Conceptual Vectors, Lexical Networks, Morphosyntactic Trees, and Ants

a bestiary for Semantic Analysis

Mathieu LAFOURCADE

LIRMM-INFO
Equipe TALN

Outline

Semantic Analysis	What to look at? – Applications
Casting	Conceptual Vectors – Analysis Trees – Lexical Network
Ant algorithm	Principles - Without lexical network - With lexical network
Ressource Production	Lexical Network - Conceptual Vectors
Future directions	Toward holistic analysis: syntax + semantic

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Semantic Analysis

What do we look at?

Selection/weighting of acceptions (WSD)

"L'avocat plaide" The lawyer pleads

avocat/fruit or avocat/justice ?

Prepositional group attachment

"He saw the girl with a telescope"

The man sees (the girl with a telescope)
/ The man (sees [the girl] with a telescope)

"Il (voit avec un télescope) la fille" or
"Il voit la (fille avec un télescope)" ?

Interpretation trails

"L'avocat est véreux" 2 trails but not 4

The avocado is rotten
/ The lawyer is corrupted

Semantic Analysis

What do we look at?

Anaphora/reference resolution

"The lawyer defended well his client. He was acquitted."

he = lawyer or he = client ?

Recognition of occurrences of lexical function [meltchuk] [schwab]

"Il a une forte fièvre"

Magn(fièvre) = forte ?

He has a high fever

Magn(fever) = high ?

Semantic Analysis Applications

Indexing for information retrieval [jaillet, prince, chauché, teissere]

WSD (mouse)
increase in precision

Synonymy (cat/true cat/feline) / semantic fields (horse/saddle)
increase in recall

Machine Translation [prince, delorme]

Reference resolution (il => he/she/it ? Son => his/her/its ?)

Contrastive phenomena (river <= rivière/fleuve ?)
(abats => ofals/giblets ?)

Lexical functions (forte fièvre <=> high fever) but (forte <=> high)

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Casting Conceptual Vectors

Thematic representation [chauché, lafourcade]

Lexical item = set of ideas => vector

An idea => a concept

For example, 873 concepts in Larousse thesaurus (French)
more than 1000 in Roget

(1)existence, (2)inexistence, (3)matérialité, ..., (516)liberté, ...,
... (872)jeux, (873)jouets

A component of the vector is the activation of the related concept

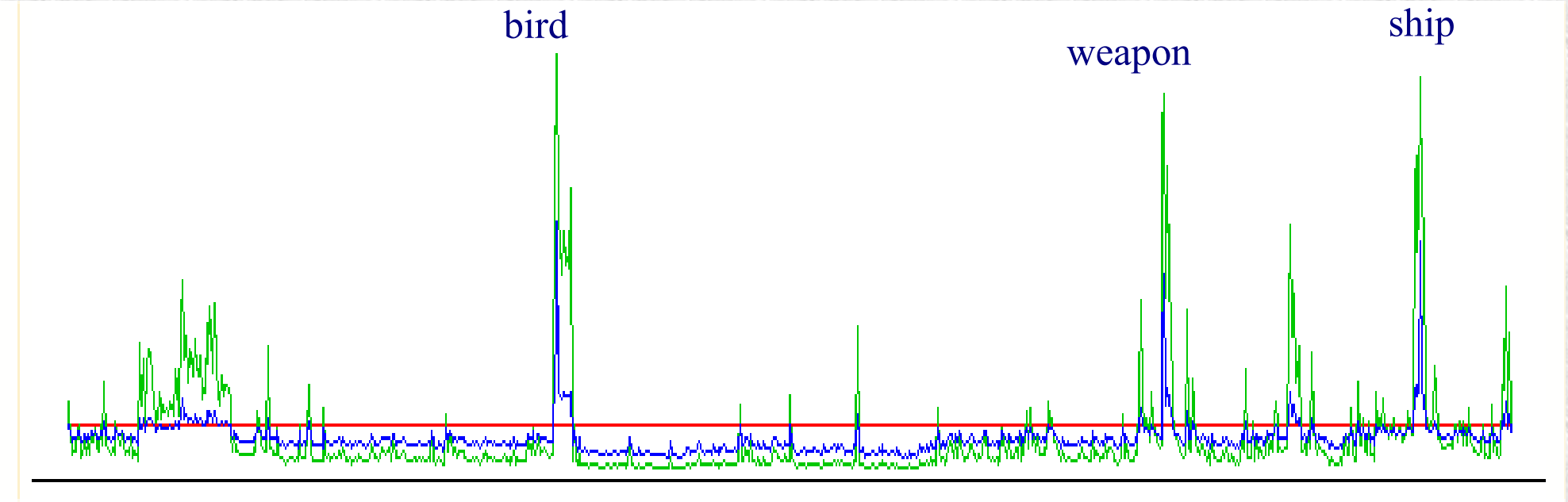
A concept is itself a vector on the same space (neighbourhood of concepts)

Concept are interdependent => « Conceptual » vectors

Vector combinations : addition, contextualisation…
[lafourcade, prince, schwab]

Conceptual Vectors Example

Frigate
- Ancient ship
- Modern ship
- Bird

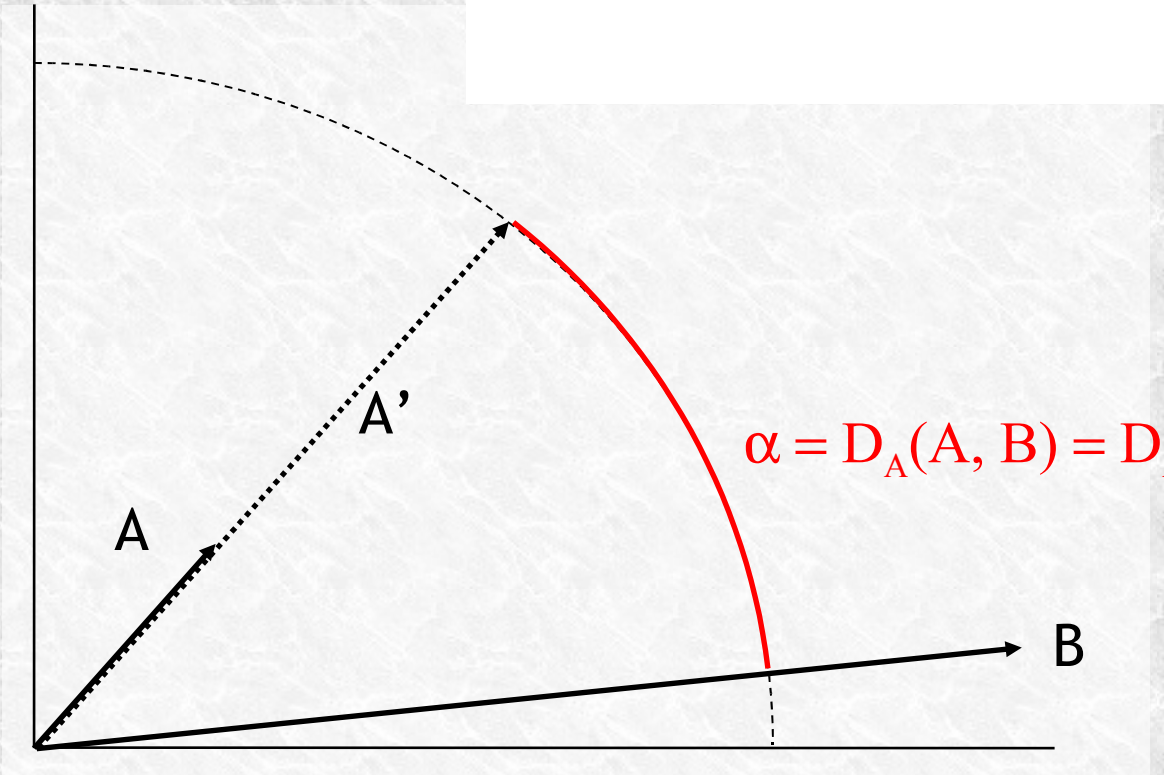


Conceptual vectors

Angular distance D_A

$$D_A(A, B) = \arccos(Sim(A, B))$$

$$Sim(A, B) = \cos(\widehat{A, B}) = \frac{A \cdot B}{\|A\| \times \|B\|}$$



Conceptual Vectors

D_A(*pelican*, *pelican*) = 0 (0°)

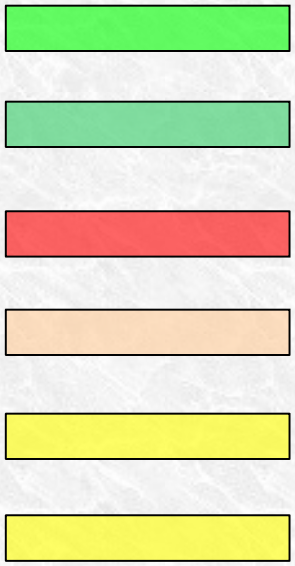
D_A(*pelican*, *white pelican*) = 0,2 (11°)

D_A(*pelican*, *train*) = 1,22 (70°)

D_A(*pelican*, *bird*) = 0,46 (26°)

D_A(*pelican*, *seagull*) = 0,4 (23°)

D_A(*pelican*, *fish*) = 0,35 (20°)



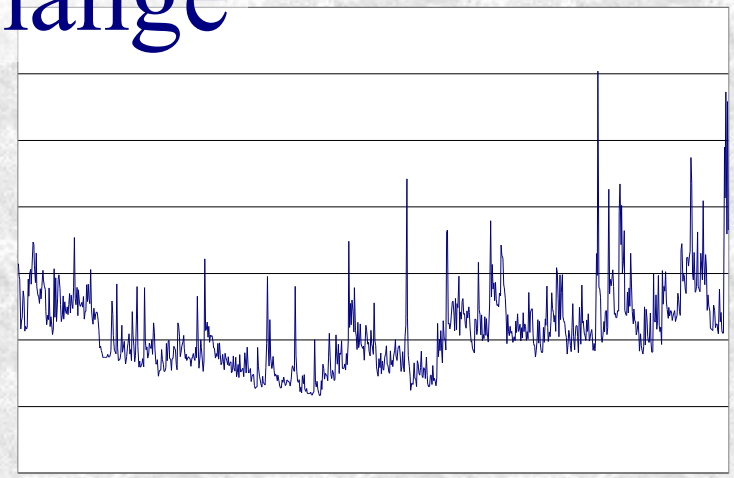
Thematic distance ≠ Ontologic distance (of type *is-a*)

