Using Multidimensional Sequences for Improvisation in the OMax Paradigm

Ken Déguernel[1,2], Emmanuel Vincent[1], Gérard Assayag[2]

[1] Inria Nancy
[2]STMS Lab, Ircam/CNRS/UPMC

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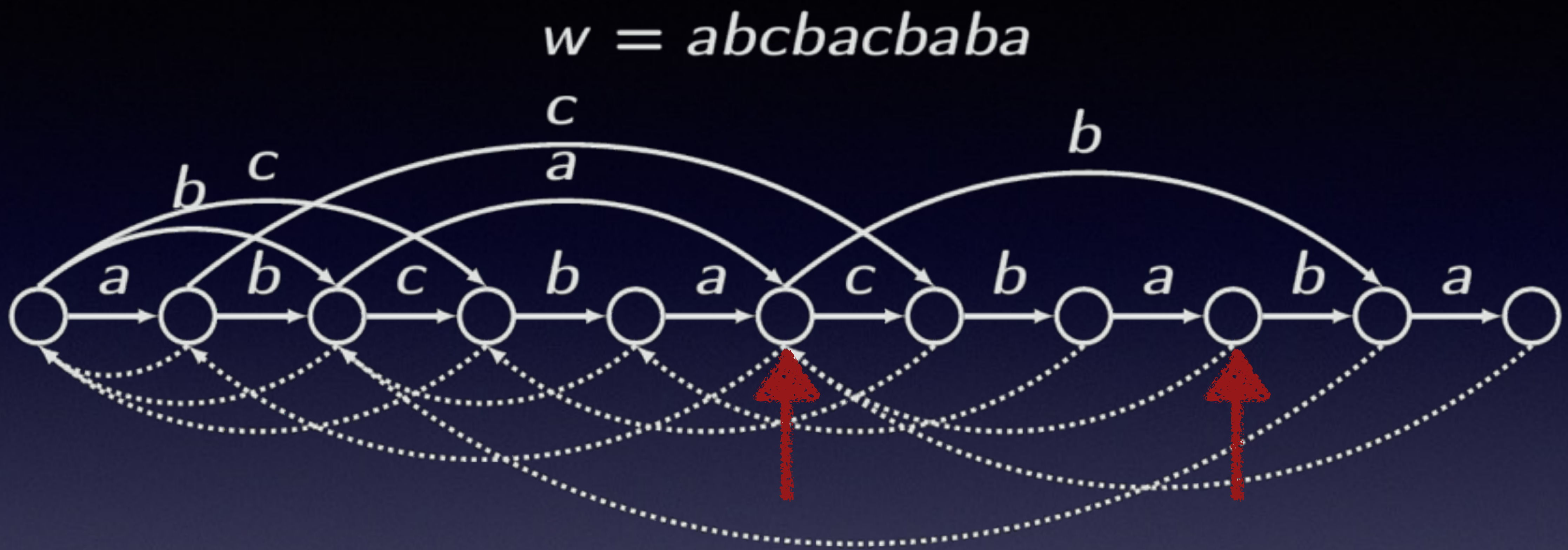
Factor Oracle

