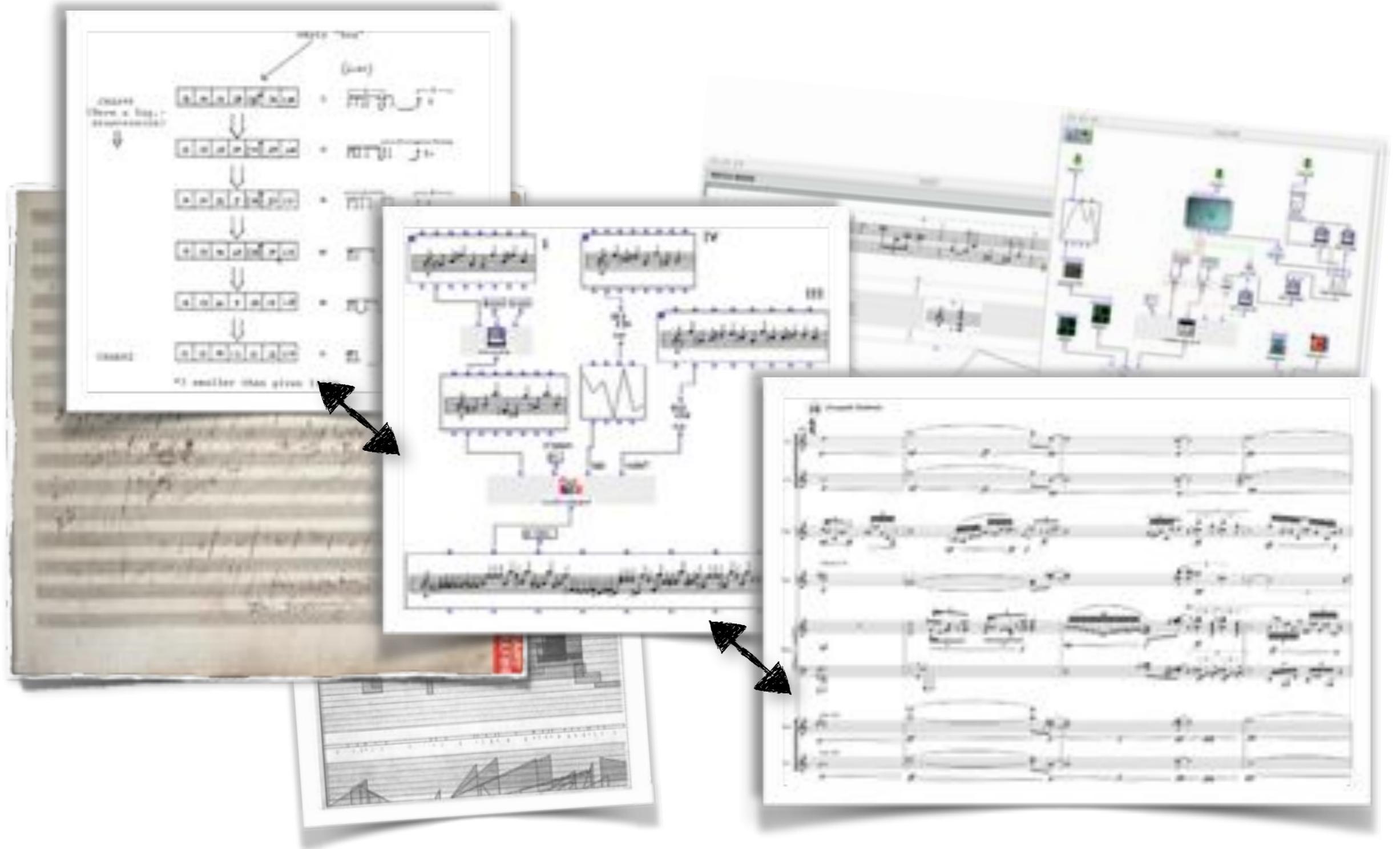
G. Assayag, C. Rueda, M. Laurson, C. Agon, O. Delerue. “**Computer Assisted Composition at Ircam: PatchWork & OpenMusic**”, Computer Music Journal, 23(3), 1999.

J. Bresson, C. Agon, G. Assayag. “**Visual Lisp/ CLOS Programming in OpenMusic**” Higher-Order and Symbolic Computation, 22(1), 2009.