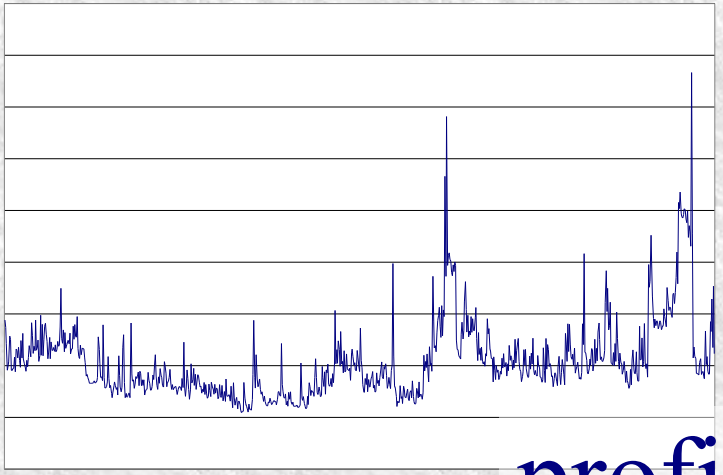
but

Thematic distance ⊃ Ontologic distance

Conceptual Vectors Examples

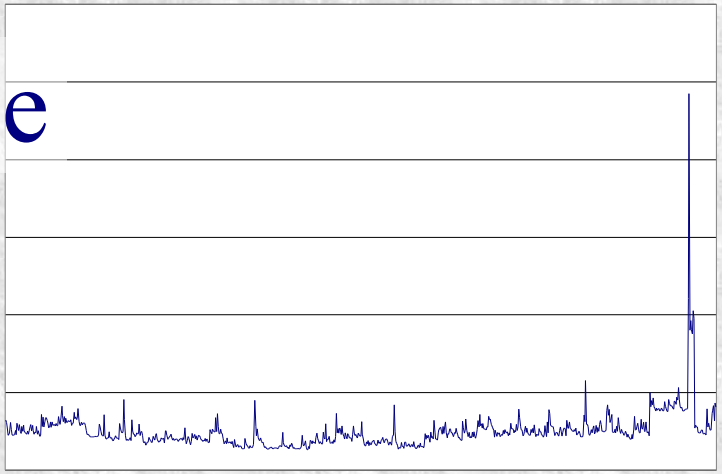
exchange





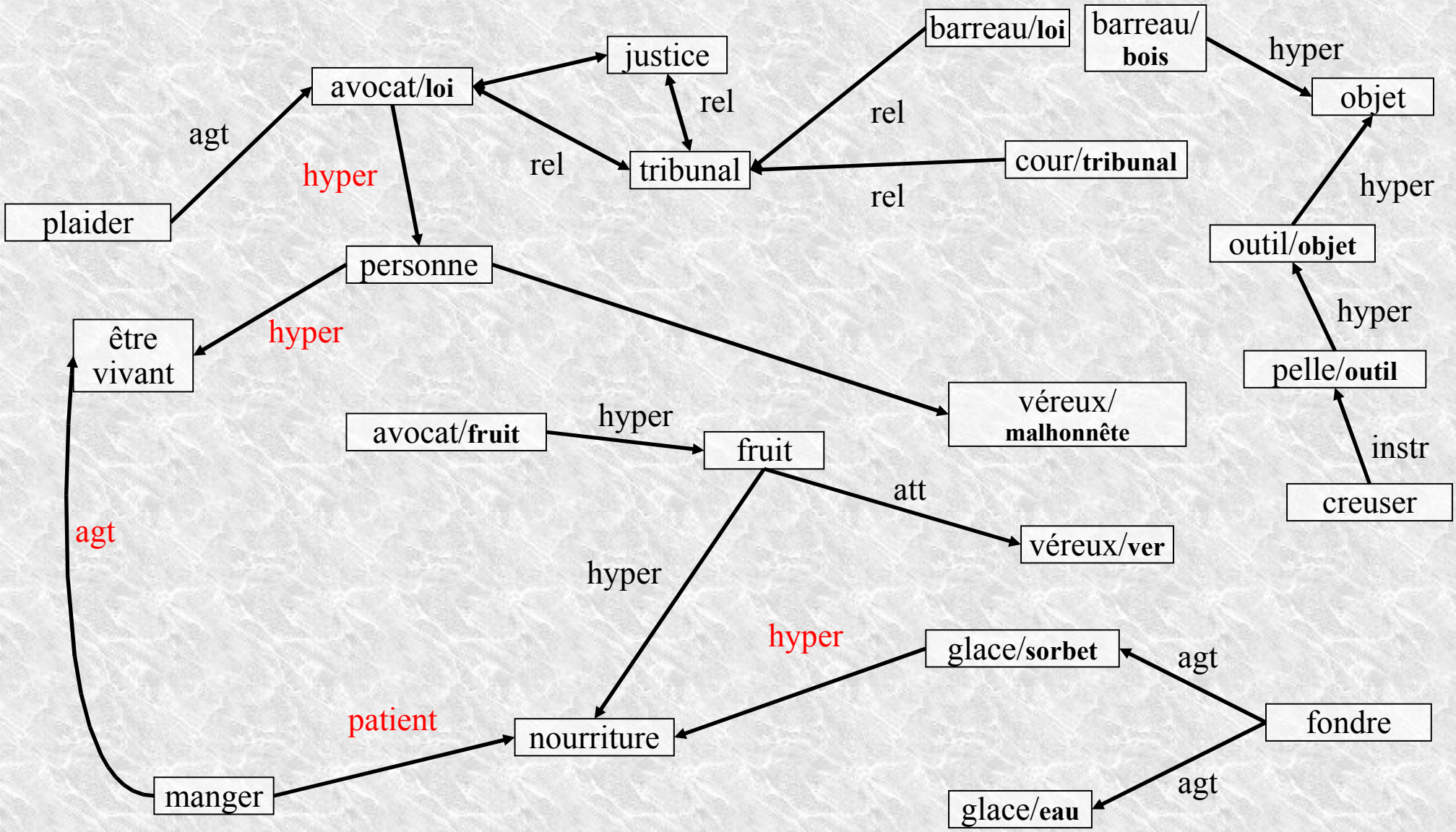
profit

finance



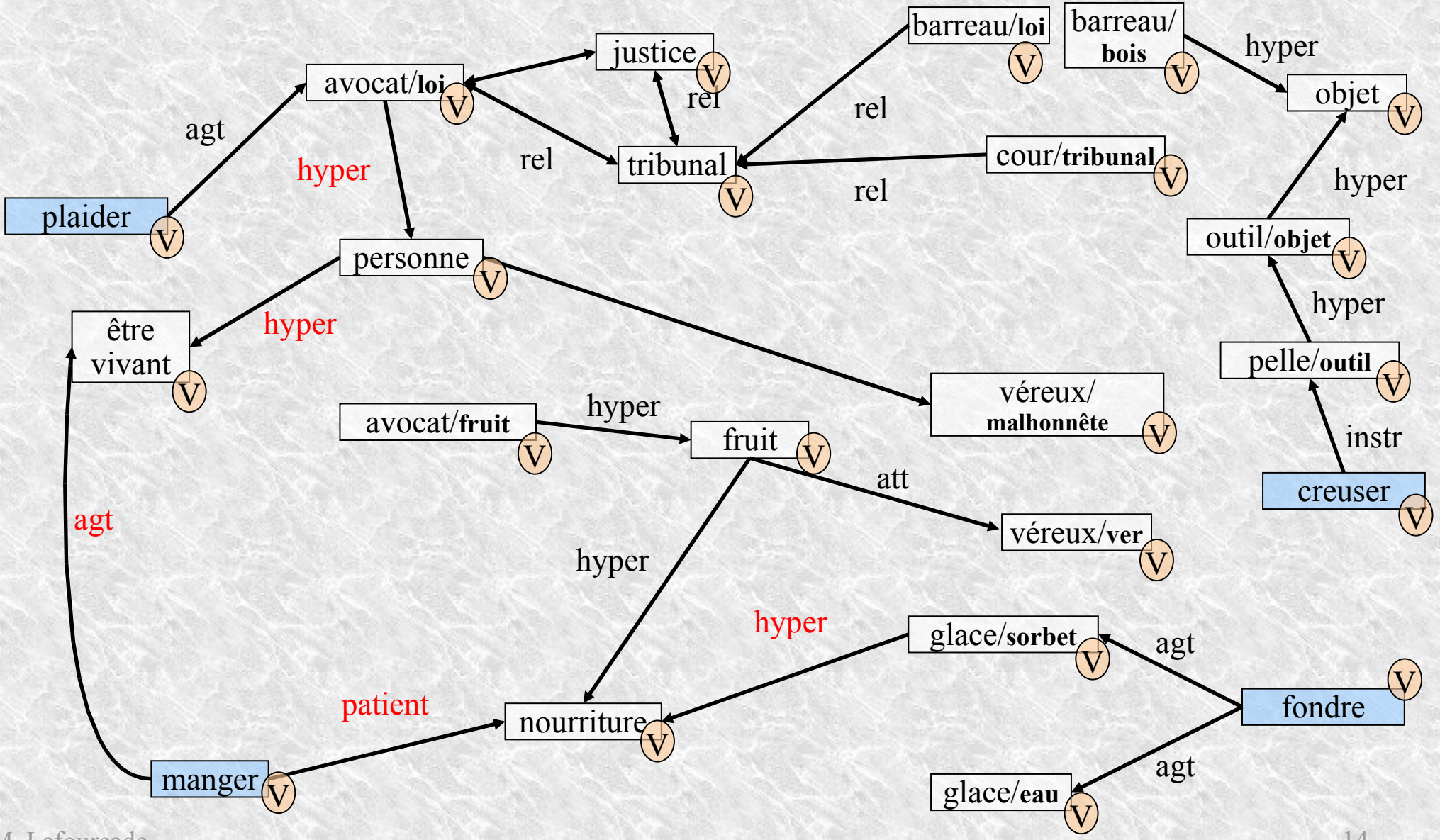
Casting

Lexical network



Casting

Lexical network with conceptual vectors



Adding vectors to graph nodes

=> a shortcut for term proximity

graph searching algorithm cost > D_A function cost

=> vectors can be computed according to points of view

=> can be done incrementally

Graphs tend to be a **precision** oriented data structure

Vectors tend to be a **recall** oriented data structure

We need both!

Casting

Morphosyntactic trees

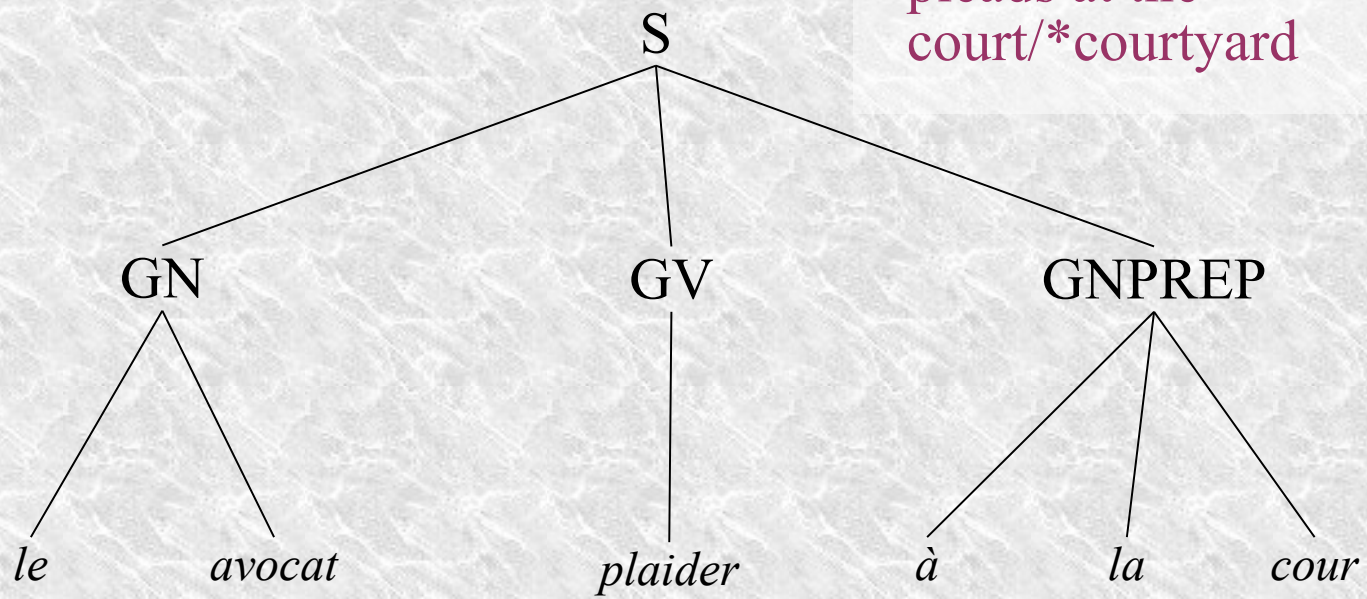
Constituent tree structure

geometry + set of instantiated variables

SYGMART application to French (SYGFRAN) **[chauché]**

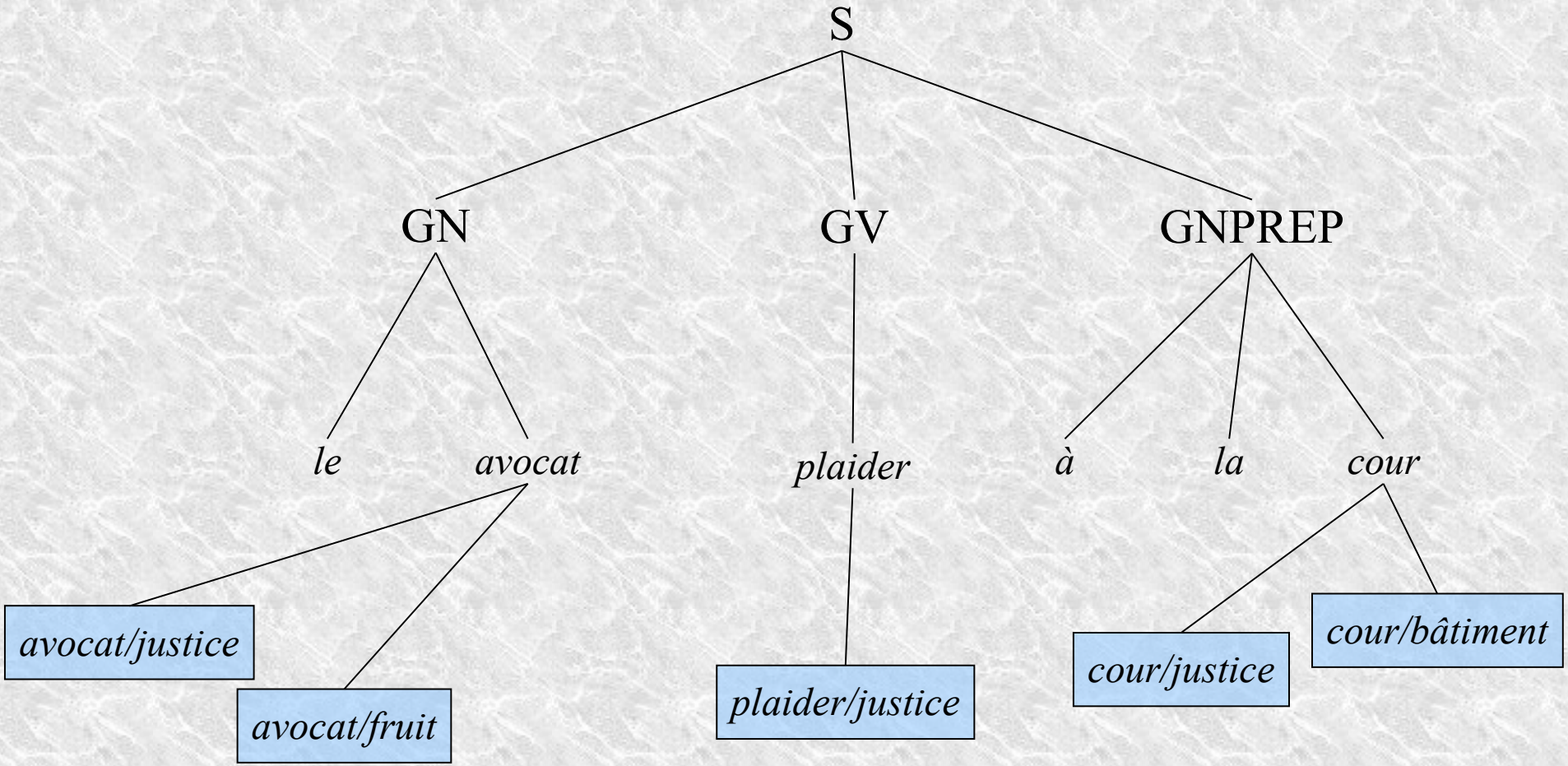
"L'avocat plaide à la cour"