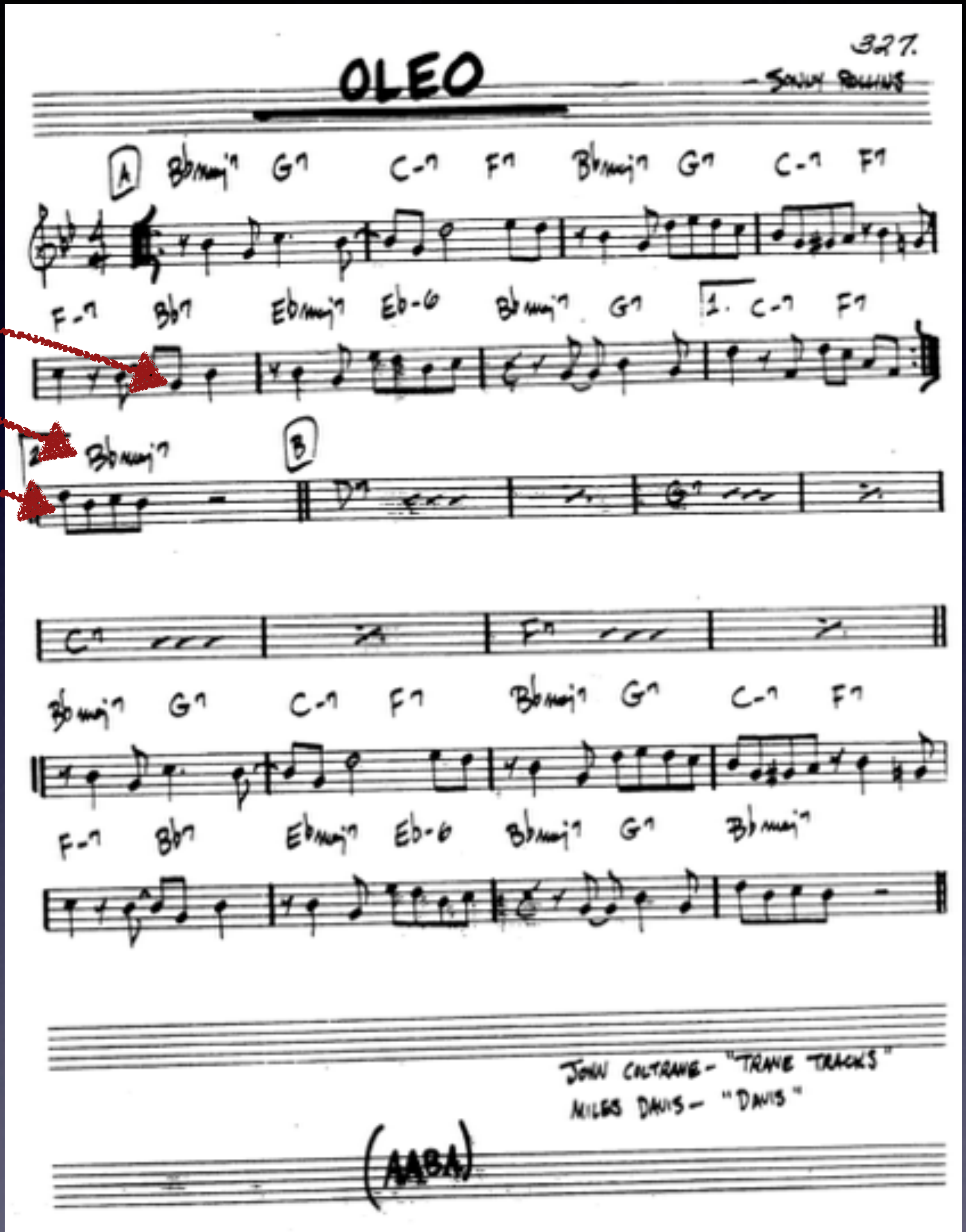


- Structure representing the evolution of an improvisation on a local context
- One-dimensional data
- Heuristics and control parameters : continuity, leap choices, loops, taboo…

Music is multidimensional

Pitch, harmony, rhythm
dynamics, timbre,
orchestration…

Dimensions are correlated and style-dependent => Difficult to model



Oleo - Sonny Rollins

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Sub-model interpolation

melody at time t   music from times 1 to t

$$P(M_t \mid X_{1:t})\ ?$$

High dimensional. Can not be used in practice.

$$P(M_t \mid X_{1:t}) = \Sigma_i\ \lambda_i P_i(M_t \mid Z_{i,t})$$

global model   sub-models

$$Z_{i,t} \subset X_{1:t}$$

$$\Sigma_i\ \lambda_i = 1 \qquad \lambda_i \geq 0\ \forall i$$

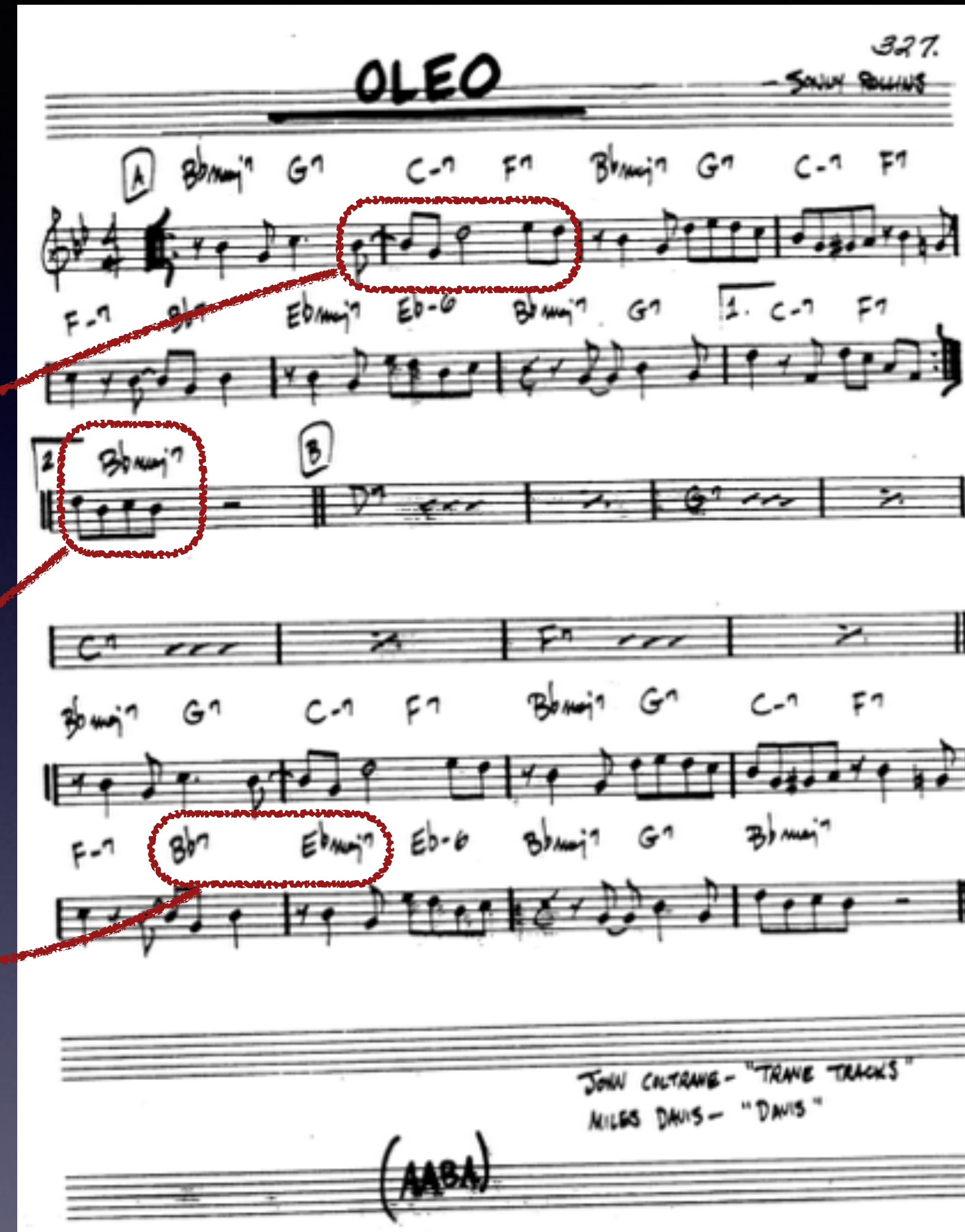
Using probabilistic sub-models to represent correlation between dimensions.