<http://repmus.ircam.fr/openmusic/>

# FORMALISATION $\Leftrightarrow$ IMPLEMENTATION $\Leftrightarrow$ PARTITION $\Leftrightarrow$ (SON)

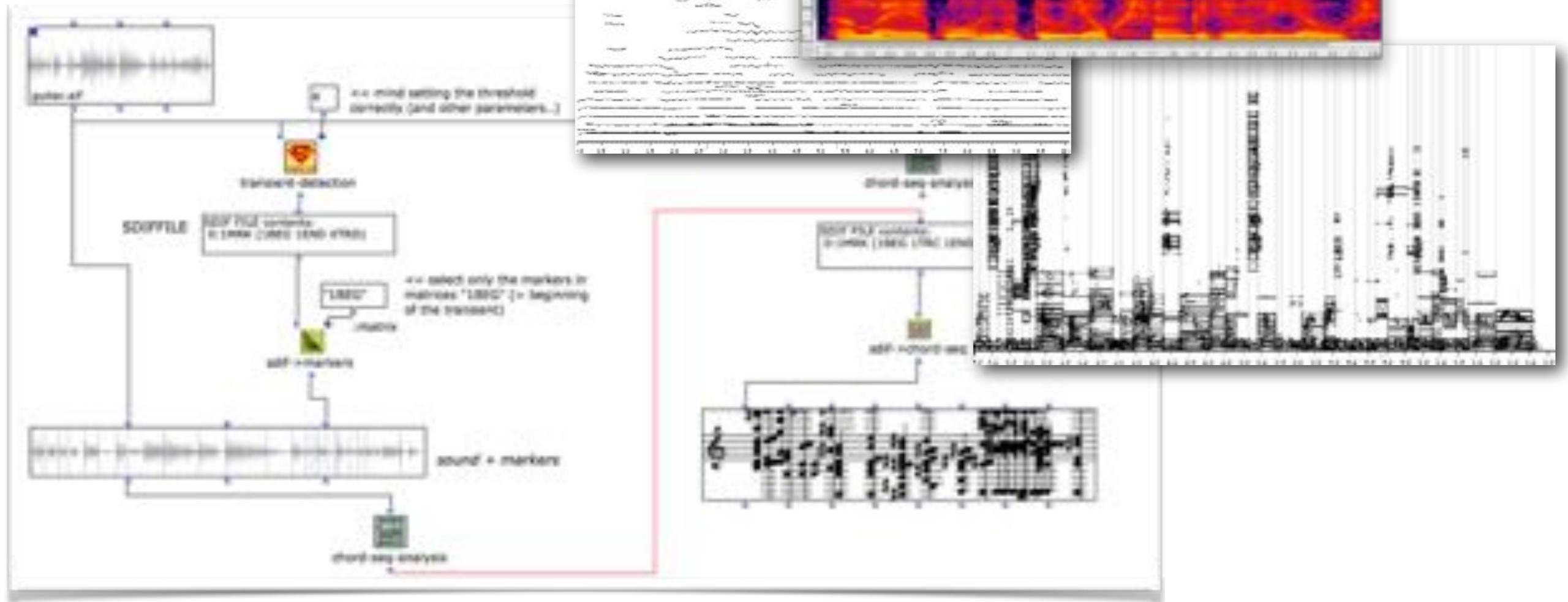


"We may view composer-program interaction along a trajectory leading from purely manual control to control exercised by some compositional algorithm (composing machine). The zone of greatest interest for composition theory is the middle zone of the trajectory, since it allows a great flexibility