The laywer/*avocado pleads at the court/*courtyard



Morphosyntactic trees

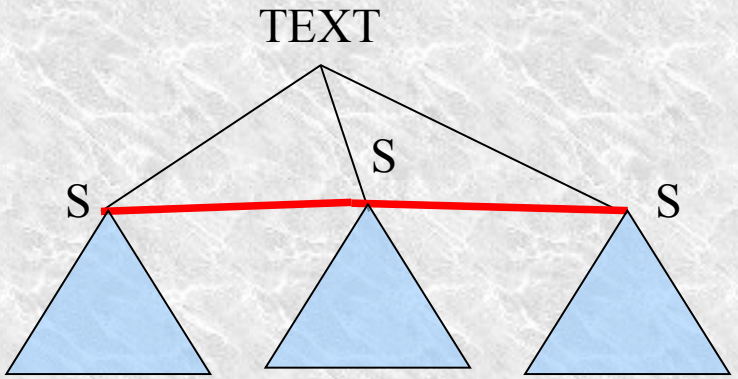
Adding acceptions



Morphosyntactic trees Adding links => Graph

Transforming the tree into a graph

Links between sentence to reconstitute text flow



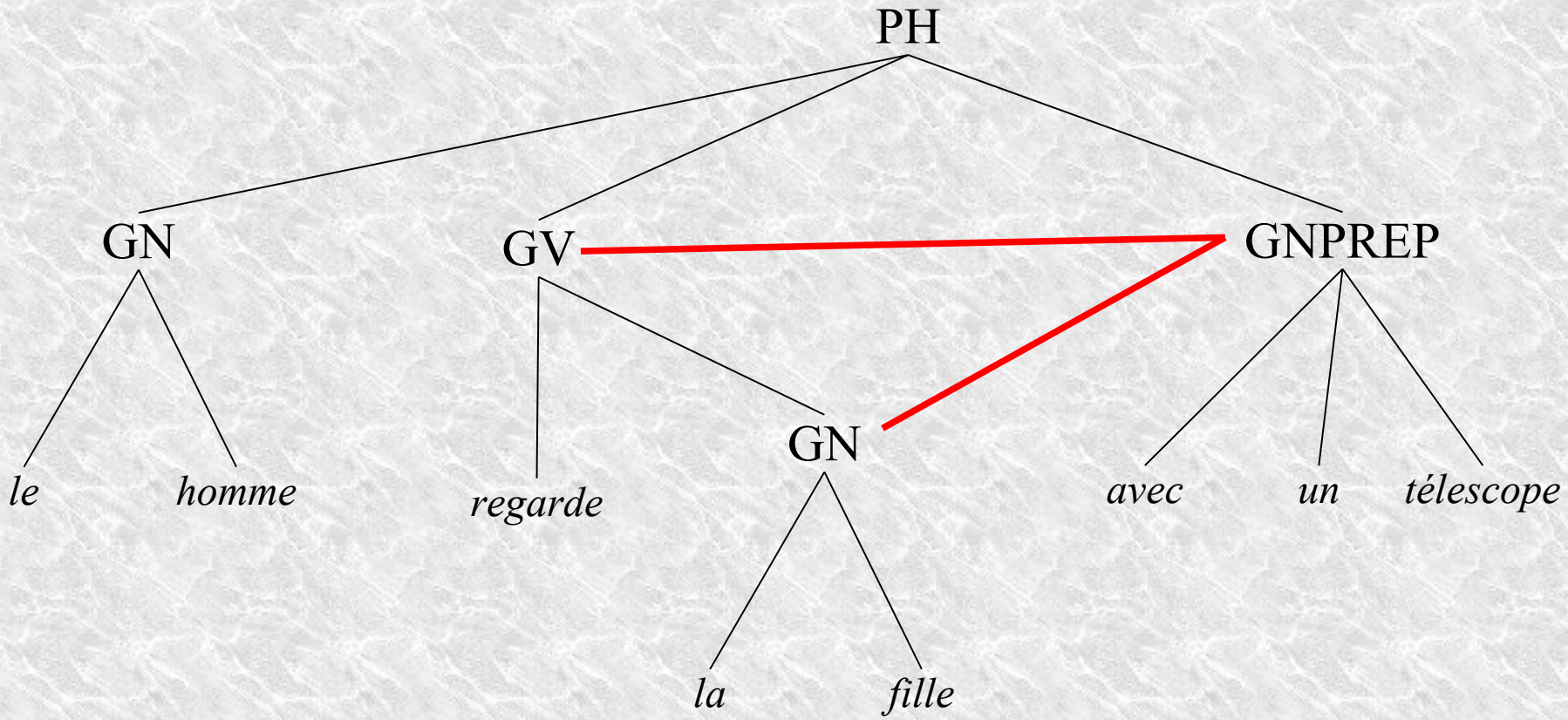
=> allows the computation of distance between sentences

Combination between structural and surface information

Morphosyntactic trees Adding links => Graph

Transforming the tree into a graph

Enumeration of syntactically possible attachments (GNPREP)



Ant algorithms

Multi-agent system – reactive agents

TSP – operational research - network – bio informatic
[dorigo] [bertelle] [bonabeau, théraulaz] [bruten] [costa, hertz]

Principle

Stygmergy = indirect communication
through modification of the environment

Pheromones drops – Slow decay over time
=> handling of an ever-changing environment

NLP

Cognitive agents [stéphanini] [sabah]

otherwise reactive [lafourcade, guinand] [+cunningham] [zamora]

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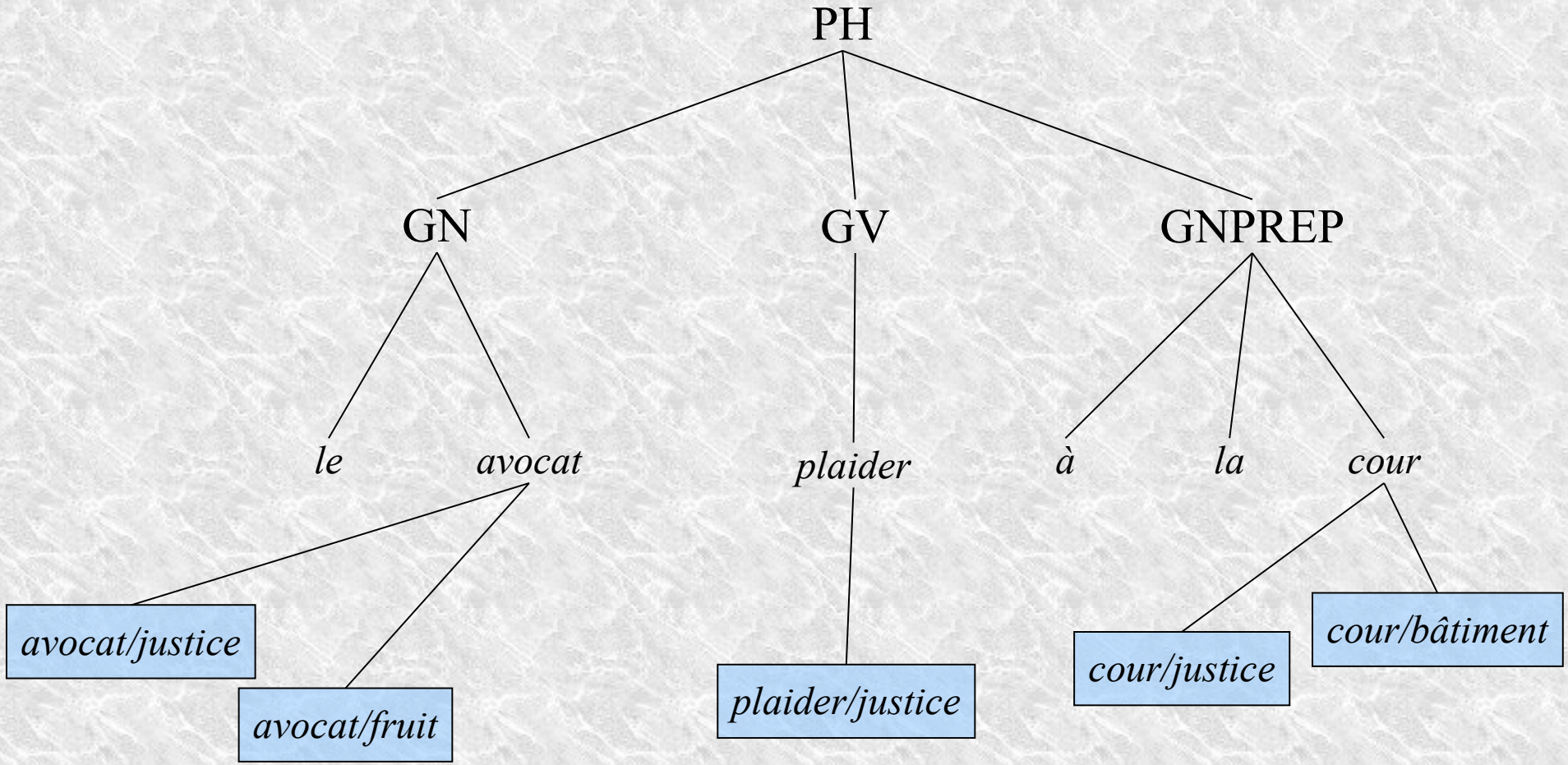
Ant algorithms

Environment

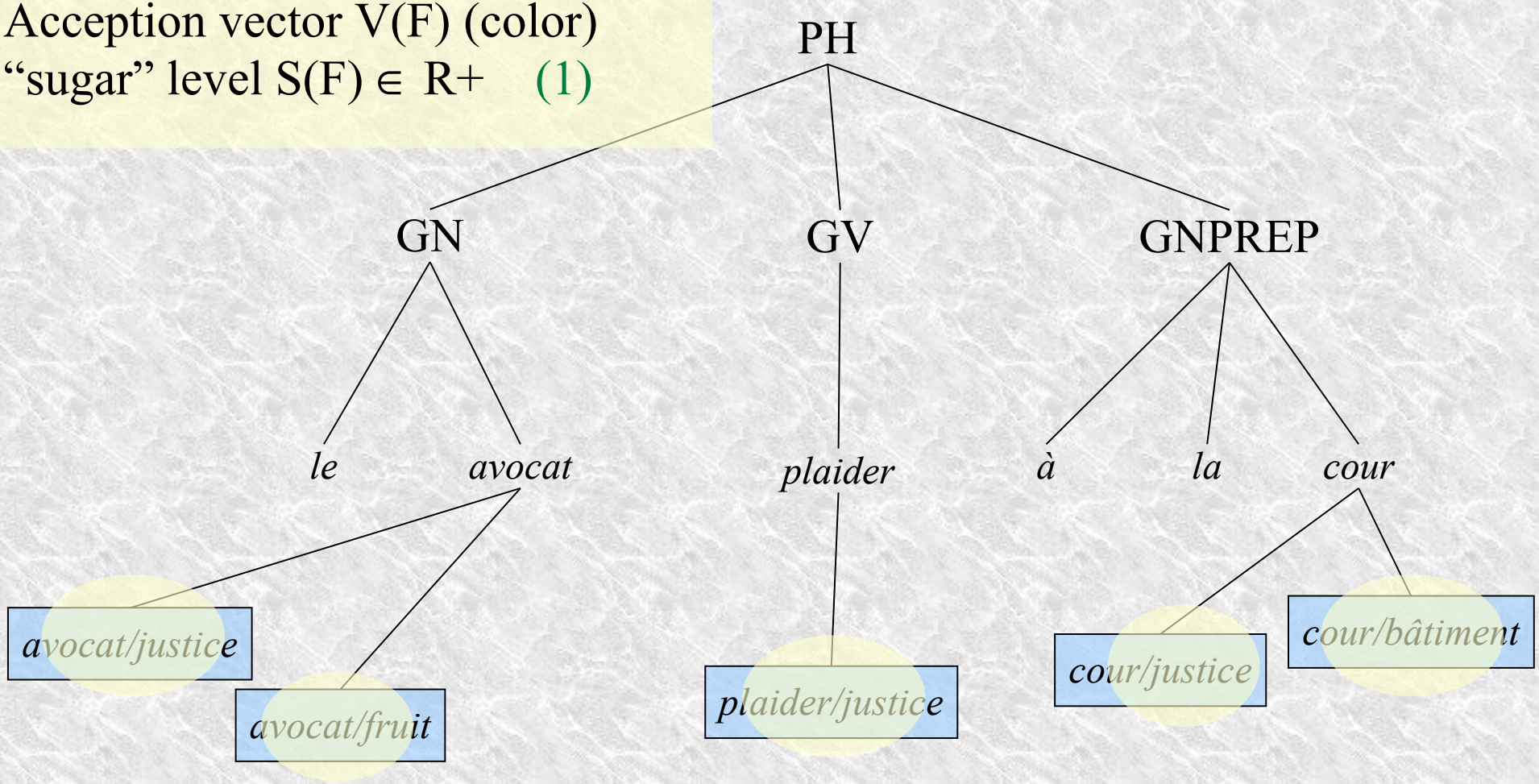


Ant algorithms

Environment

Anthill / Acception nodes

Acception vector V(F) (color)
"sugar" level S(F) ∈ R+ (1)

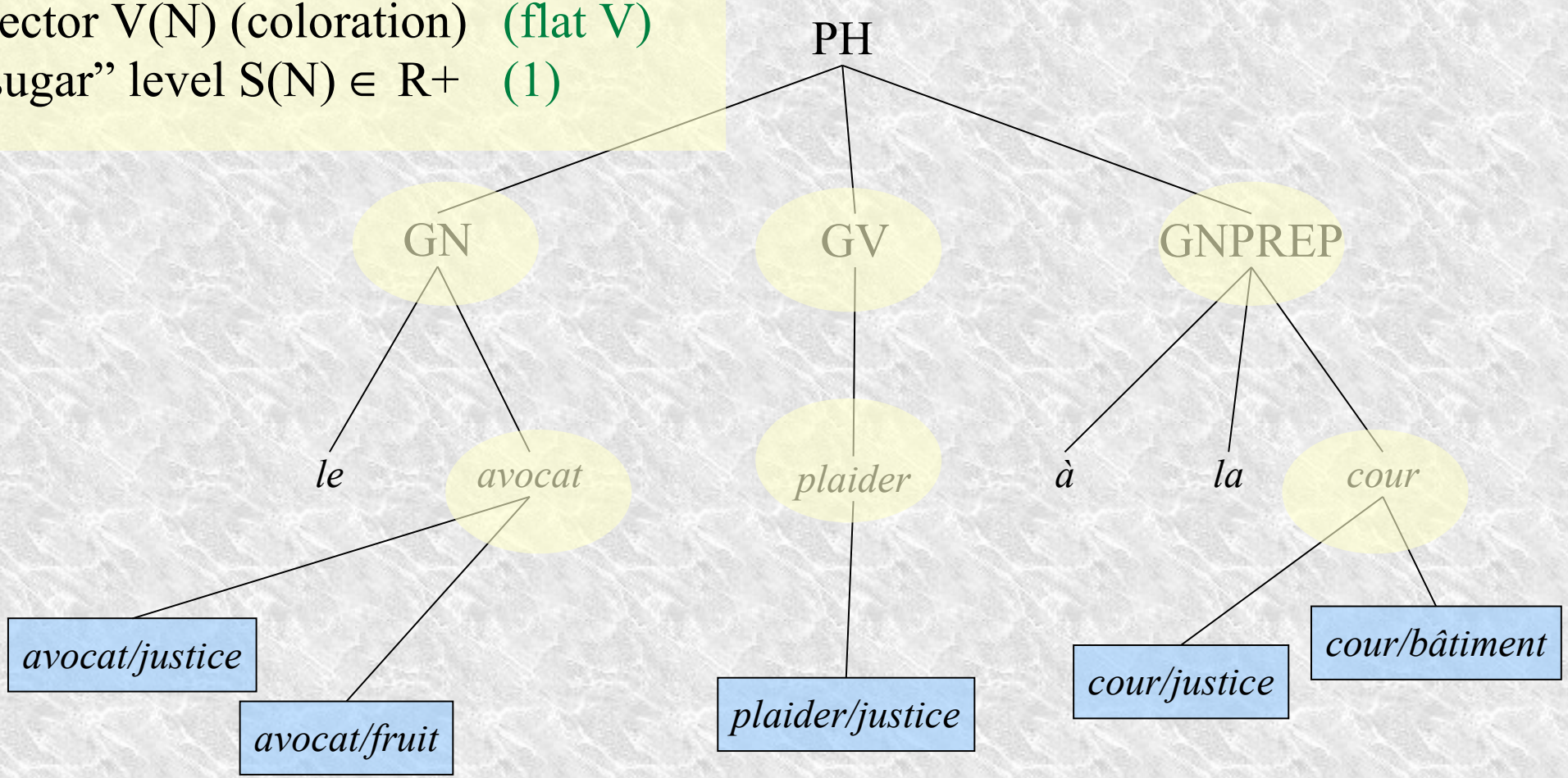


Ant algorithms

Environment

Standard node

Vector V(N) (coloration) (flat V)
"sugar" level S(N) ∈ R+ (1)