$P(M_t \mid M_{t-1},\dots,M_{t-n})$

$P(M_t \mid C_t)$

$P(C_t \mid C_{t-1})$

…



Smoothing techniques

- Training corpora are small.
- Smoothing techniques help avoiding of zero-valued probabilities and overfitting.
  - Additive smoothing : every possible event appears δ times more than it actually appears in the corpus.
  - Back-off smoothing : interpolation with a lower order model.
    $P(X \mid Y) = \lambda P(X \mid Y) + (1-\lambda)\, P(X \mid Z)$, with $Z \subset Y$

Experimental Results

$$(B) \qquad P(M_t \mid X_{1:t}) = P(M_t \mid M_{t-1})$$

$$(M) \qquad P(M_t \mid X_{1:t}) = P(M_t \mid C_t)$$

$$P(M_t \mid X_{1:t}) = \alpha P(M_t) + \beta U(M_t) + \lambda_1 P(M_t \mid M_{t-1}) + \lambda_2 P(M_t \mid C_t)$$

Training on Charlie Parker's Omnibook (50 tunes with improvisation) :

- Training corpus : 40 tunes and improvisations to train the sub-models
- Validation corpus : 5 tunes and improvisations to train the interpolation and smoothing coefficients
- Test corpus : 5 tunes and improvisations

Experimental Results

(B) $P(M_t \mid X_{1:t}) = P(M_t \mid M_{t-1})$

(M) $P(M_t \mid X_{1:t}) = P(M_t \mid C_t)$

$$P(M_t \mid X_{1:t}) = \alpha P(M_t) + \beta U(M_t) + \lambda_1 P(M_t \mid M_{t-1}) + \lambda_2 P(M_t \mid C_t)$$

	Coefficients				Cross-entropy
	λ_1	λ_2	α	β	H(M)
B+M	**0,582**	**0,129**	**0,289**	**0**	**4,543**
B	0,672	0	0,328	0	4,572
M	0	0,639	0,361	0	4,881
U	0	0	0,998	0,002	5,858

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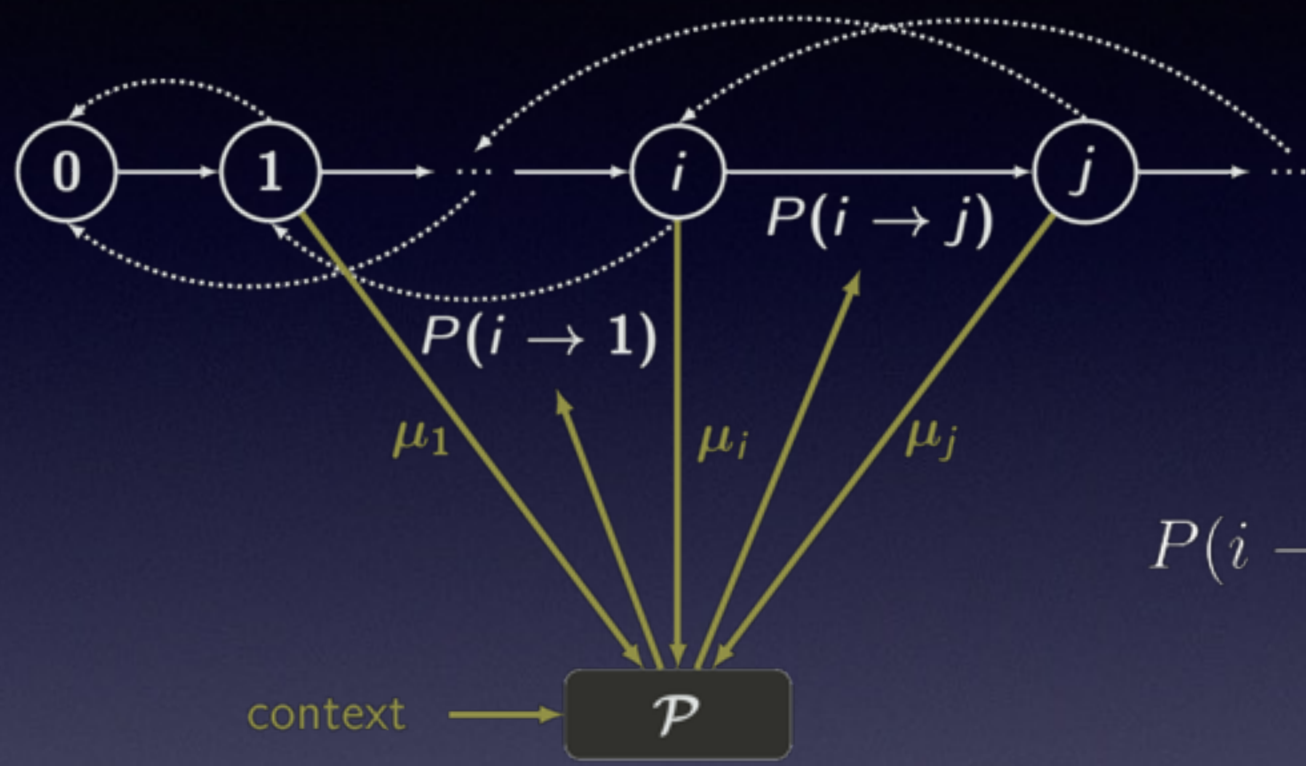
"The development of a motive should be done in a logical, organic way, not haphazardly (improvisation as spontaneous composition) - not, however, in a preconceived way - rather in a way based on intuition enriched with knowledge (from all the study, playing, listening, exposure to various musical styles, etc., that have occurred through a lifetime including all life experiences); the result is a personal musical vocabulary."