of approach. The powers of intuition and machine computation may be combined."

Otto Laske, *Composition Theory in Koenig's Project One and Project Two*. *Computer Music Journal* (1981)

# CAO et création sonore

Conjonction de la pensée spectrale,  
des musiques formelles et des  
musiques électroacoustiques

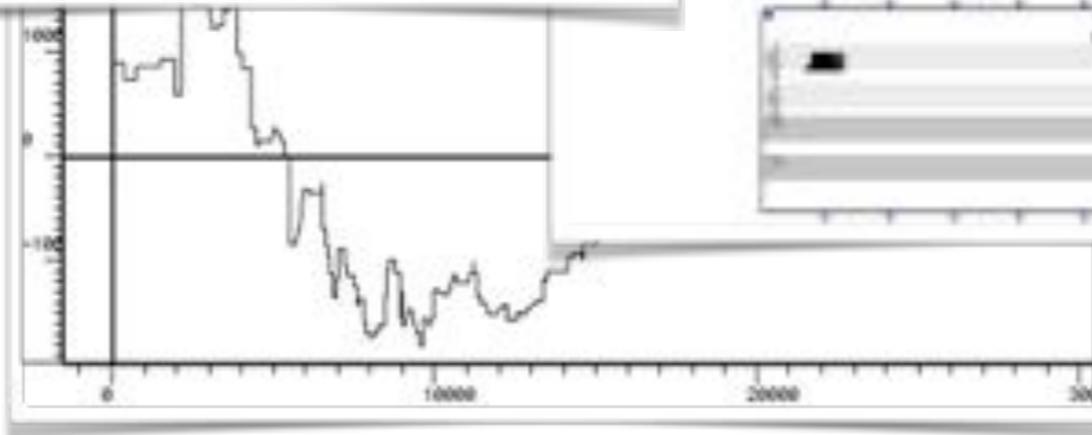
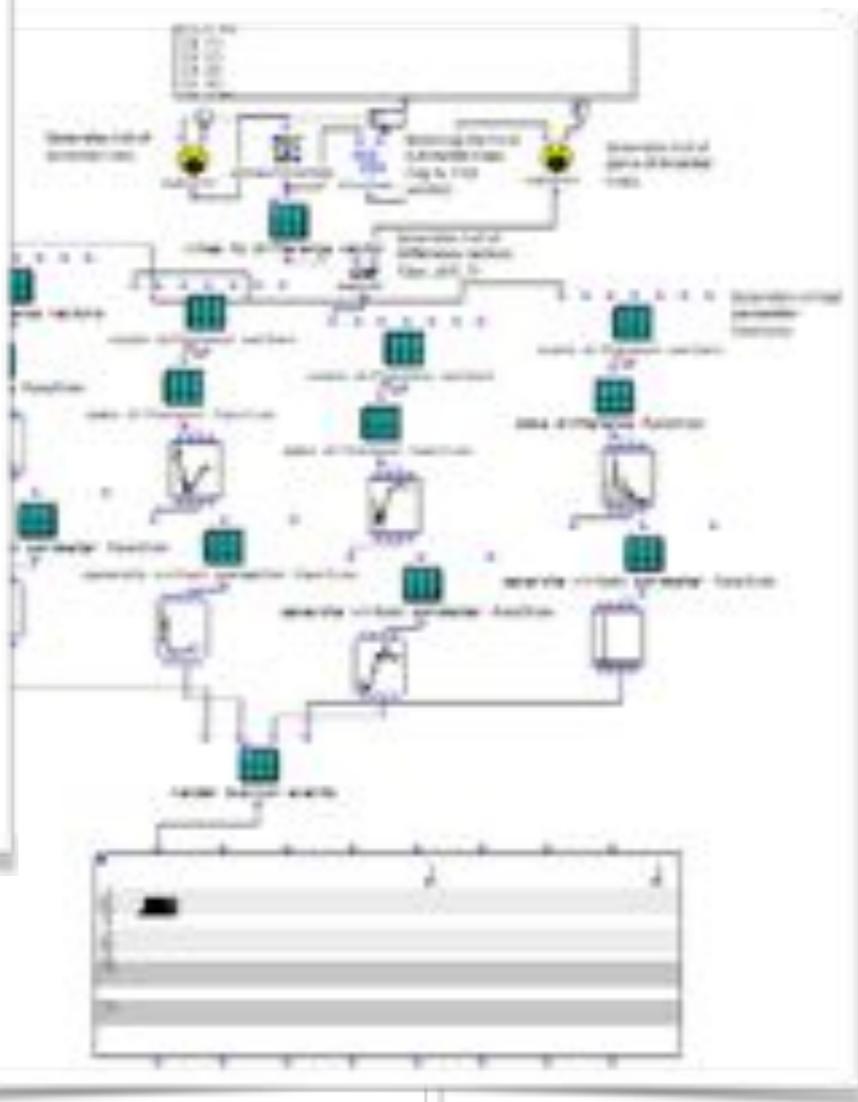
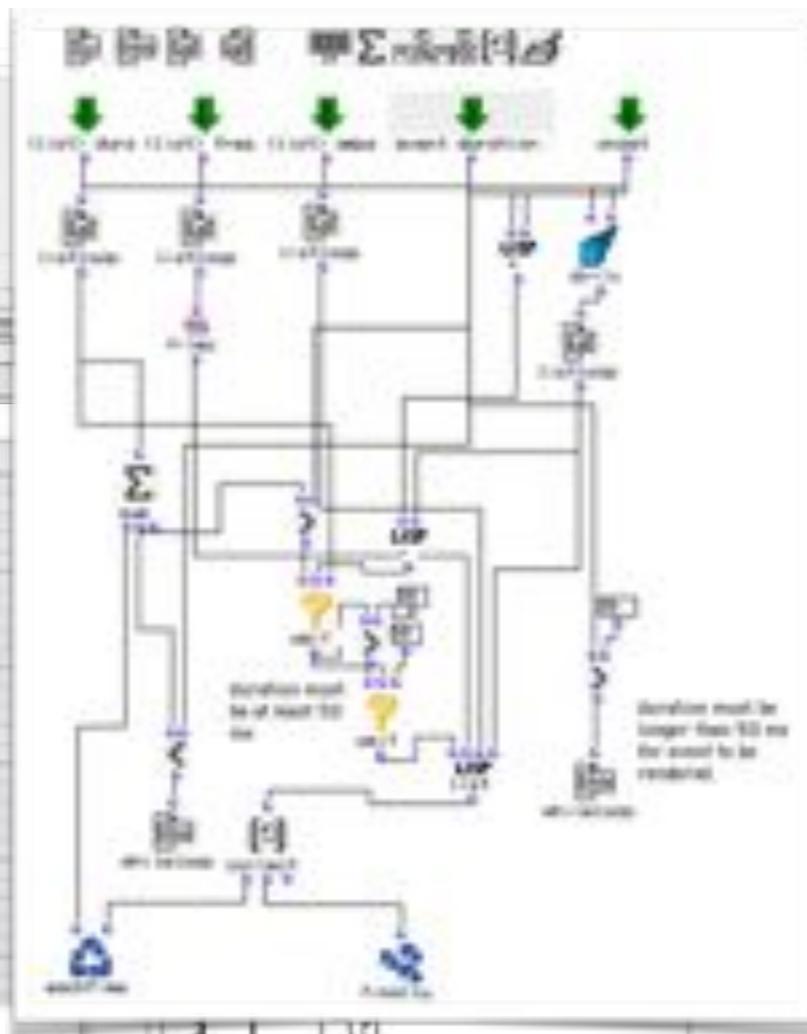
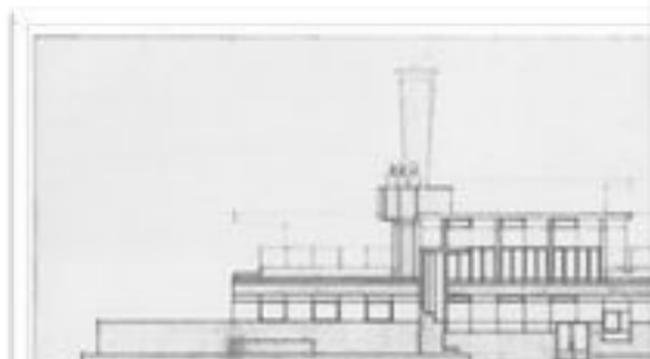