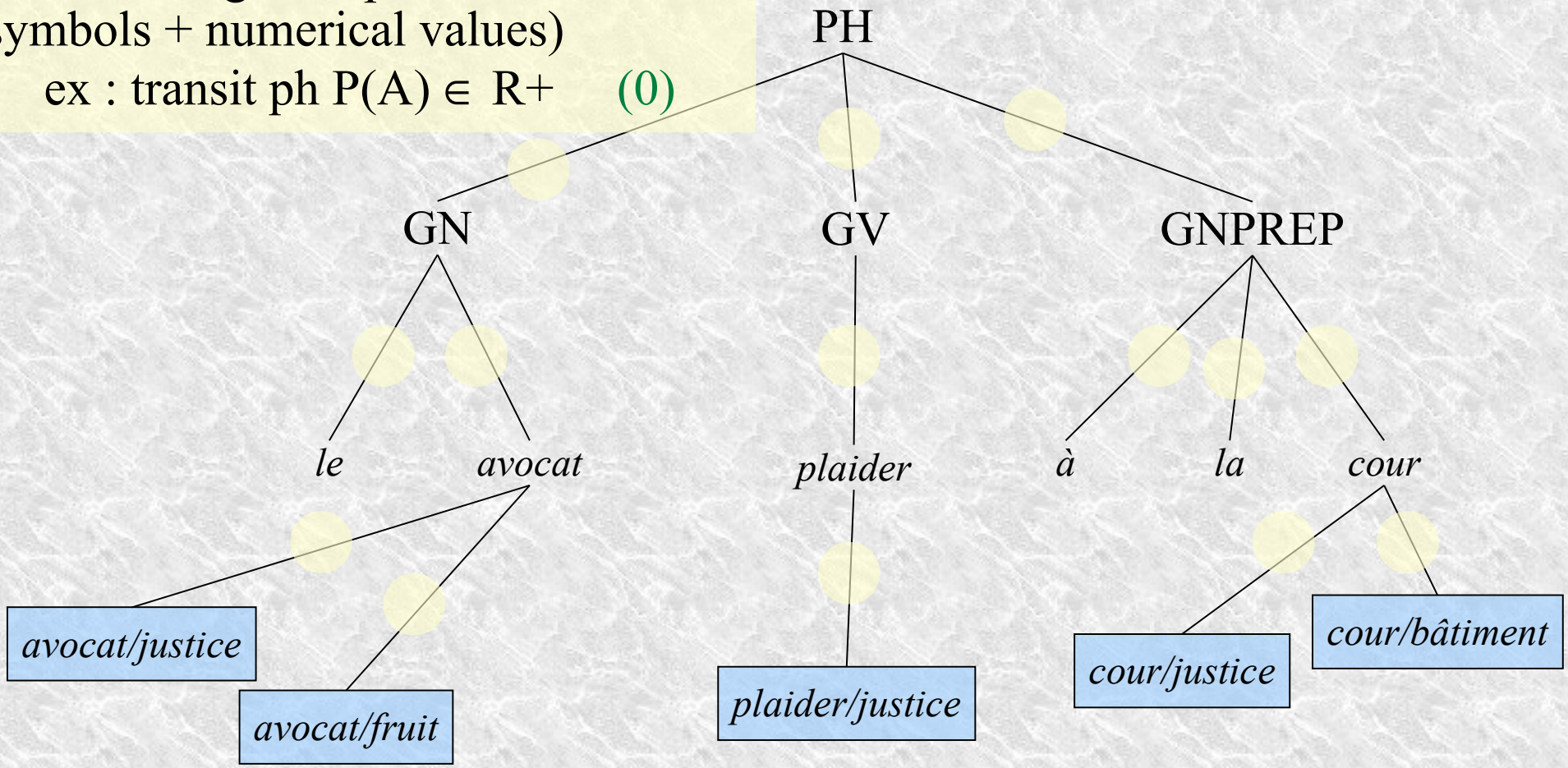
Ant algorithms

Environment

Arc A

- type
- Valuated signal = pheromones (symbols + numerical values)

ex : transit ph P(A) ∈ R+ (0)



Ant algorithms

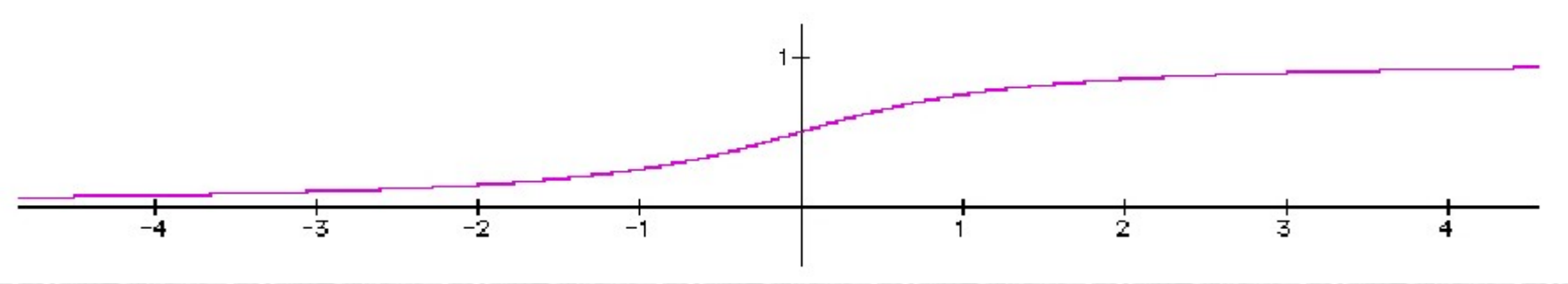
Environment

Ant production

one or several ants at each cycle

with a probability equal to the sugar level S(F)

"sigmoïde" function



Production cost (experiment with 1/10)

Ant algorithms

Agents

Attributes of an ANT

« sugar » load	Q real in [0,1]
sugar dropped at death	
Life span	20 cycles
Reference to its home F	V(*f*) = V(F)
Current moving strategy	Prob = Q

Two moving strategies

Looking for « sugar » - **search mode**

Bringing the « sugar » back home – **return mode**

Ant algorithms

Ant moves

Pseudo-random moves

Evaluation of possible destinations + pseudo taboo list (k = 1)

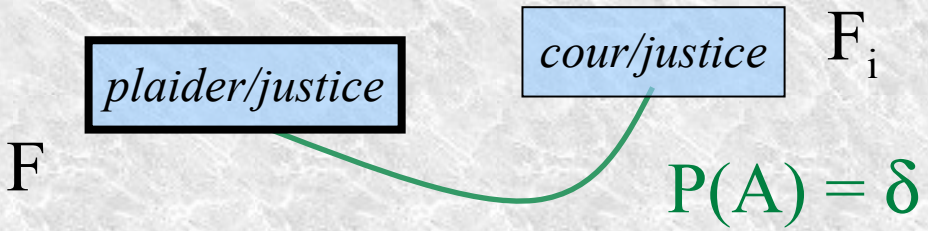
Environment modification

Drop of pheromones of the arc $P(A) = P(A) + \delta$

Modification of the vector of the reached node $V(N) = V(N) + \alpha V(f)$

normed sum with α and δ small

Creation of a bridge towards F



Ant algorithms

Ant moves

General principle

Current position = a node N with k neighboors N_i through arcs A_i

Evaluation function for each N_i = Eval(N_i)

Evaluation function for each A_i = Eval(A_i)

Global evaluation function of destination $dest_i$

$$Eval(dest_i) = \max \begin{cases} Eval(N_i) + Eval(A_i) \\ \epsilon \end{cases}$$

$$Prob(dest_i) = \frac{Eval(dest_i)}{\sum_{k=1}^{n} Eval(dest_k)}$$

Ant algorithms

Sugar foraging and sharing

Search mode

Specific action: taking sugar from the node

$$Eval(N_i) = S(N_i)$$

$$Eval(A_i) = 1 - P(A_i)$$

Return mode

Specific action: dropping sugar on the node if its looks like home

$$Eval(N_i) = 1 - \frac{2}{\pi} D_A(V(N_i), V(f)))$$

$$Eval(A_i) = P(A_i)$$

Ant algorithms

Signal Decay

At each simulation cycle, pheromone signals decay slightly

$P(A) = \text{Min}\,(P(A) - d * \eta, 0)$

$d = \text{dist}(N_a, N_b)$ and η a decay factor

Arc of the tree between N_a and N_b

$P(A) = \text{Min}\,(P(A) - \eta, 0)$ because $\text{dist}(N_a, N_b) = 1$

Bridge between N_a and N_b

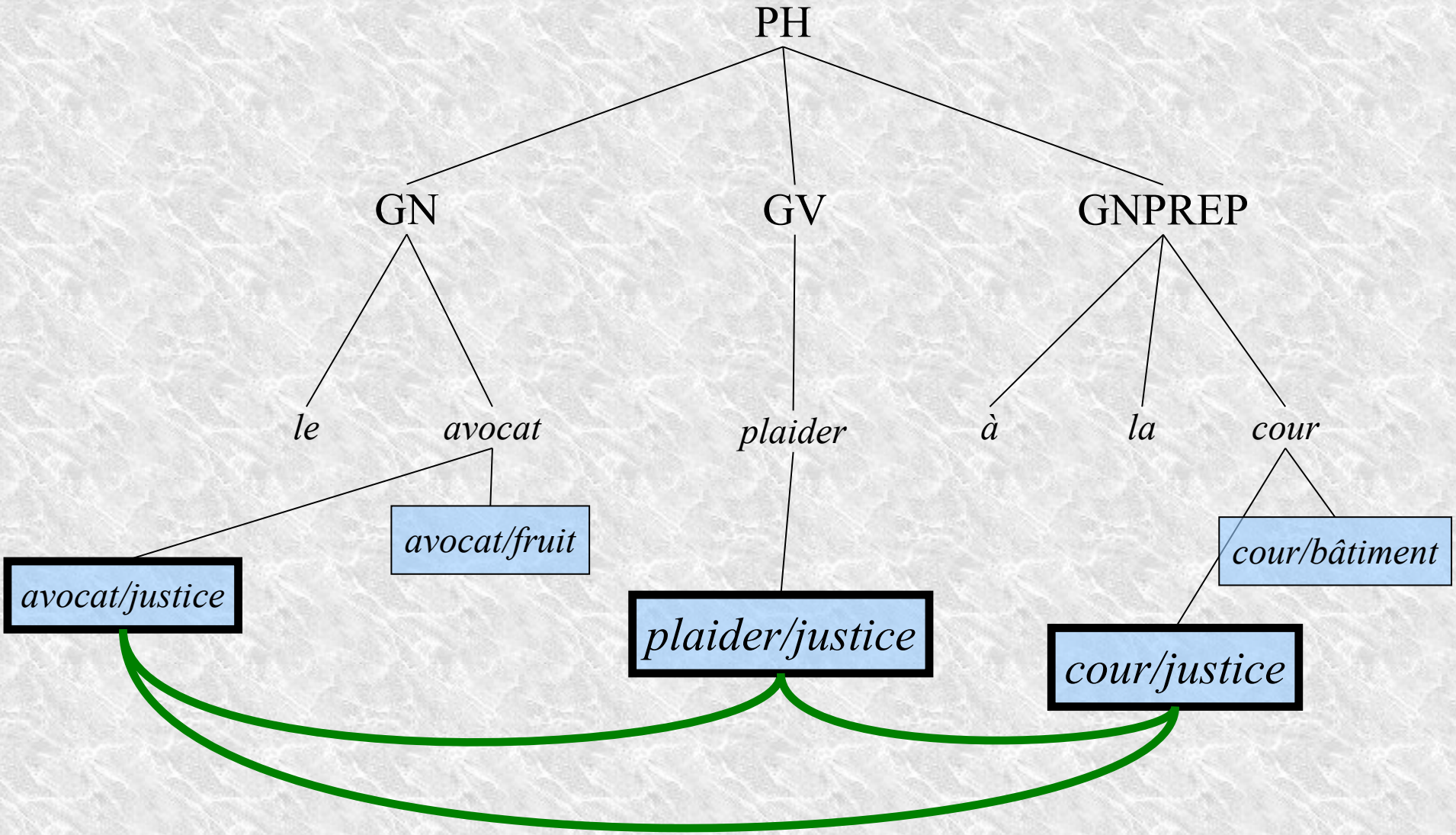
Deleted if $P(A) = 0$

The longer the bridge, the harder it is to keep

Ant algorithms

Simple example

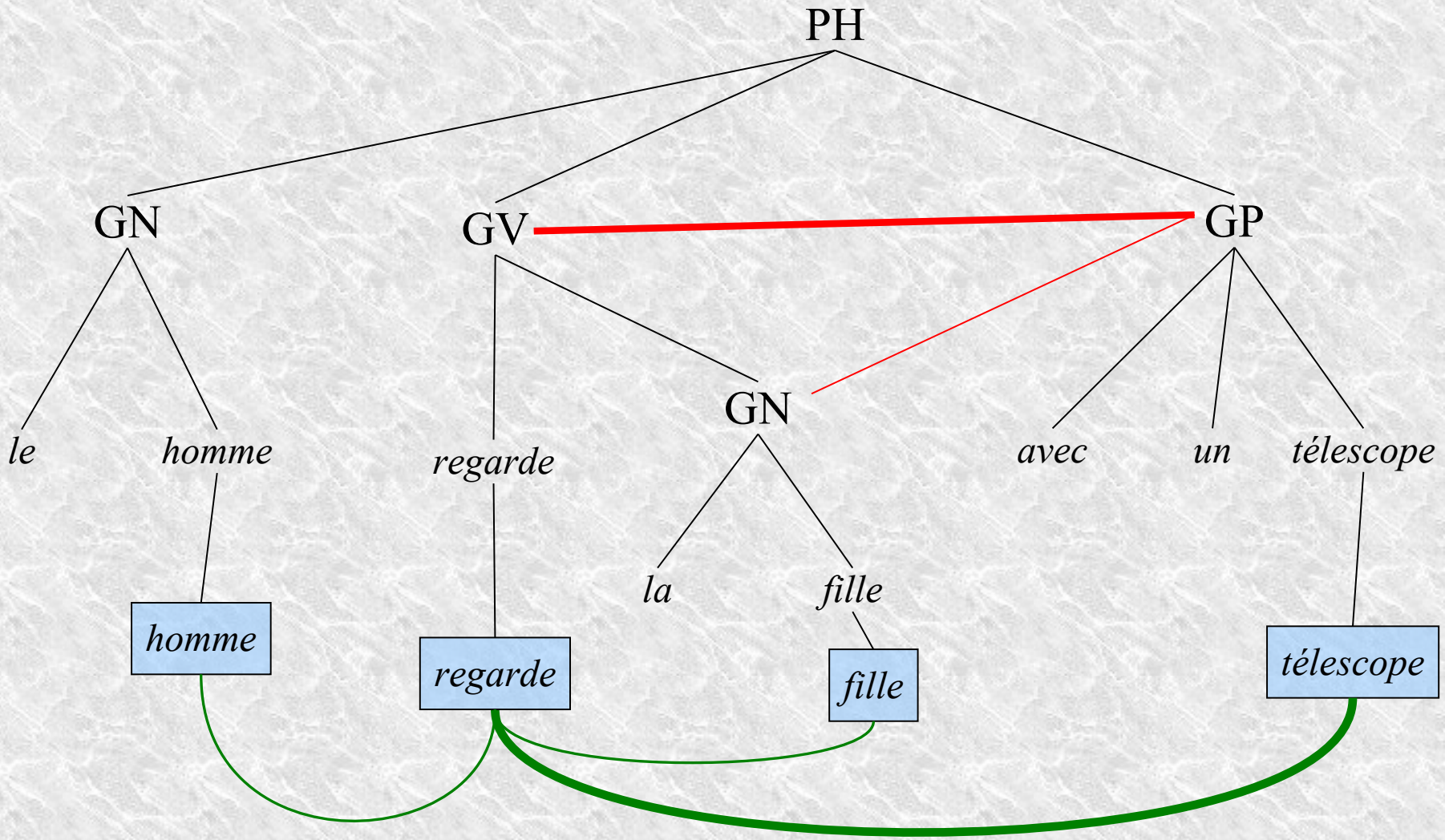
The laywer/*avocado pleads at the court/*courtyard