–Marylin Crispell, Elements of Improvisation.

Combining probabilistic models with the factor oracle



$$P(i \to j | X_{1:t}) = \frac{P(M_t(\mu_j)|X_{1:t})}{\sum_{k \in \mathrm{Att}(i)} P(M_t(\mu_k)|X_{1:t})}$$

- Interpolated models represent the system's knowledge
- The Factor Oracle represents the local context
  - Acts as a constraint for the probabilistic model.
  - Enables the system to take into consideration a longer context.
- Navigation in the Factor Oracle is now guided by previous knowledge.

Experimental Results

- Generated improvisations on Charlie Parker's music following 3 methods (15 improvisations per method over 3 tunes) :
  - OMax without any probabilistic module.
  - OMax with a probabilistic module trained on the Omnibook (50 improvised tunes).
  - Omax with a probabilistic module trained on a classical music corpus (850 non improvised tunes).

Improvisation on Donna Lee

Ab F7 Bb7 % Bb- Eb7 Ab Eb- Ab7 Db Gb7 Ab

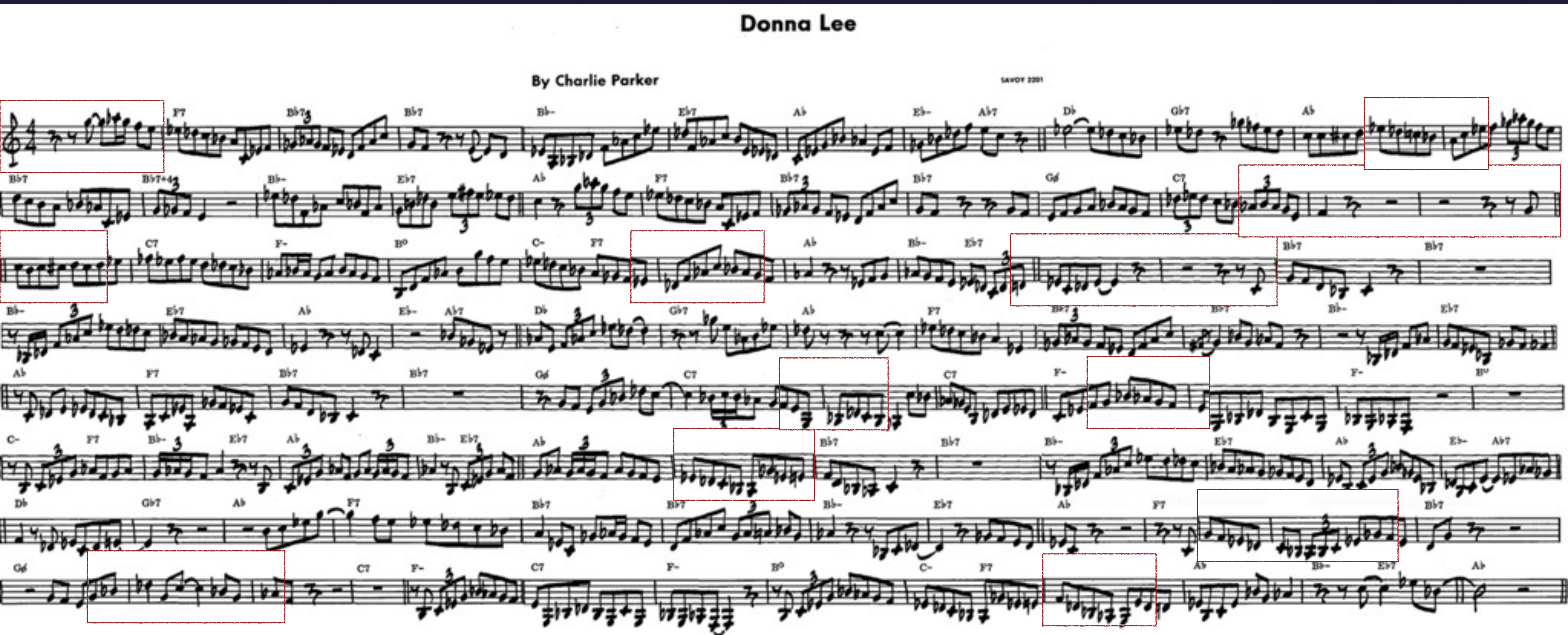
7th 5th 3rd 3rd 5th 9th 5th

F7 Bb7 % Bb-

7th 5th 13th

…

other examples on members.loria.fr/evincent/files/smc16



Experimental Results

$$P(M_t \mid M_{t-1})$$
$$P(M_t \mid C_t)$$
$$P(C_t \mid C_{t-1})$$

- Informal listening
- When using a probabilistic module :
    - Better harmonic stability.
    - Charlie Parker's musical language a bit faded when trained on classical music.
    - Improvisations are more "diverse, fluid and creative". The combination of dimensions and the smoothing provide escape mechanisms.