➡ Assistance informatique pour l'exploration, le traitement symbolique et le rendu de structures musicales complexes.

**Quelques exemples ?**

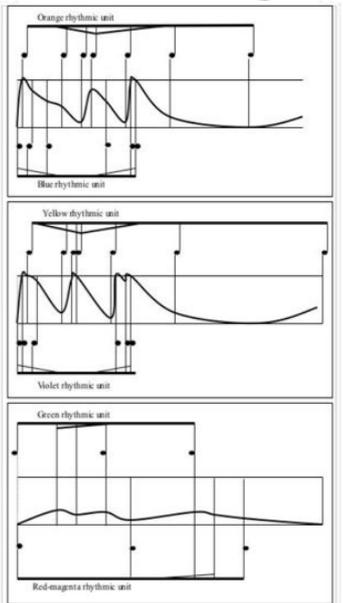
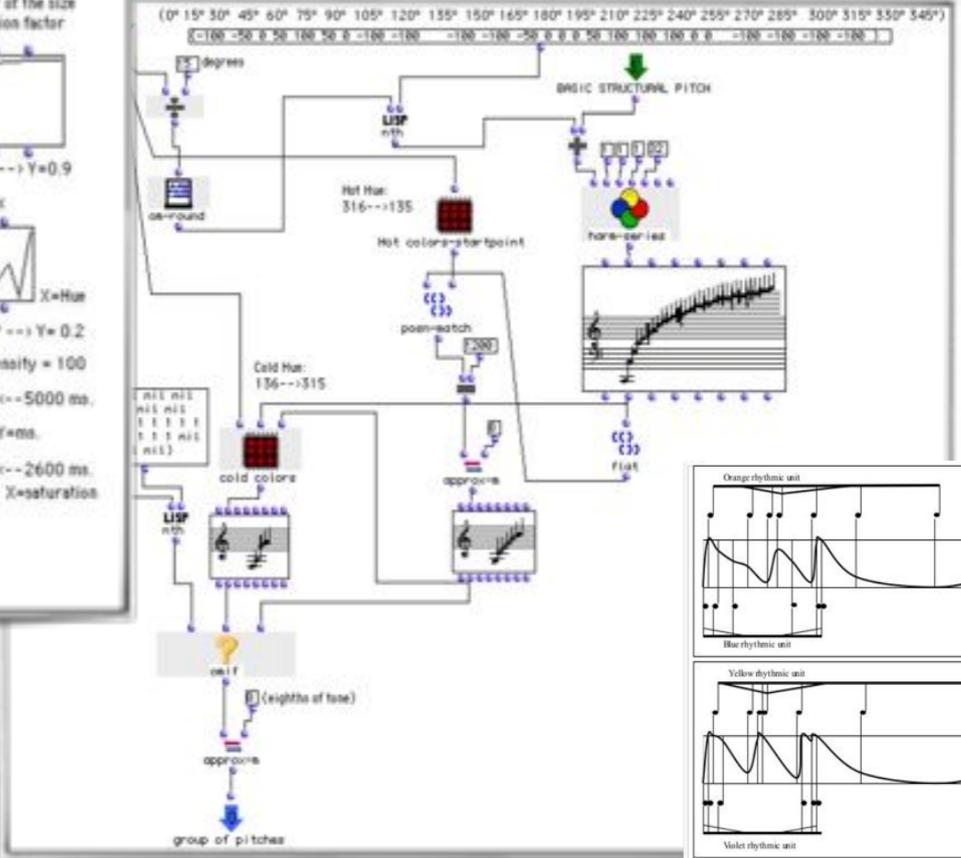
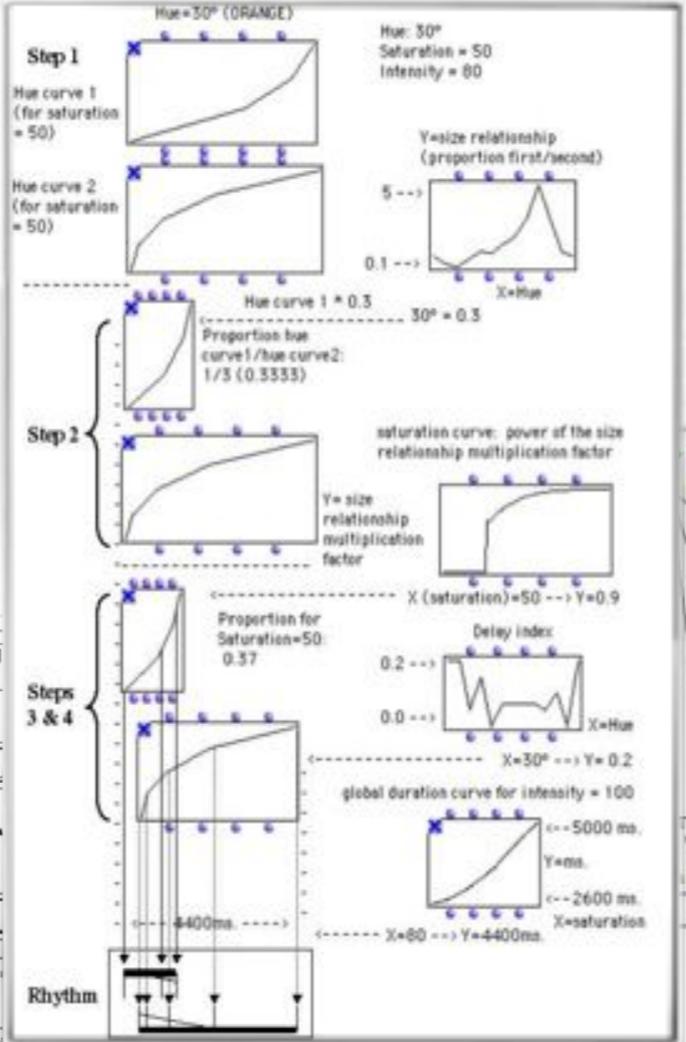
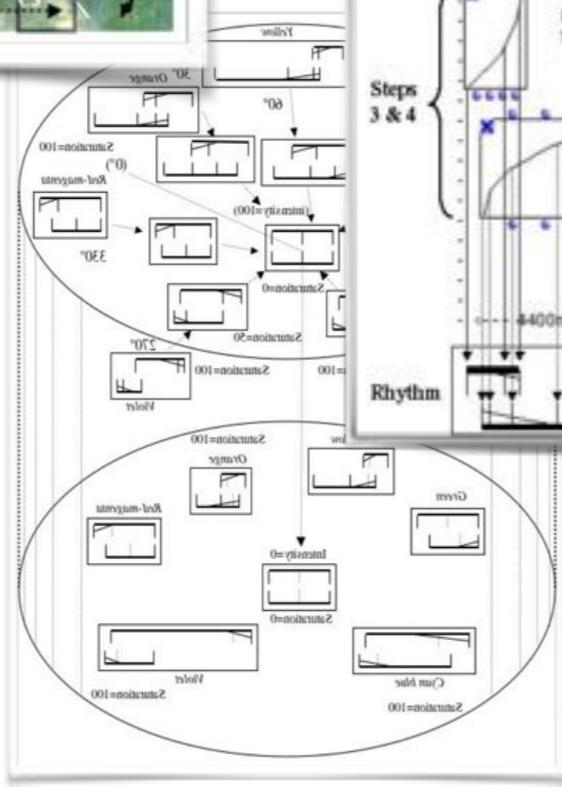
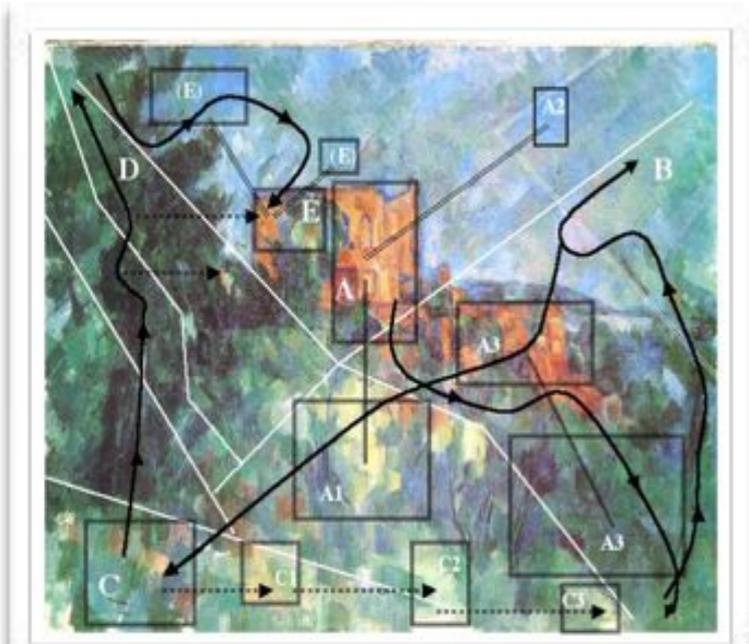
# la métaphore spatiale en CAO (exemples)

... où la notion d'espace (et la navigation dans l'espace) donnent lieu à la production de structures musicales.