Ant algorithms

Simple example for attachment

The man sees (the girl with a telescope)
/ The man (sees [the girl] with a telescope)



Ant algorithms

Results for the simple approach

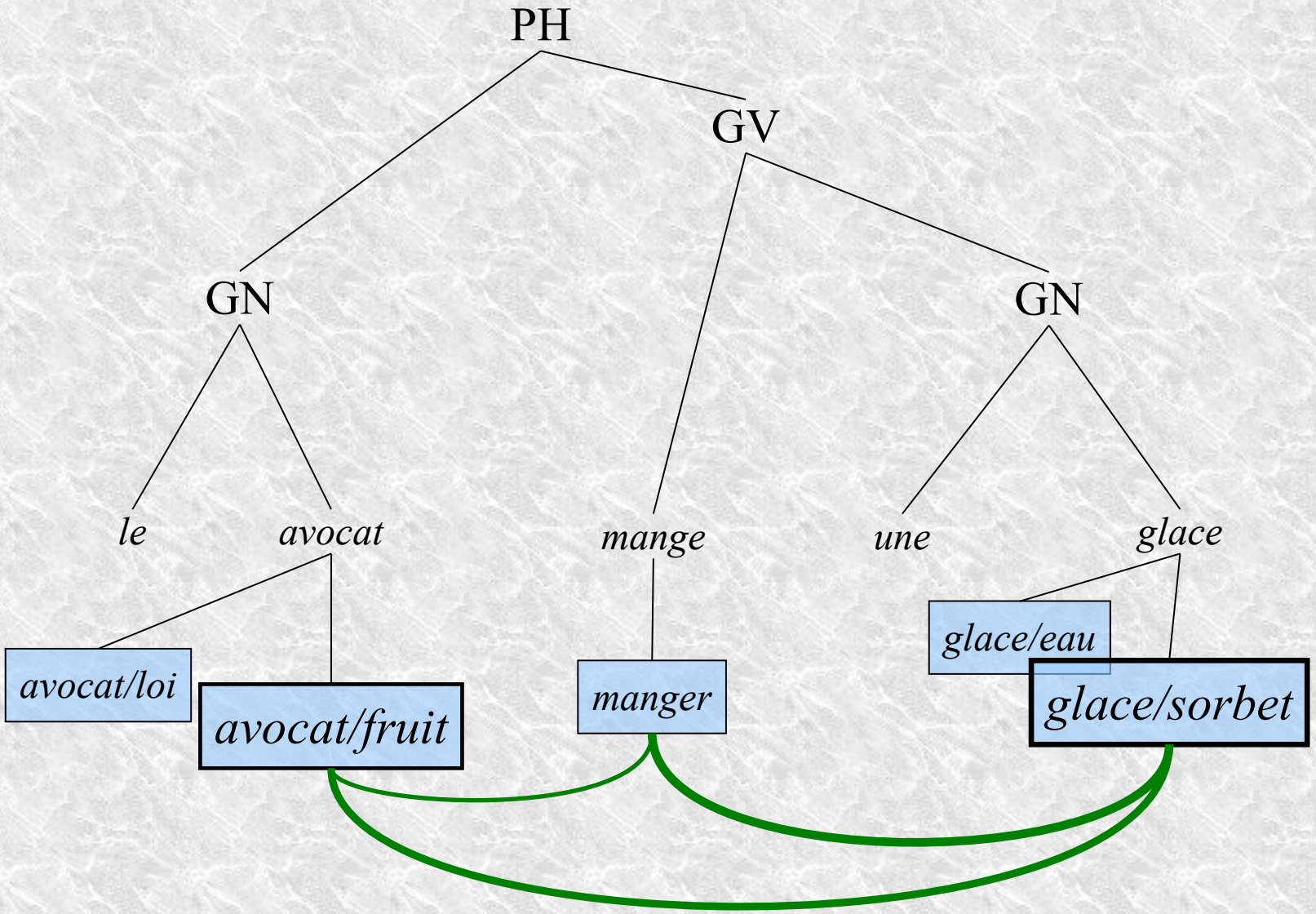
Thematic information is enough for WSD in 73% of the cases

Scoring scheme	All terms	Nouns	Adjectives	Verbs	Adverbs
Fine Grain Scoring	0.73	0.76	0.78	0.61	0.85
Coarse Grain Scoring	0.85	0.88	0.9	0.72	0.95
Base Line with POS	0.33	0.30	0.4	0.17	0.60
Base Line no POS	0.25	0.24	0.25	0.12	0.52

Room for improvement

Ant algorithms

*Simple example



Ant algorithms — Ant Caste

Ant castes

Ants with some constraints on the evaluation functions

Castes exploiting the lexical network

Predicate => agent

Prédicate => patient

Prédicate => instrument …

Local copy

Acceptions and relations of the networks

Local fusion

of nodes that seems to be identical

Ant algorithms caste Predicate => Patient

Ant caste created by a verb (predicate)

Search mode

$$Eval(N_i) = S(N_i)$$

$$Eval(A_i) = 1 - P(A_i) + \max \begin{cases} 2 & si \quad type(A_i) = patient \\ 0 & sinon \end{cases}$$

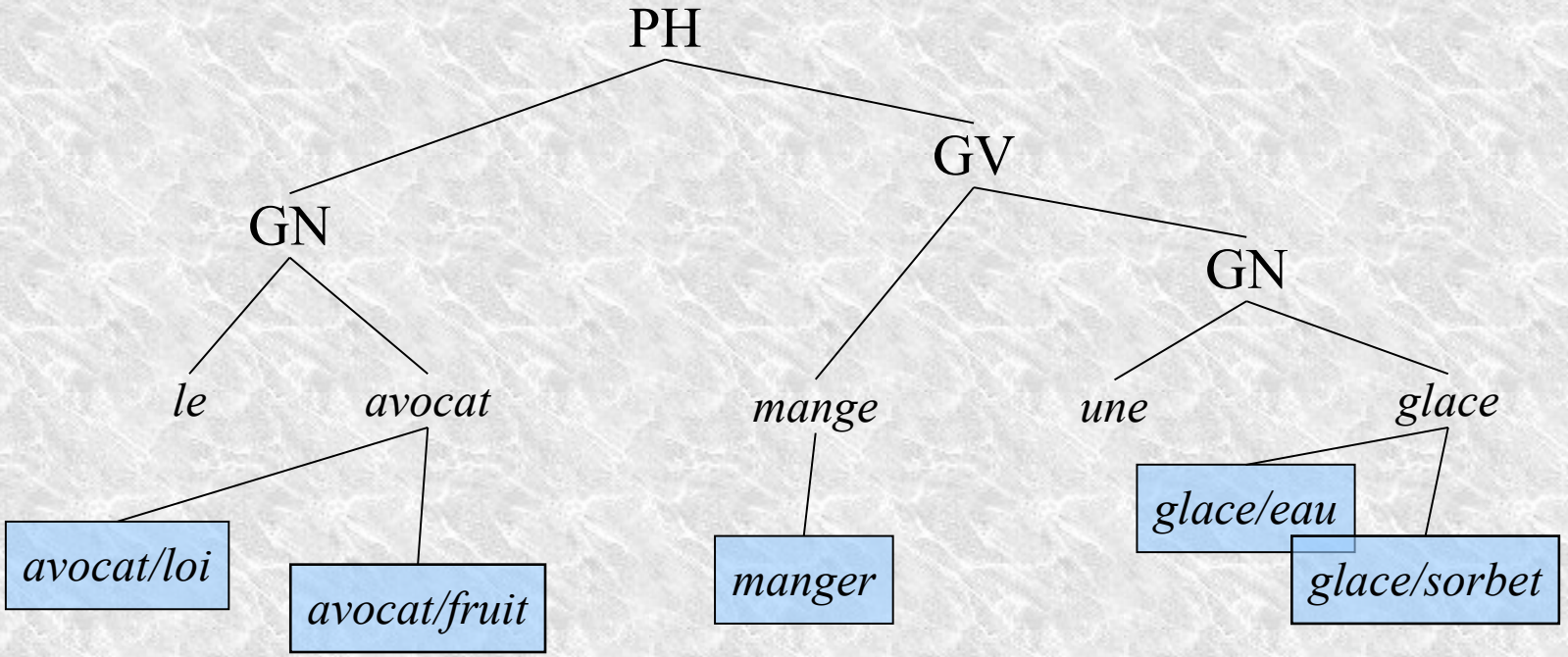
Return mode

$$Eval(N_i) = 1 - \frac{2}{\pi} D_A(V(N_i), V(f)))$$

$$Eval(A_i) = P(A_i) + \max \begin{cases} 2 & si \quad type(A_i) = patient \\ 0 & sinon \end{cases}$$

Ant algorithms

Example with lexical network



Ant algorithms

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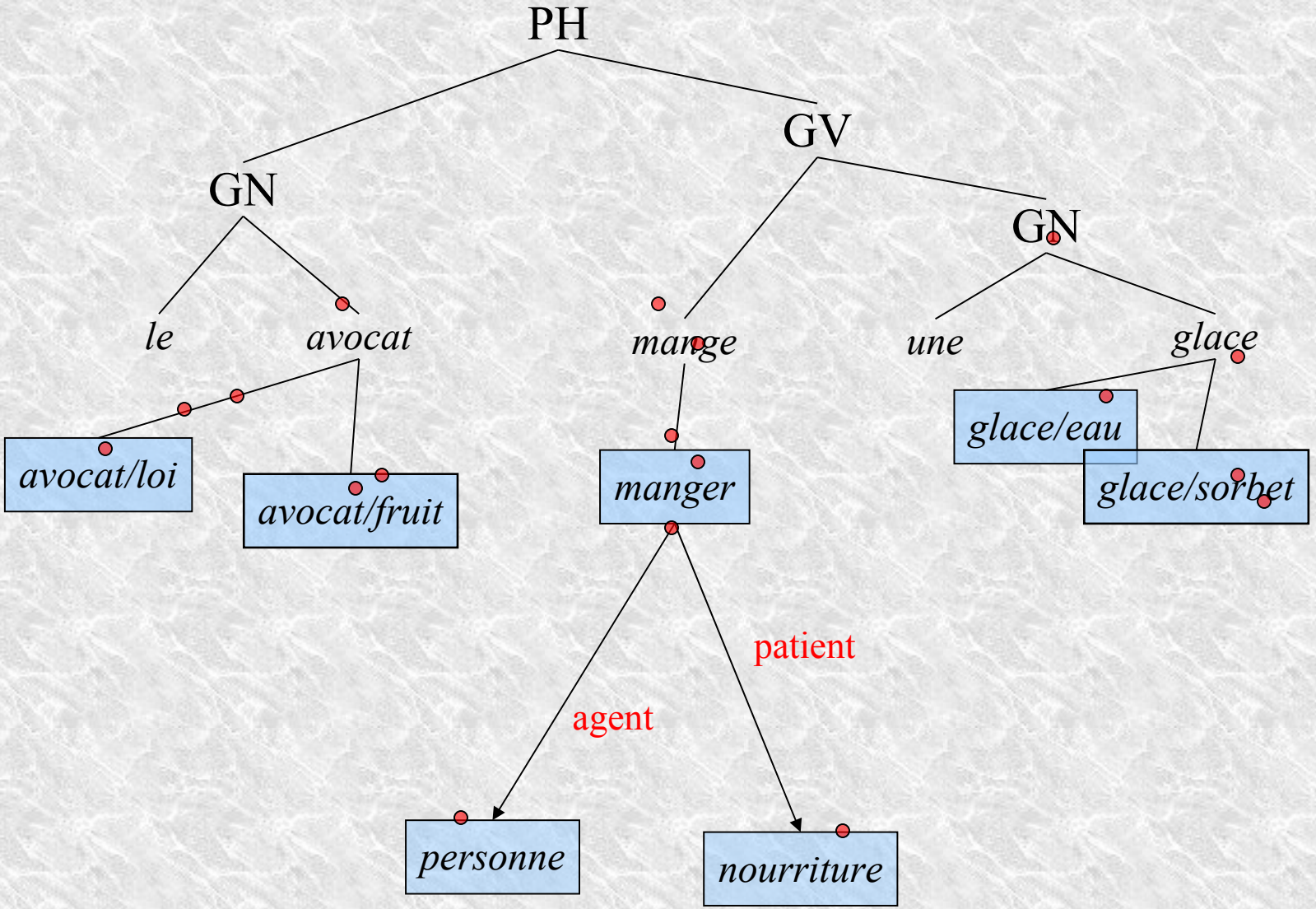