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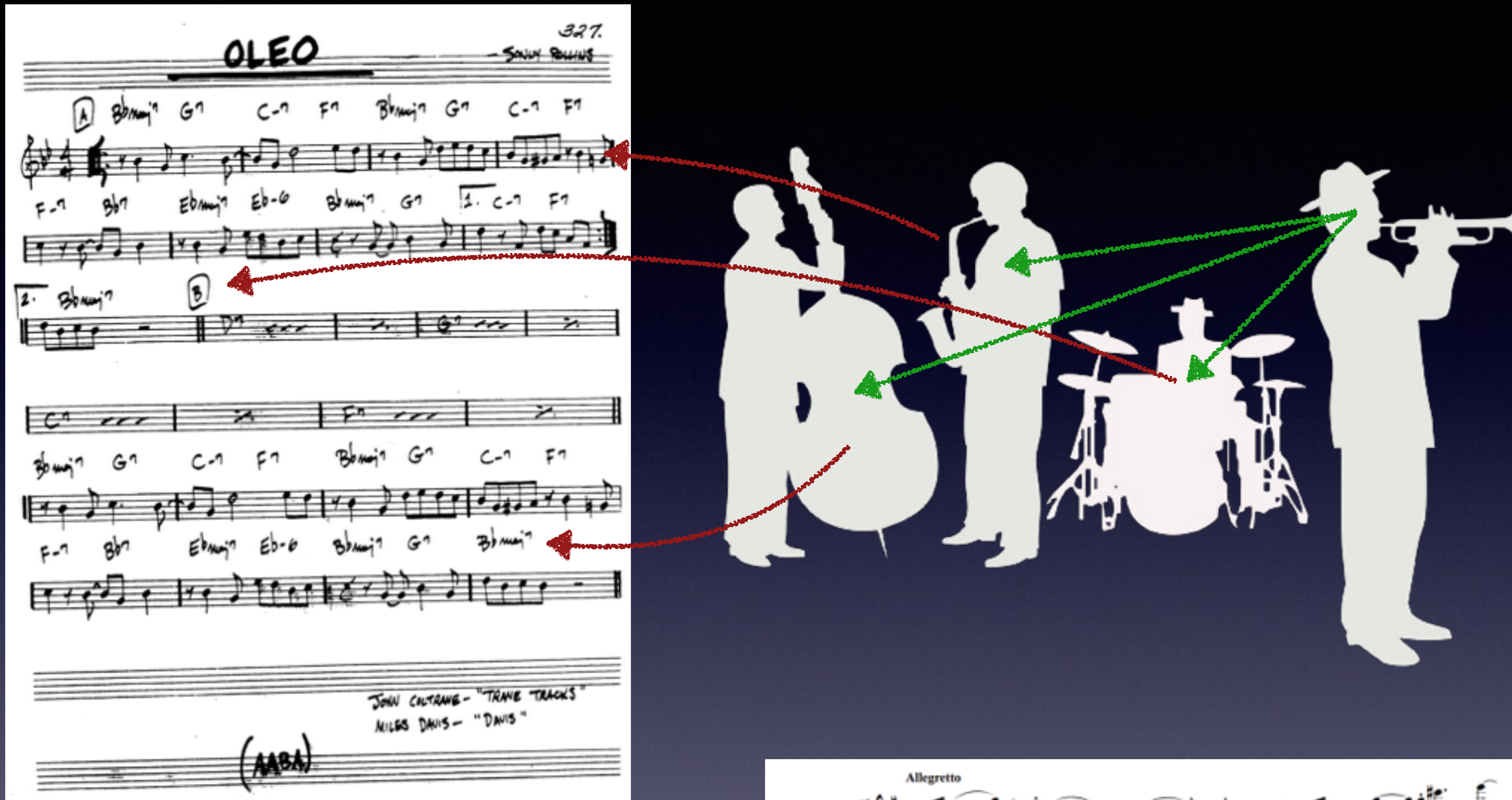