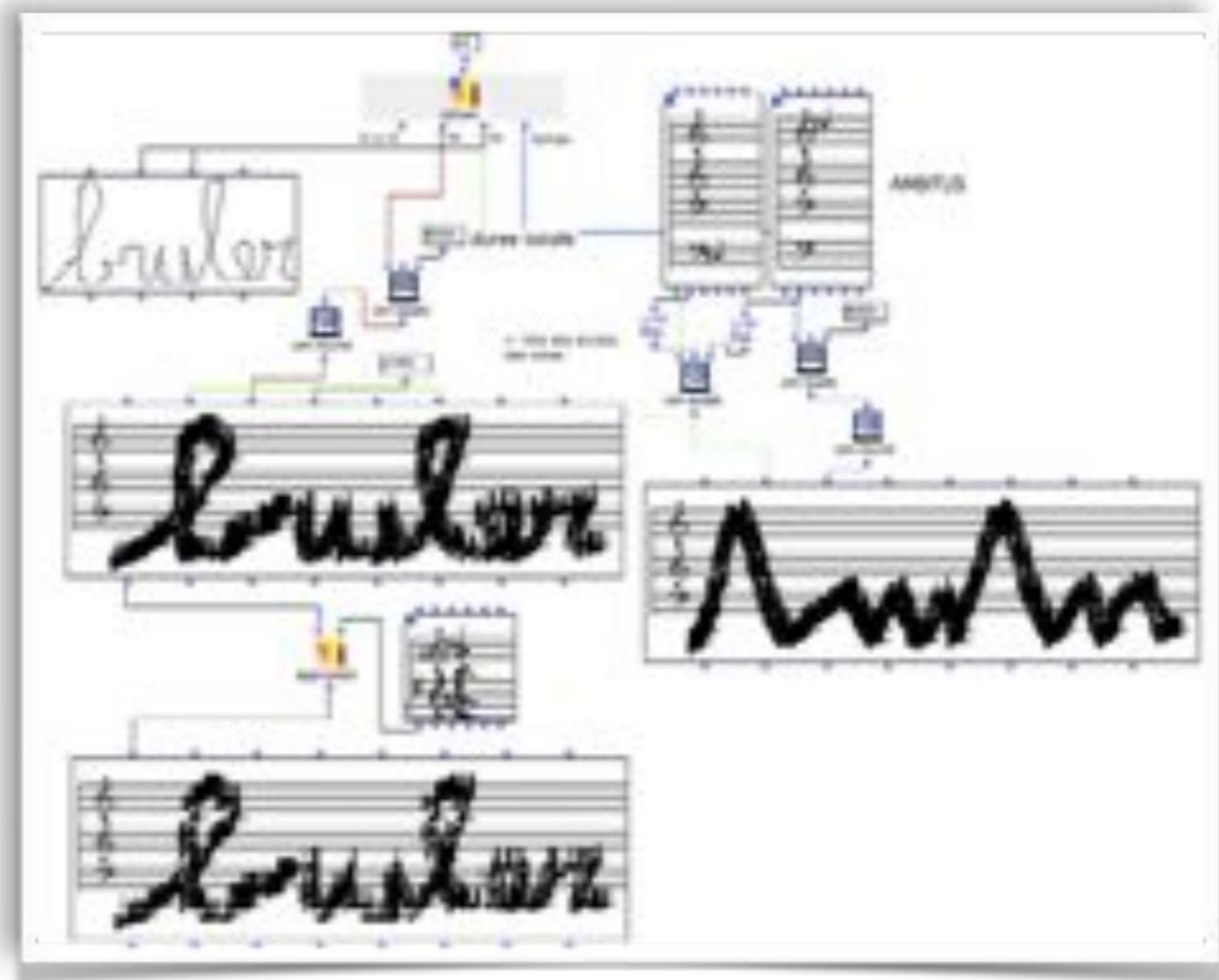
C. Jaksjo  
*Undergrounded [Zoonestraal] I* (2002)  
*Zoonestraal* (2008)