Ant algorithms

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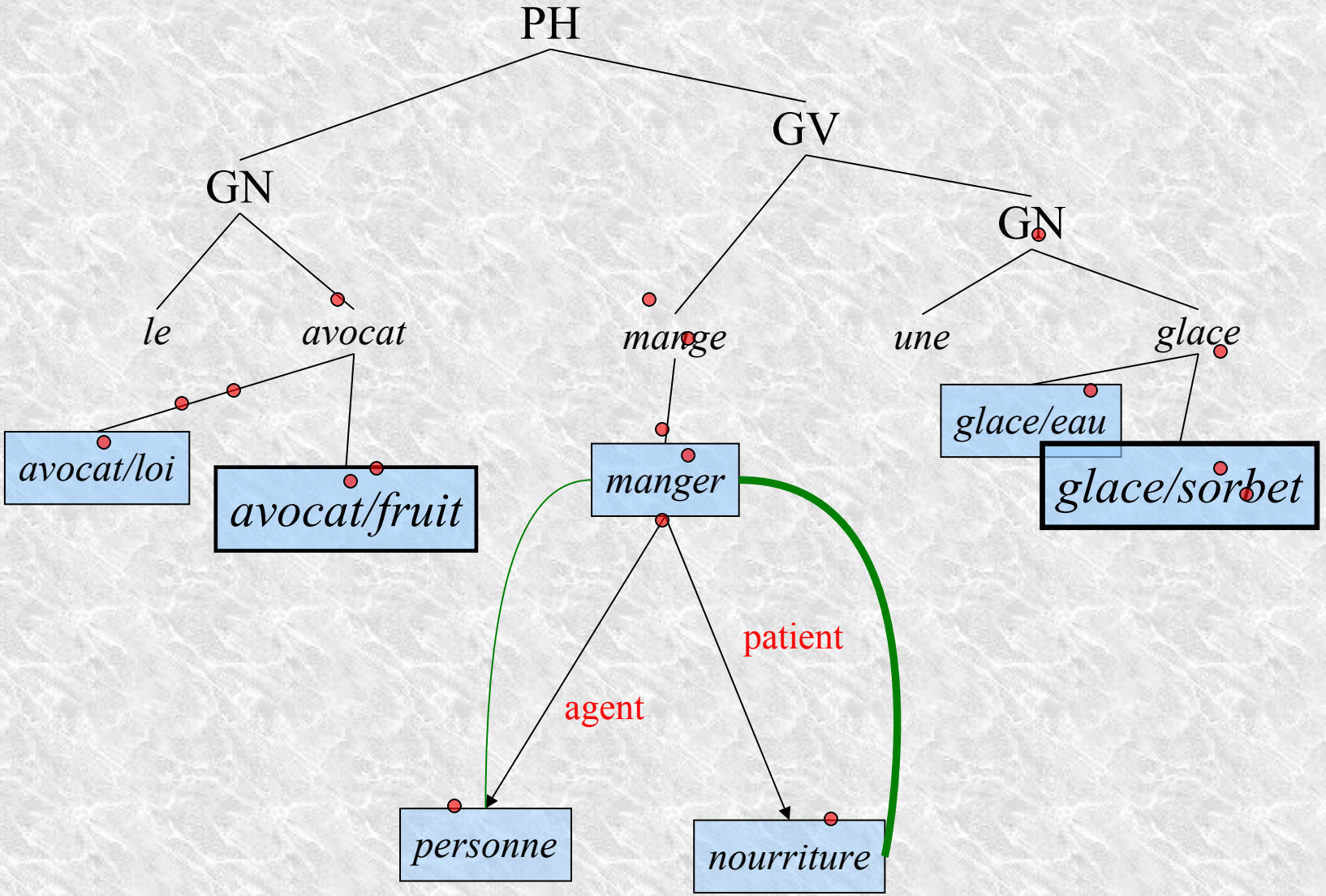

Ant algorithms

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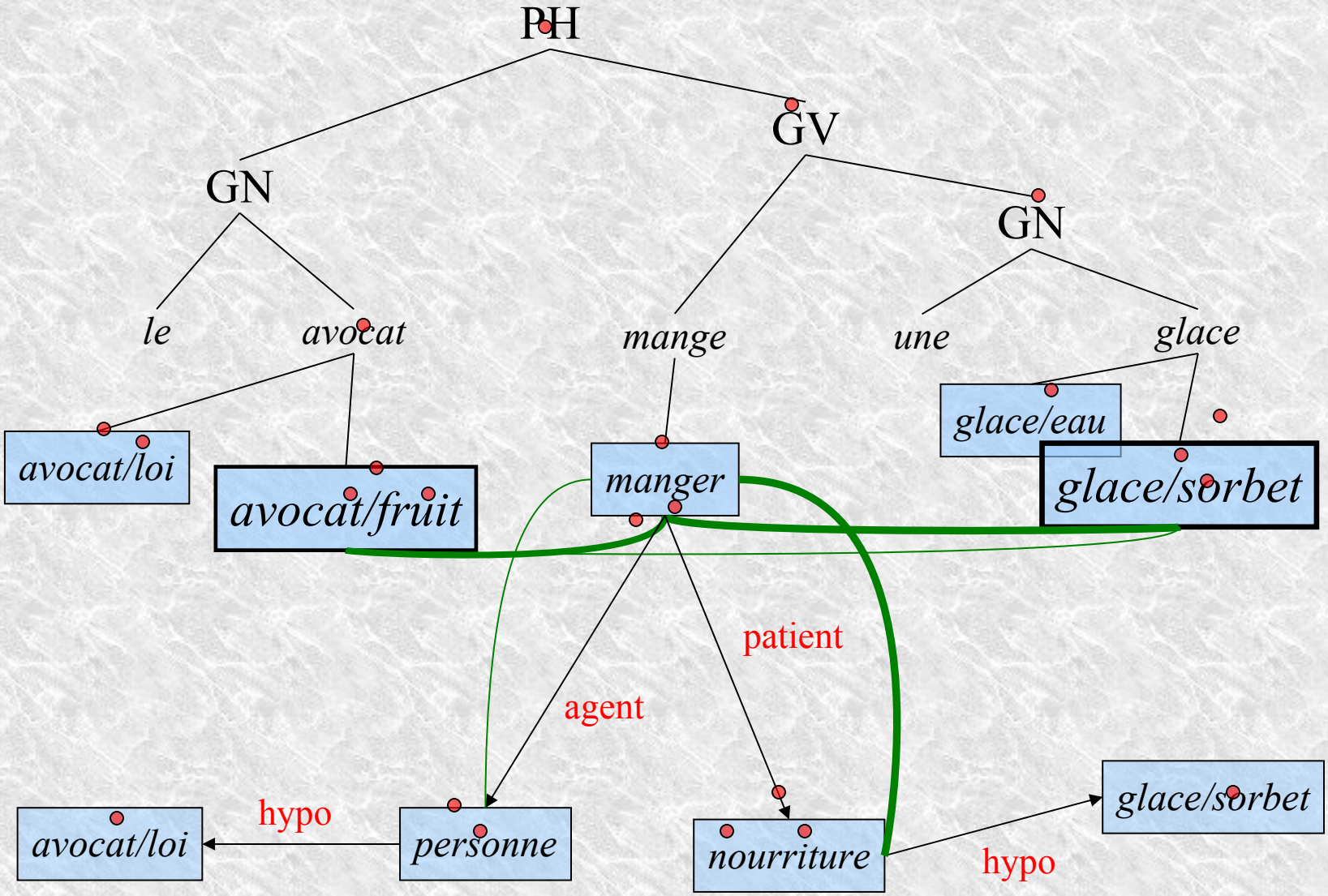

Ant algorithms

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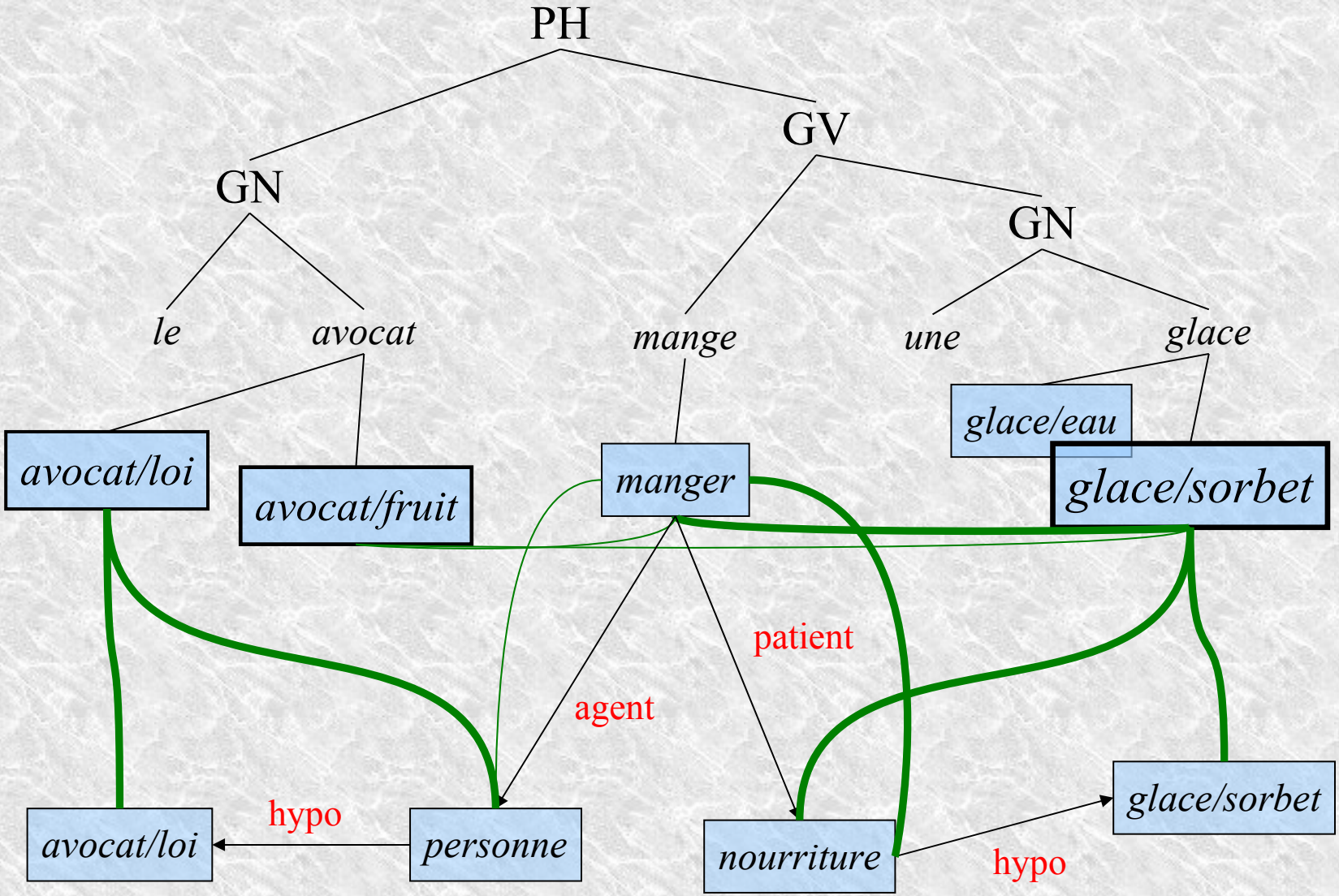
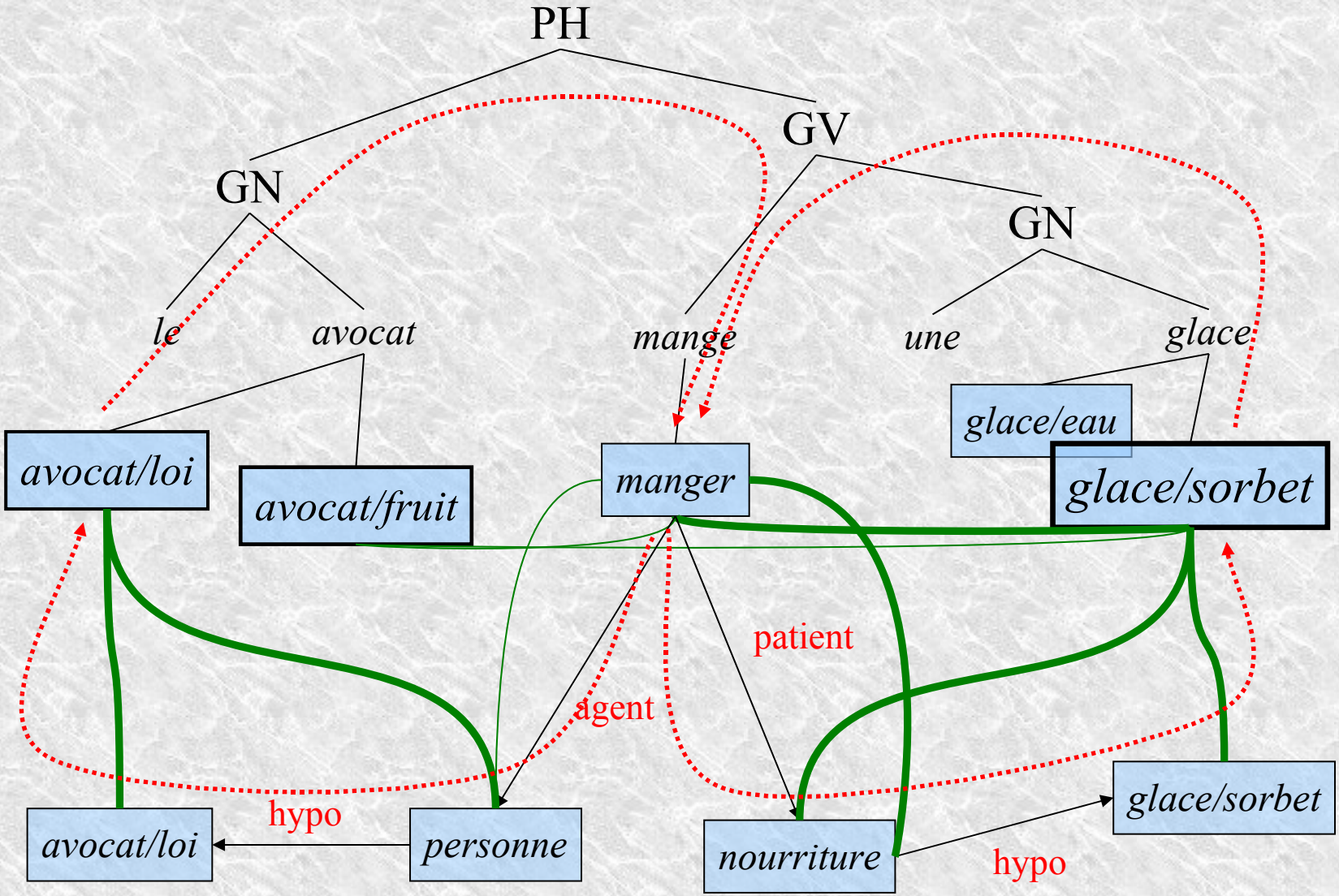