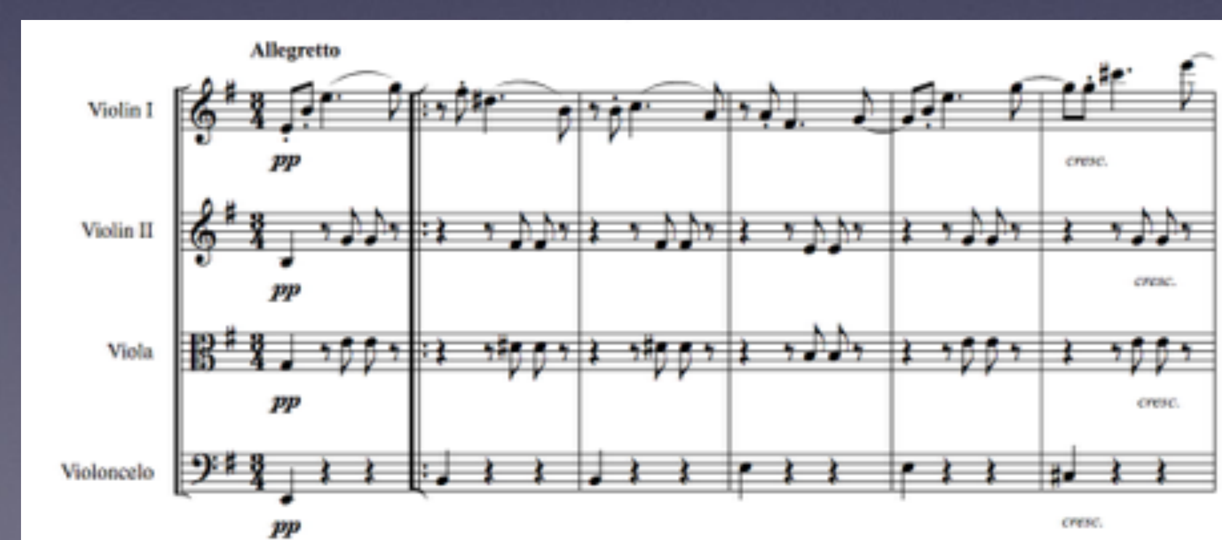
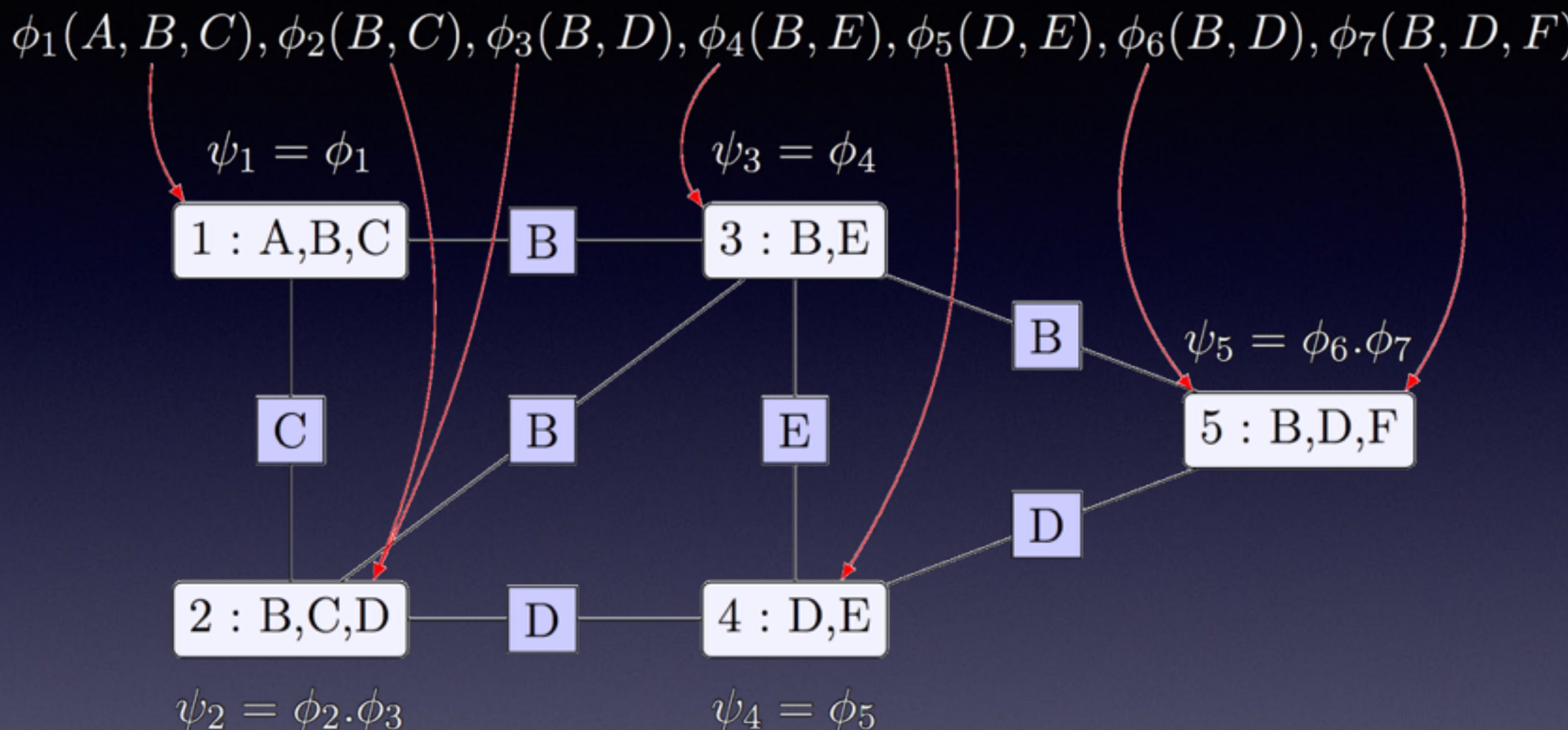