**The OM Composer's Book vol. 2**  
J. Bresson, C. Agon, G. Assayag (Eds.)  
Editions Delatour France / IRCAM, 2008.



H. Parra  
 Strette (2006)

**The OM Composer's Book vol. 2**  
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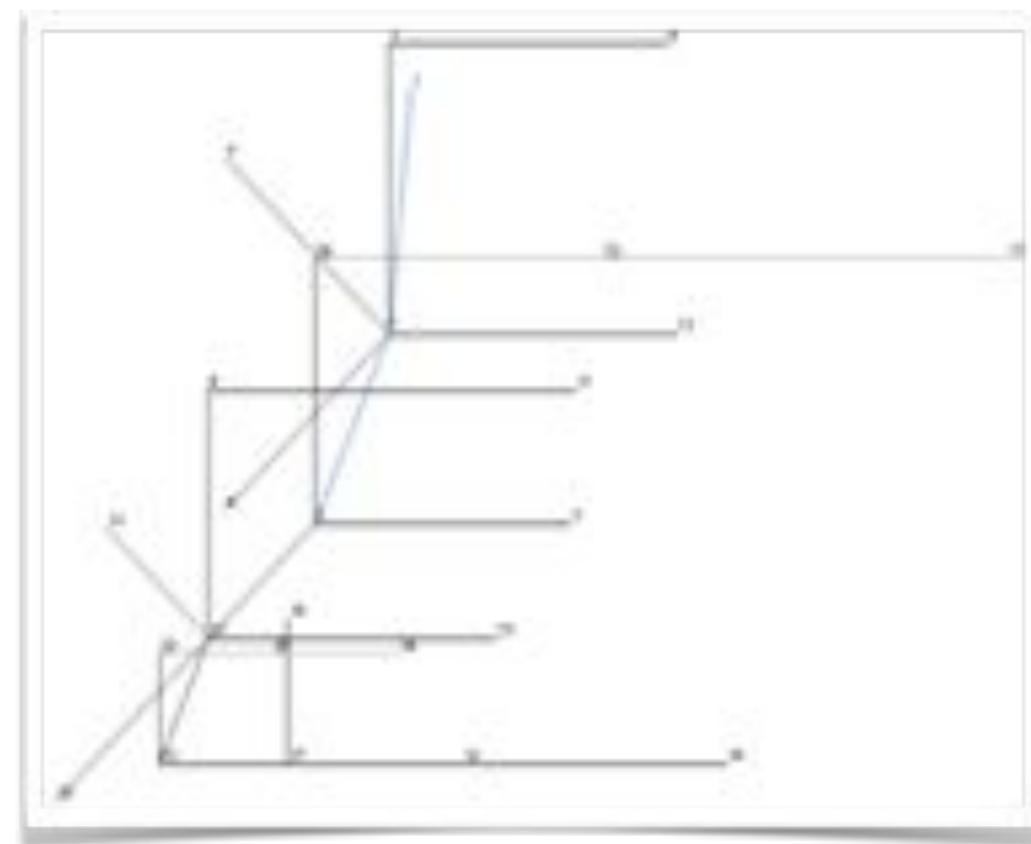
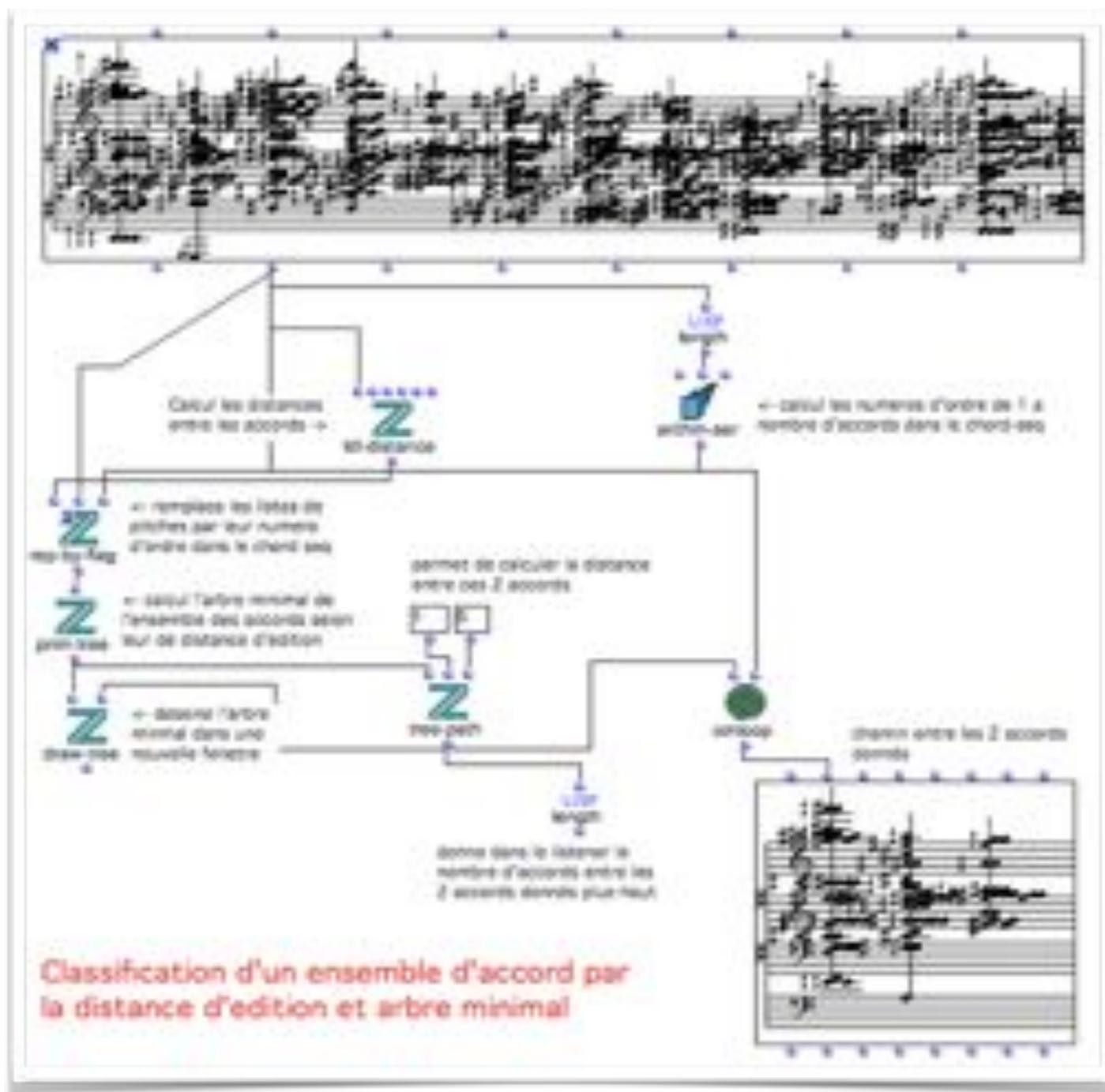


Ph. Leroux  
 VOI(REX) (2006)

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# Recherche et navigation dans les *espaces de représentation...*

Ordonnancement et parcours harmoniques



Ph. Leroux  
VOI(REX) (2006)

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J. Bresson, C. Agon, G. Assayag (Eds.)  
Editions Delatour France / IRCAM, 2008.

# Recherche et navigation dans les *espaces de représentation*...

Do ← do<sub>m</sub> ← Sol# ← fa<sub>m</sub> ← Fa ← la<sub>m</sub> ← La ← fa#<sub>m</sub> ← Fa# ← sib<sub>m</sub> ← Do# ← do#<sub>m</sub>

mi<sub>m</sub> → Sol → si<sub>m</sub> → Ré → ré<sub>m</sub> → Sib → sol<sub>m</sub> → Mi# → mi#<sub>m</sub> → Si → sol#<sub>m</sub> → Mi