Ant algorithms

Example with lexical network



Ant algorithms

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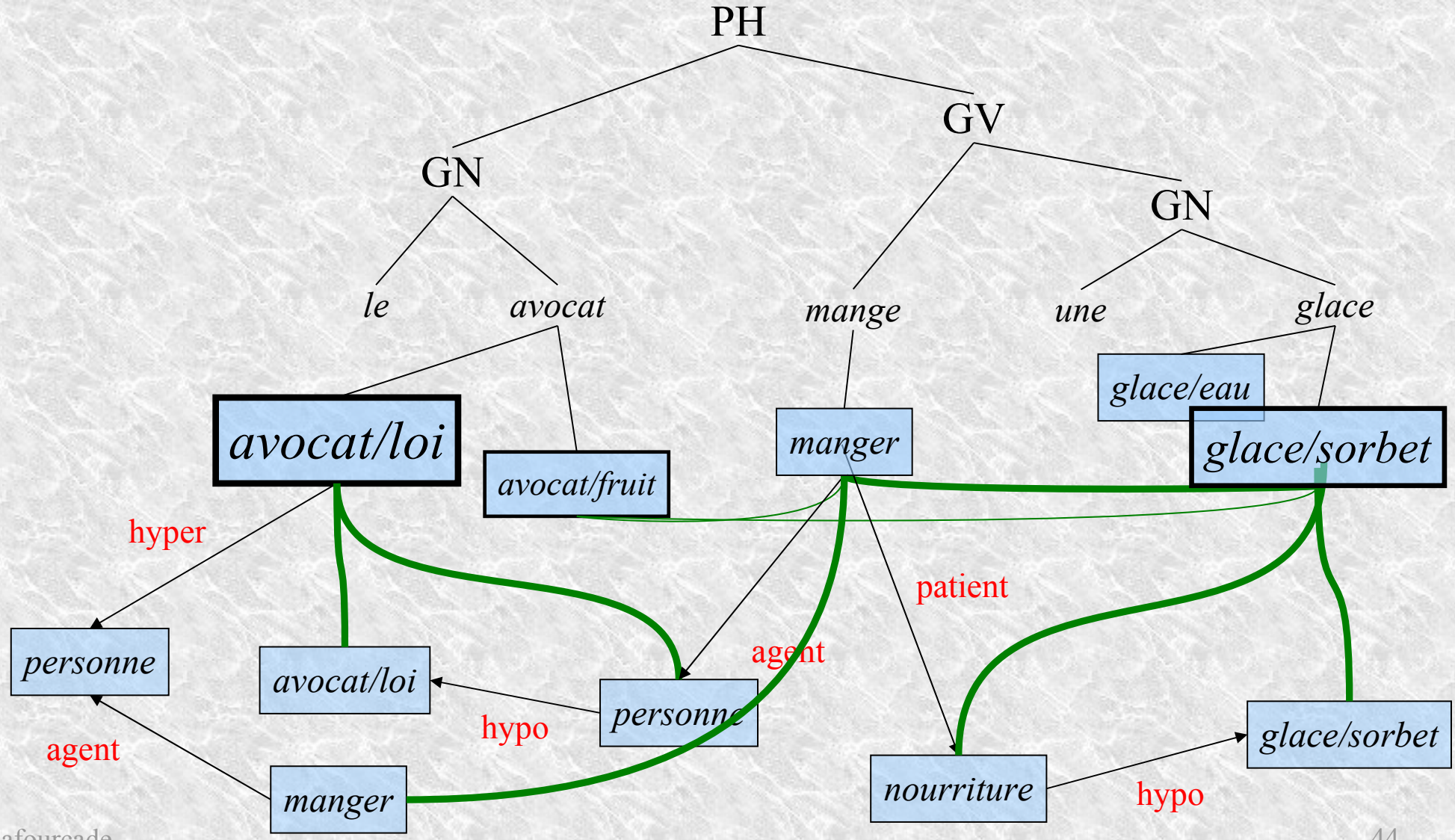
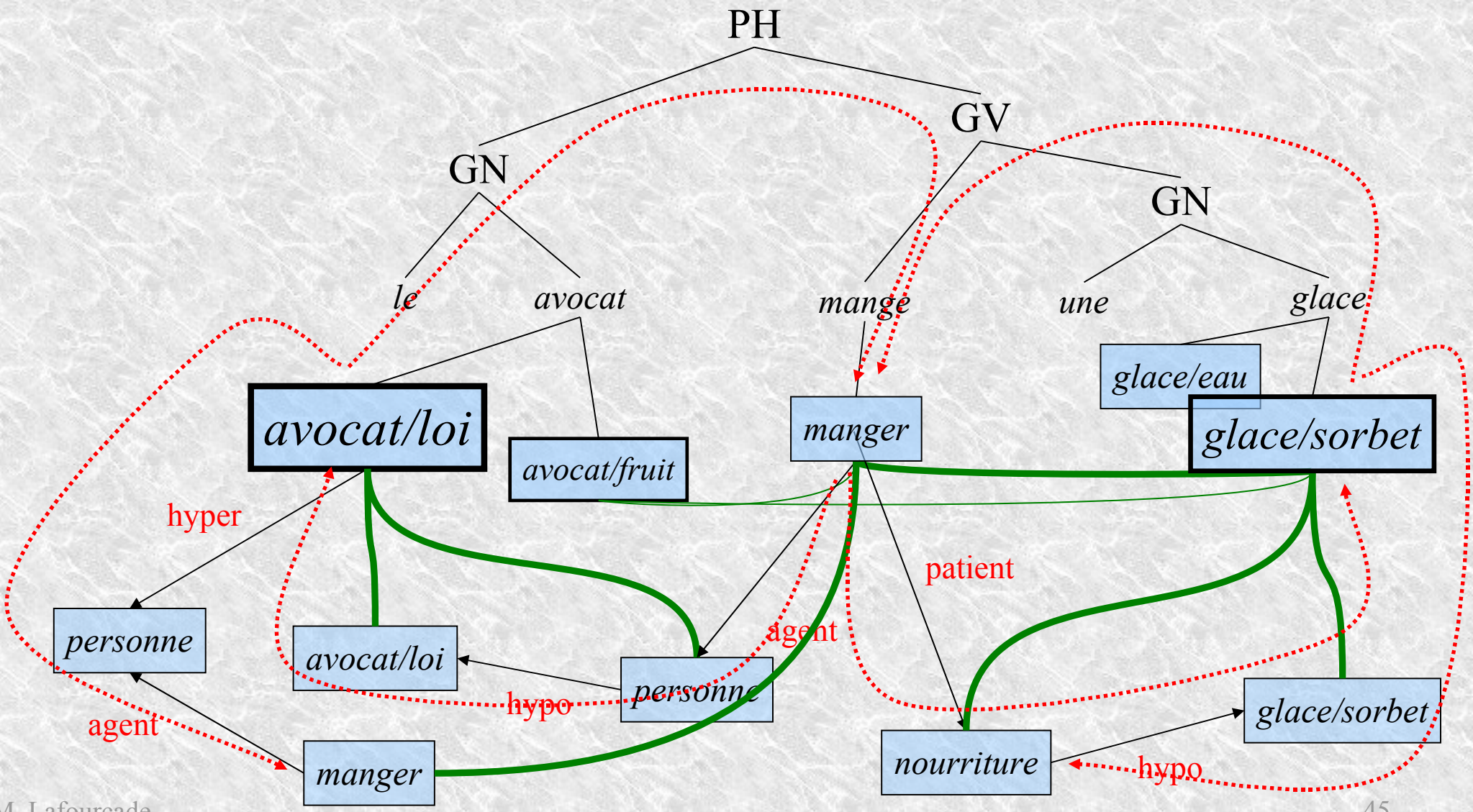


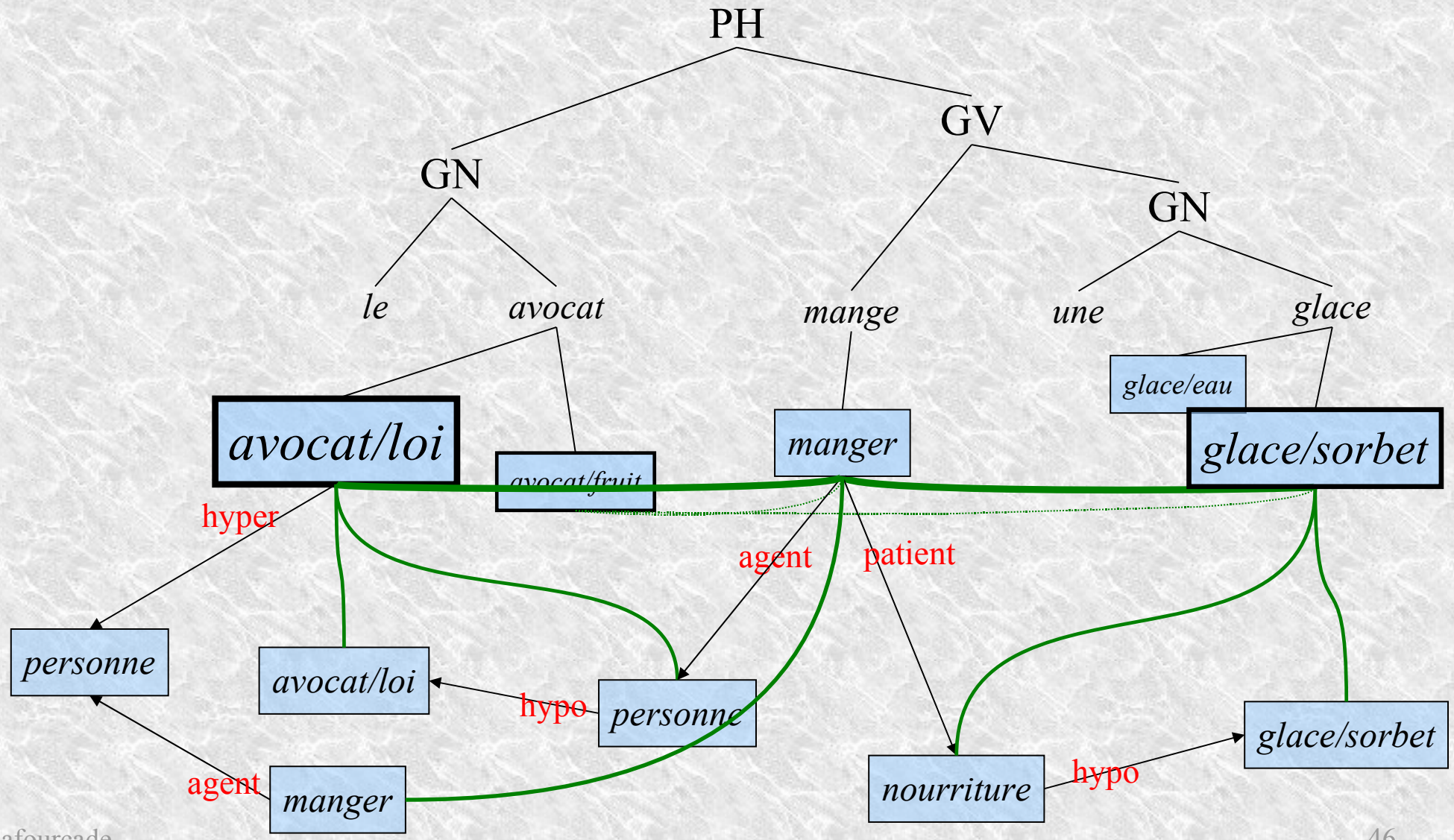
Ant algorithms

Example with lexical network



Ant algorithms

Example with lexical network



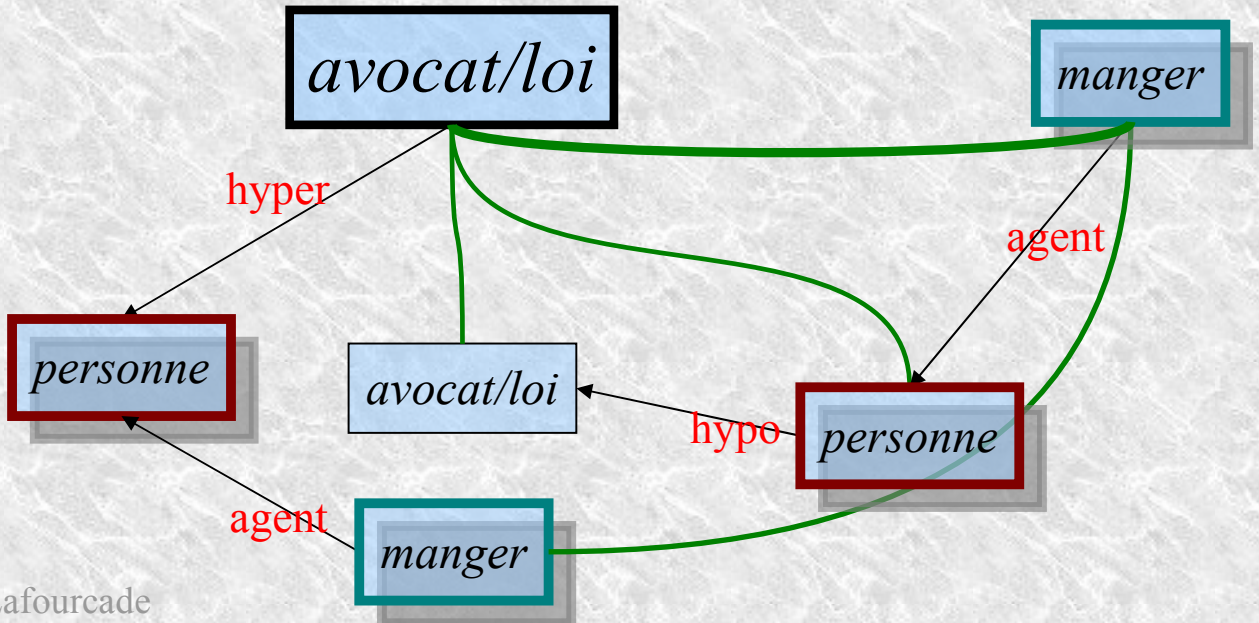
Lexical Network — Node fusion

Node fusion between identical nodes

same label (simplified view here)