327.
OLEO
— Sonny Rollins
A
Bbmaj7 G7 C-7 F7 Bbmaj7 G7 C-7 F7
F-7 Bb7 Ebmaj7 Eb-6 Bbmaj7 G7 1. C-7 F7
2. Bbmaj7
B
D7
G7
C7
F7
Bbmaj7 G7 C-7 F7 Bbmaj7 G7 C-7 F7
F-7 Bb7 Ebmaj7 Eb-6 Bbmaj7 G7 Bbmaj7
John Coltrane – "Trane Tracks"
Miles Davis – "Davis"
(AABA)


Allegretto
Violin I
Violin II
Viola
Violoncello
pp
cresc.

Cluster graph



- ϕ_i : factors ; Ψ_i : initial potentials
- C_i : Clusters ; $S_{i,j} \subseteq C_i \cap C_j$: Sepsets

Belief Propagation

- Message passed from cluster i to cluster j :

$$\delta_{i\to j}(S_{i,j}) = \sum_{C_i - S_{i,j}} \psi_i \prod_{k\in(N_i-\{j\})} \delta_{k\to i}$$

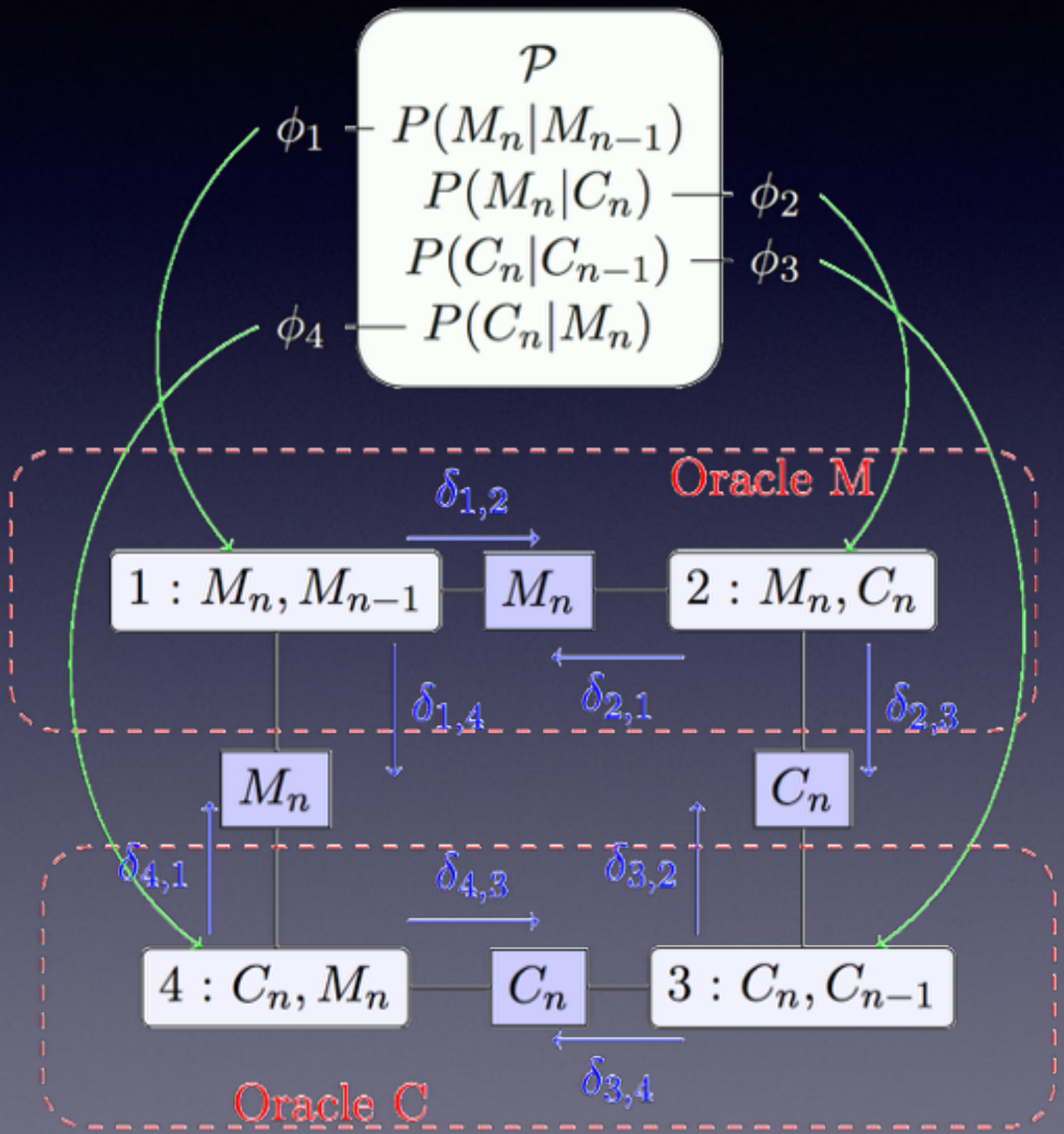
- Belief Propagation algorithm :