Chord 1174

TUNNETZ 3

Chord 1174

Contraste

Auto-play on is

Memory

L. Bigo. **Représentations symboliques musical et calcul spatial**, PhD thesis, Université Paris Est, 2013.

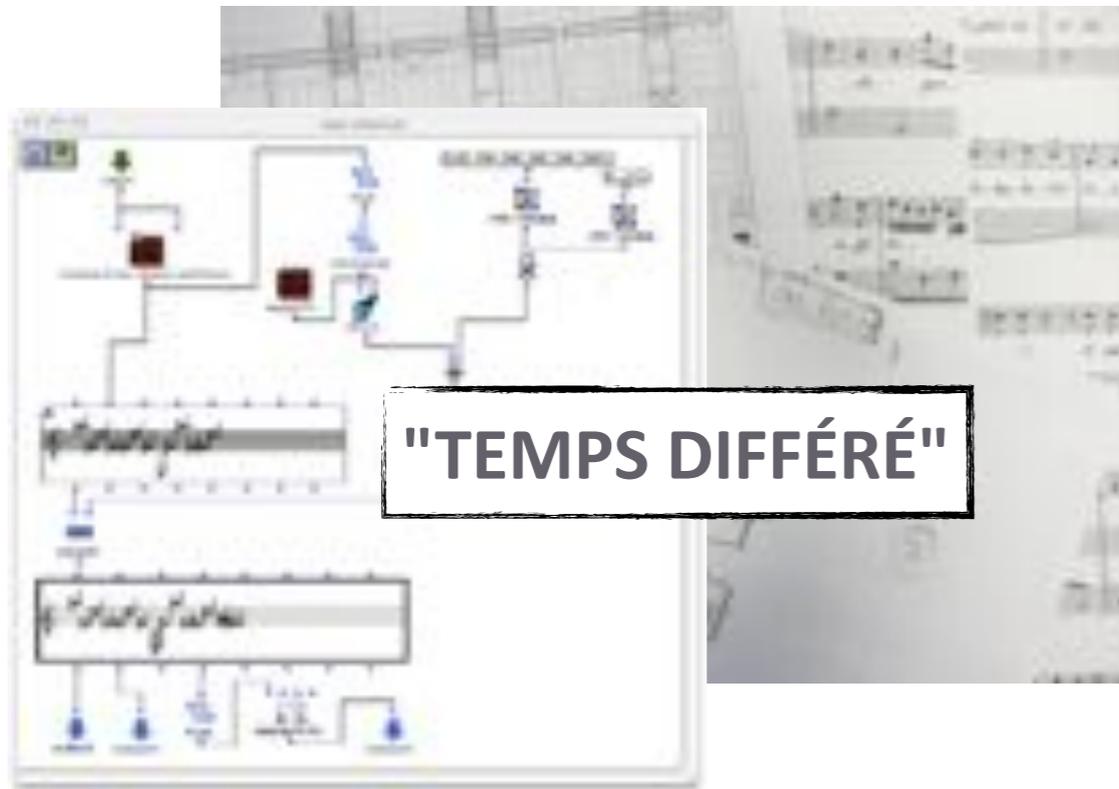
➡ Lien vers les analyses formelles et la musicologie assistée par ordinateur



# **Recherches actuelles en CAO**

# Temps et calcul musical

[critères discriminants dans les outils actuels de création musicale]

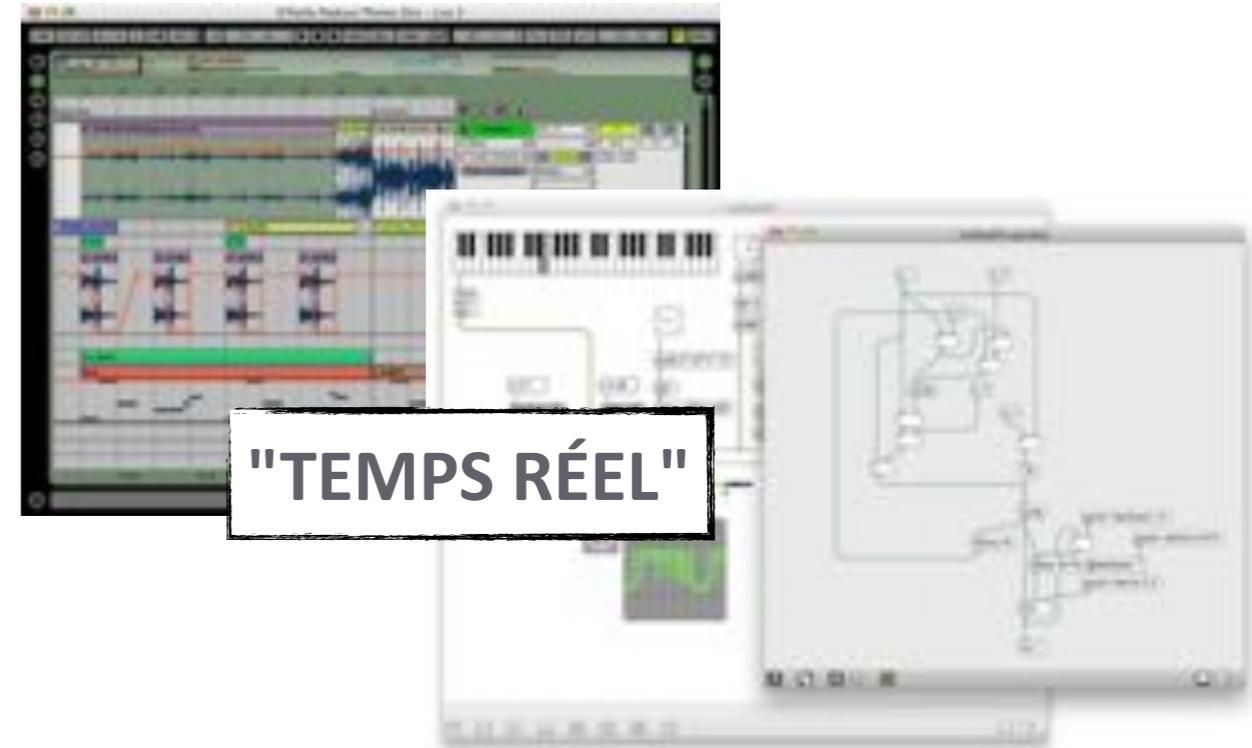


**"TEMPS DIFFÉRÉ"**

Composition

Manipulation/calcul symbolique

Données complexes et structurées



**"TEMPS RÉEL"**

Performance/concert

Interaction "live"