1. Assign each factor ϕ_k to a cluster.
2. Construct initial potentials of each cluster (product of assigned factors).
3. Initialise all messages to be 1.
4. Repeat message passing.
5. Compute final beliefs :

$$\beta_i(C_i) = \psi_i \prod_{k\in N_i} \delta_{k\to i}$$

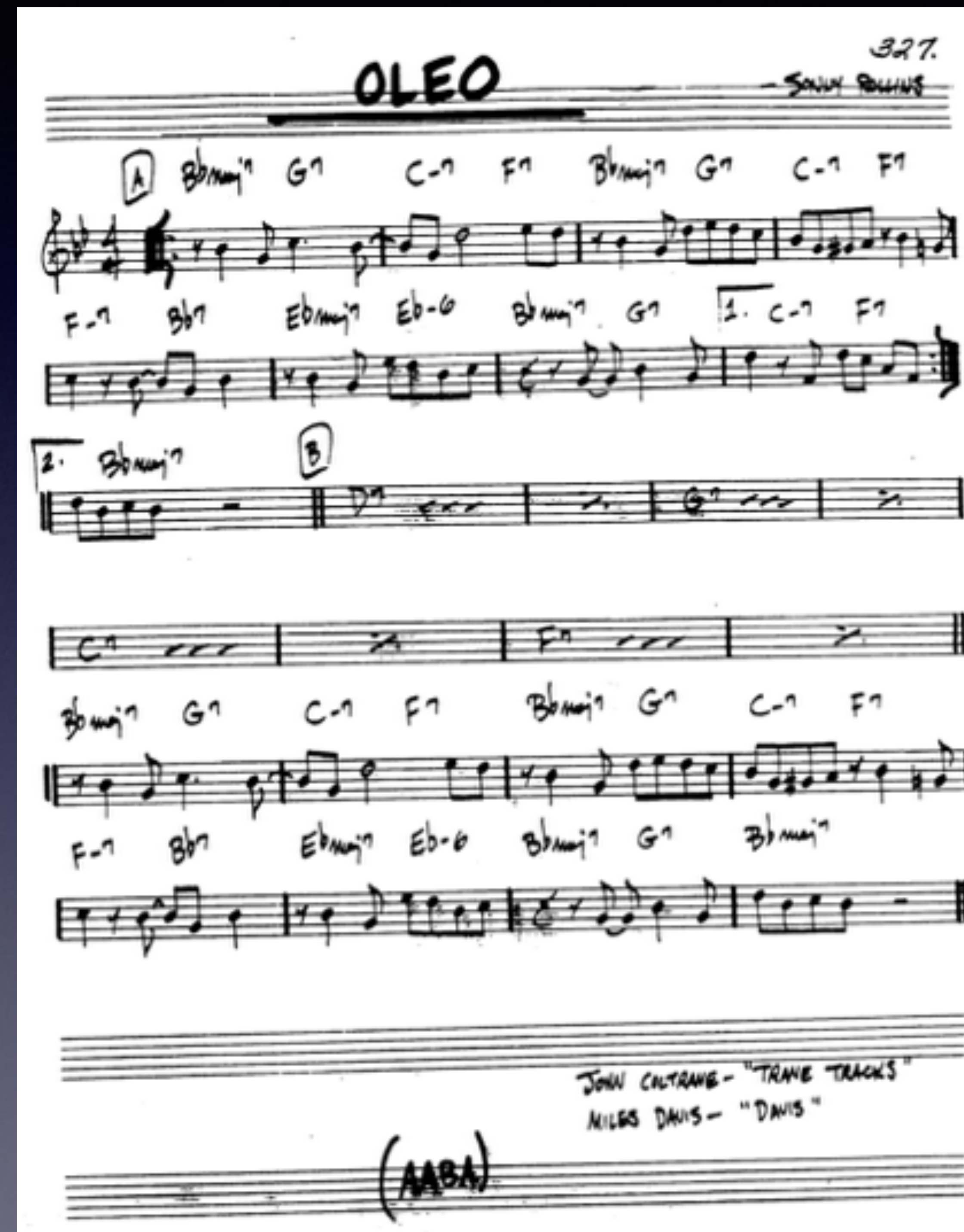
Application to the factor oracle and sub-models

- Sub-models are factors for the cluster graph.
- A subset of clusters represents the oracles.
- Oracles communicate via the cluster graph through messages.



Coda

- What about the multi-scale organisation?
- How to combine dimensions evolving on different time scales?
- How can we extend the concept of scenario used in ImproTek? (inference of scenario)



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