Traitement audio temps réel

*Fonctionnel  
Demand-driven  
Transformationnel*



*Data-flow  
Event/data-driven  
Réactif*

# Temps et calcul musical

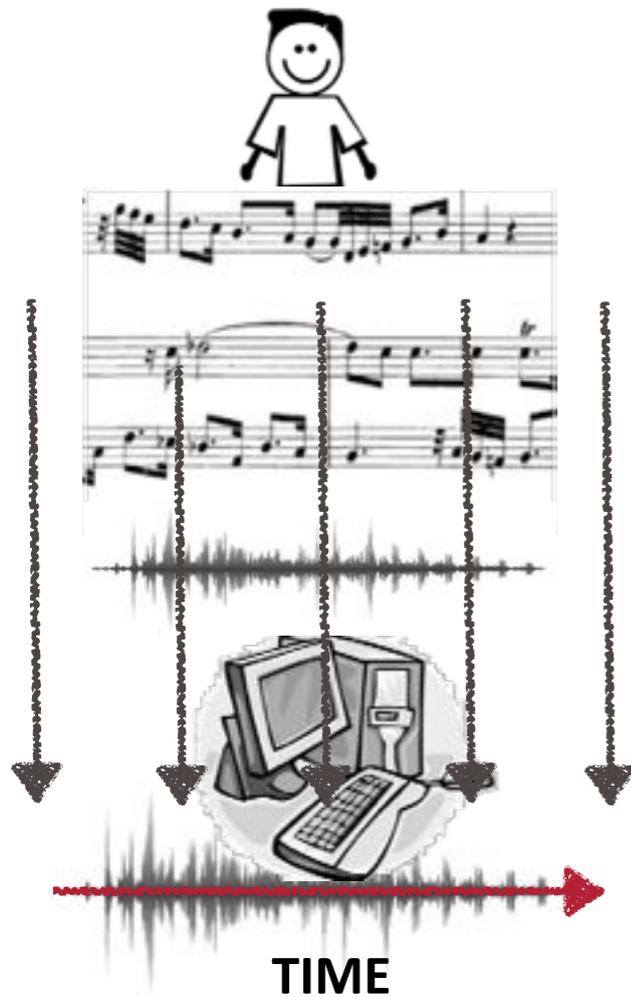


TIME

## Approche "composition" / CAO - temps différé:

- Structures musicales générées "hors-temps"  
**temps du calcul  $\neq$  temps "réel" musical**
- Formalisation et traitement de structures complexes non contraintes par le temps réel.

# Temps et calcul musical



## Approche "performance" / Temps-réel :

- Processus *réactifs*
- Structures musicales produites "à la volée" par le système.
- temps du calcul  $\approx$  temps "réel" musical

# Vers des environnements de CAO réactifs



EFFICACE *Extended Frameworks For In-time Computer-Aided Composition*  
 (ANR-13-JS02-0004-01)  
<http://repmus.ircam.fr/efficace/>

## Unification des paradigmes d'execution "demand-driven" et "data-flow réactif"

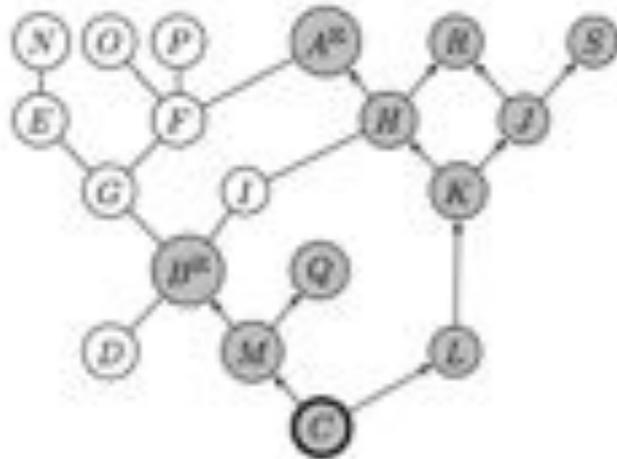


Figure 3: Call graph of the evaluation of C in Fig. 1.

*Staggered Evaluation.* The previous framework leads to a staggered evaluation

$$[\cdot]^r(\cdot) : \mathcal{B} \times \mathcal{N} \rightarrow \mathcal{V}$$

where only the values of the boxes required to compute the outputs of  $r^i$  are updated:

$$[\cdot]^r(k) = \begin{cases} * & \text{if } b \notin B^r \\ e^i(b, A) & \text{if } \text{flag}^r(b) = \mathbb{Q} \\ [b]^{r-1}(k) & \text{if } \text{flag}^r(b) = \mathbb{S} \\ u & \text{if } \text{flag}^r(b) = \mathbb{I} \\ [b]_k(v_1, \dots, v_{\text{in}(b)}) & \text{if } b \in \mathcal{T}(r^i) \\ [b]^{r-1}(k) & \text{otherwise} \end{cases}$$

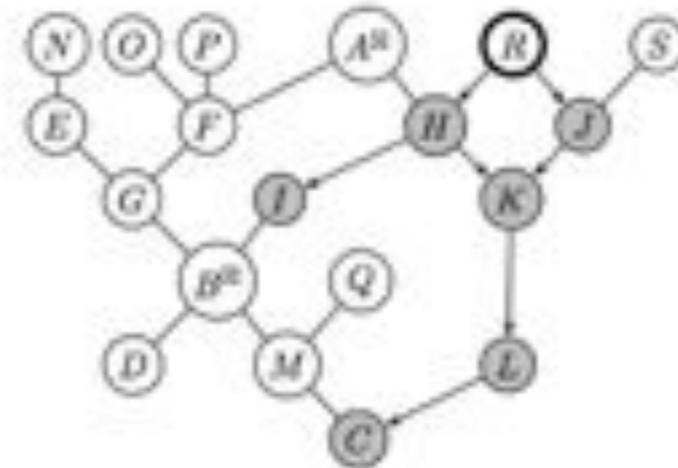


Figure 4: Propagation of event {R} in the reactive patch from Fig. 1. We suppose that all boxes are active. Notice that  $R \notin \mathcal{T}(R)$ : the values associated to R are obtained by editon, not by evaluation.

J. Bresson, J.-L. Giavitto, "A Reactive Extension of the OM Visual Programming Language", **Journal of Visual Languages and Computation**, 2014.



## OpenMusic

<http://repmus.ircam.fr/openmusic/>

Téléchargement gratuit !

## Profet ANR Efficace

<http://repmus.ircam.fr/efficace/>

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