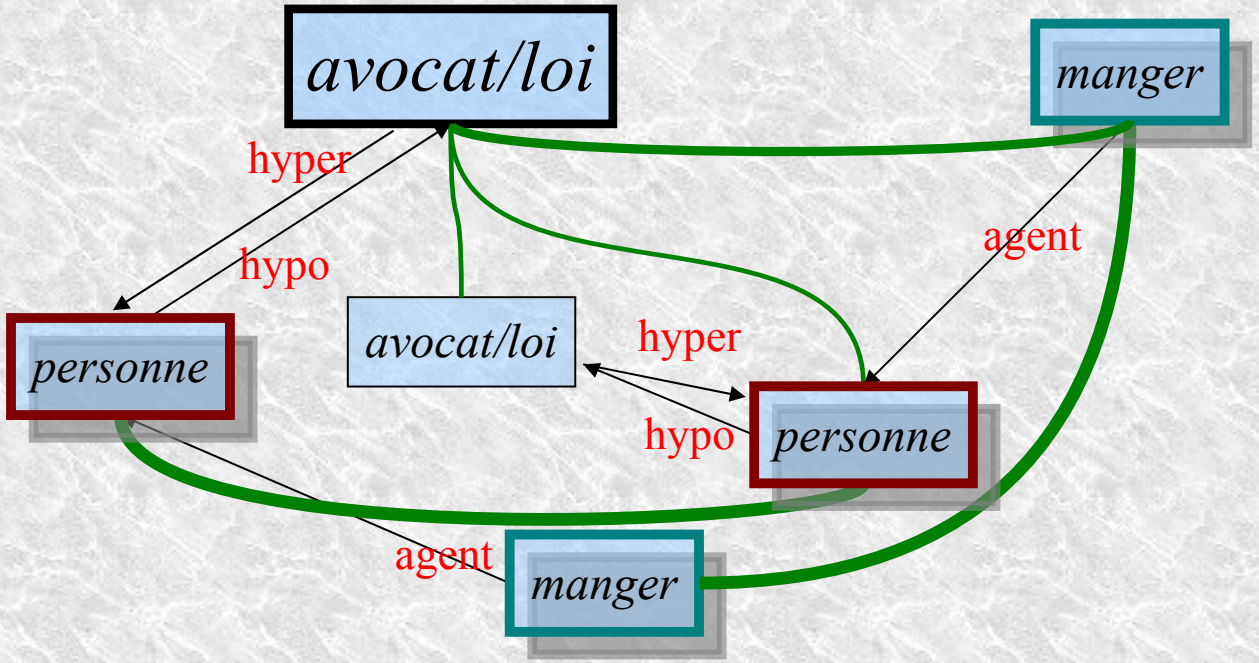
... if they are not too far

... if they are similar regarding their relations



Lexical Network

Node fusion



Lexical Network

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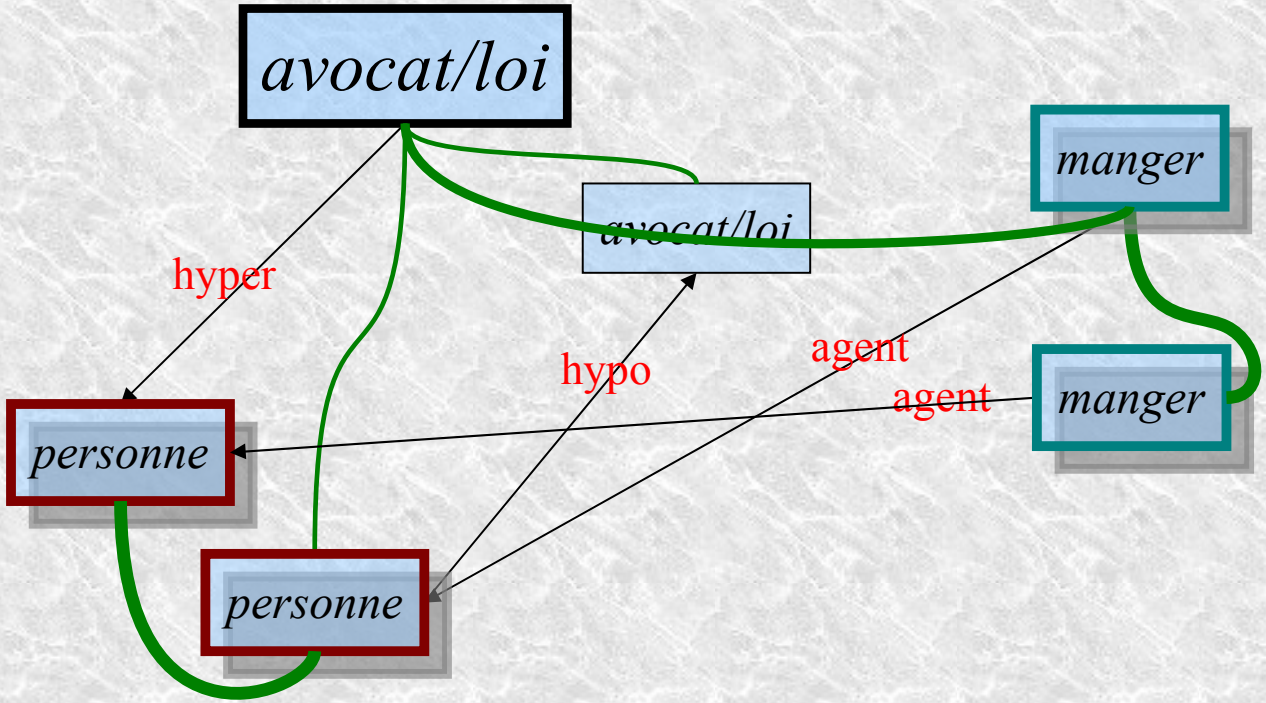
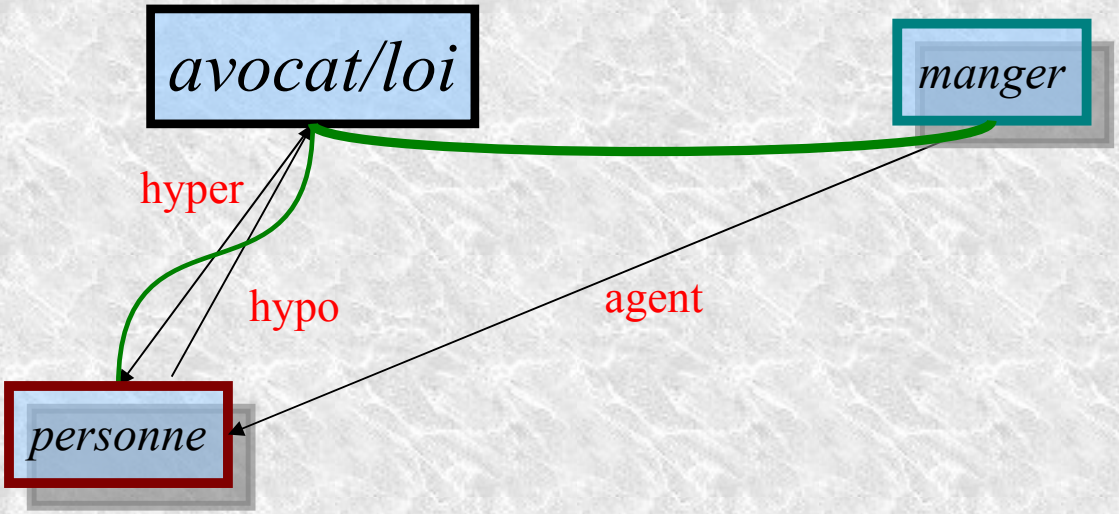


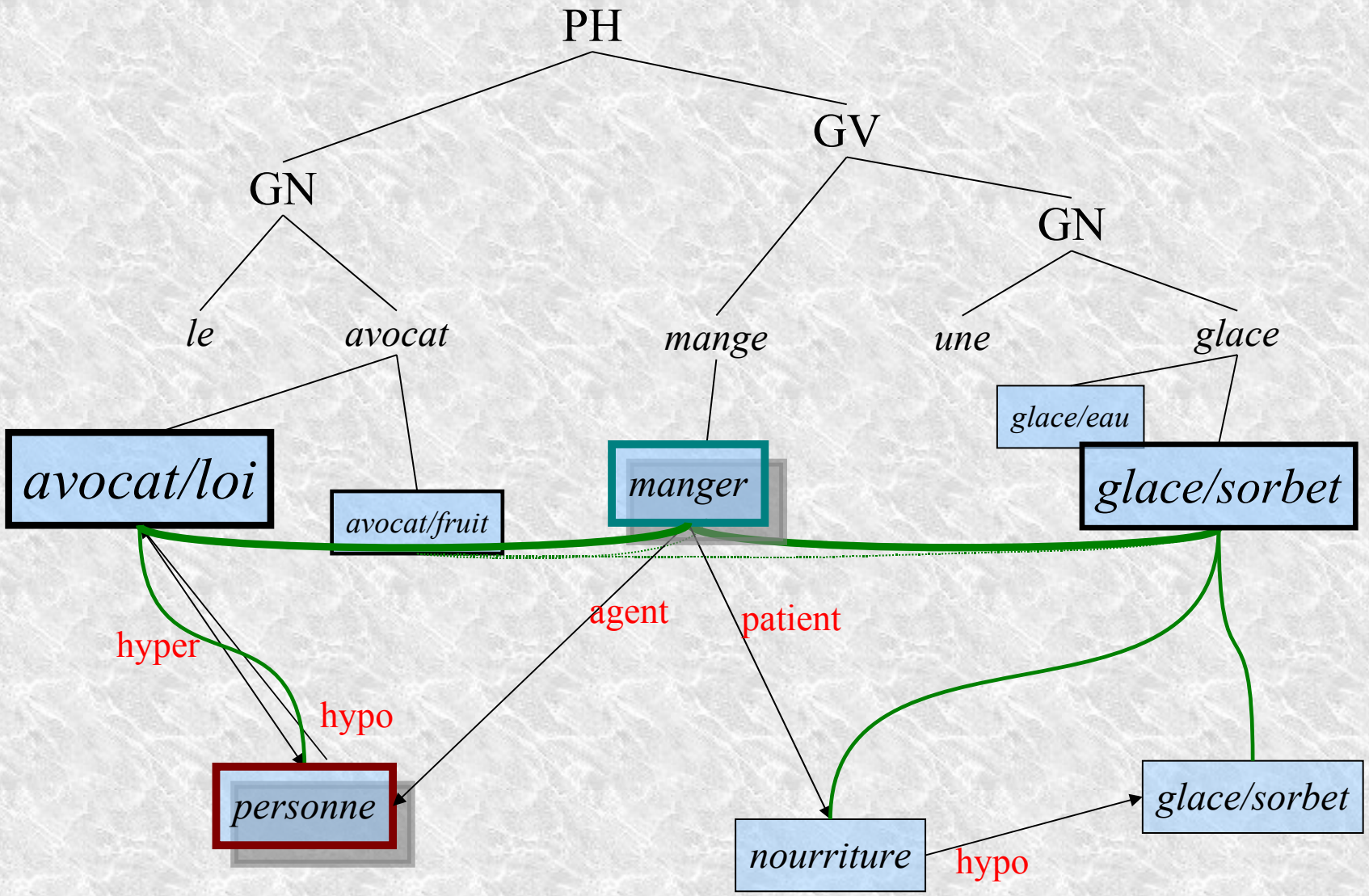
Lexical Network

Node fusion



Ant algorithm

Finally...



Adding a lexical network with

hyponym/hyperonym
part-of/whole-of
agent/patient/instrument
typical location

leads to proper WSD in 87% of the cases

Still room for improvement

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Lexical Network Construction

Hand made

WordNet – EurowordNet – HowNet

=> precise but not much recall

=> normative

Automatic Extraction

... (many)

=> many errors mainly due to polysemy
and bad relation identification

There is room for improvement

Lexical Network Construction

http://www.lirmm.fr/jeuxdemots

There is room for education

Conceptual Vectors Construction

With a given set of concepts (Thesaurus Larousse – Roget – ...)

=> problem of lexical density

From human usage dictionary, thesaurii, ...

=> problem of WSD and word relation identification

=> problem of saliency

Give up set of concepts => ask only for the set size
Use more explicit ressources => lexical network

Conceptual Vectors Construction

Emergence - infinite iteration through the lexical network nodes

Step 1 – Agglomeration

Spring attraction model

V(N) = Weighted means of neighbour vectors v_i

If $v_i = 0$ then v_i = random

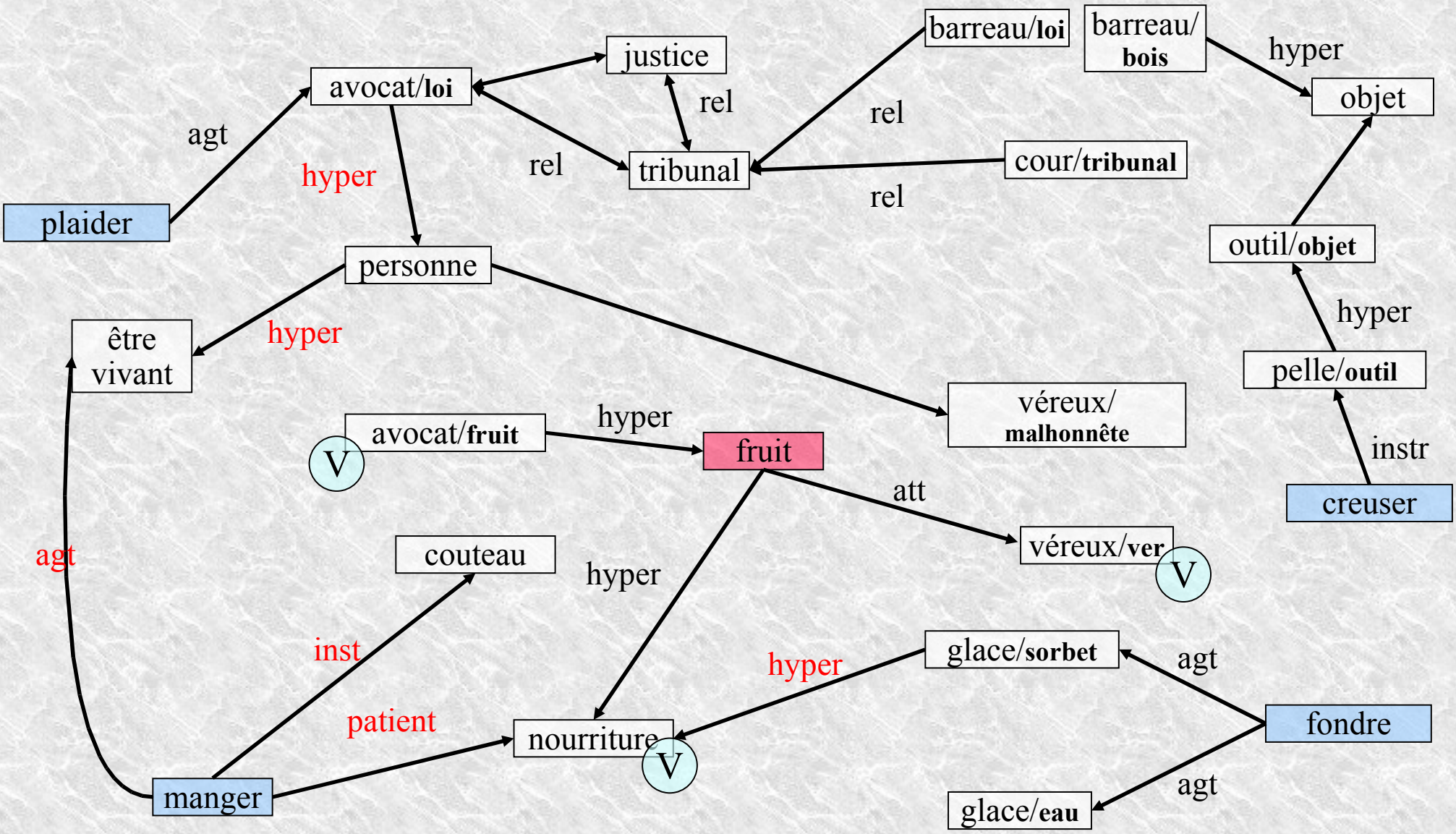
Step 2 – Separation

Repulsive particular model

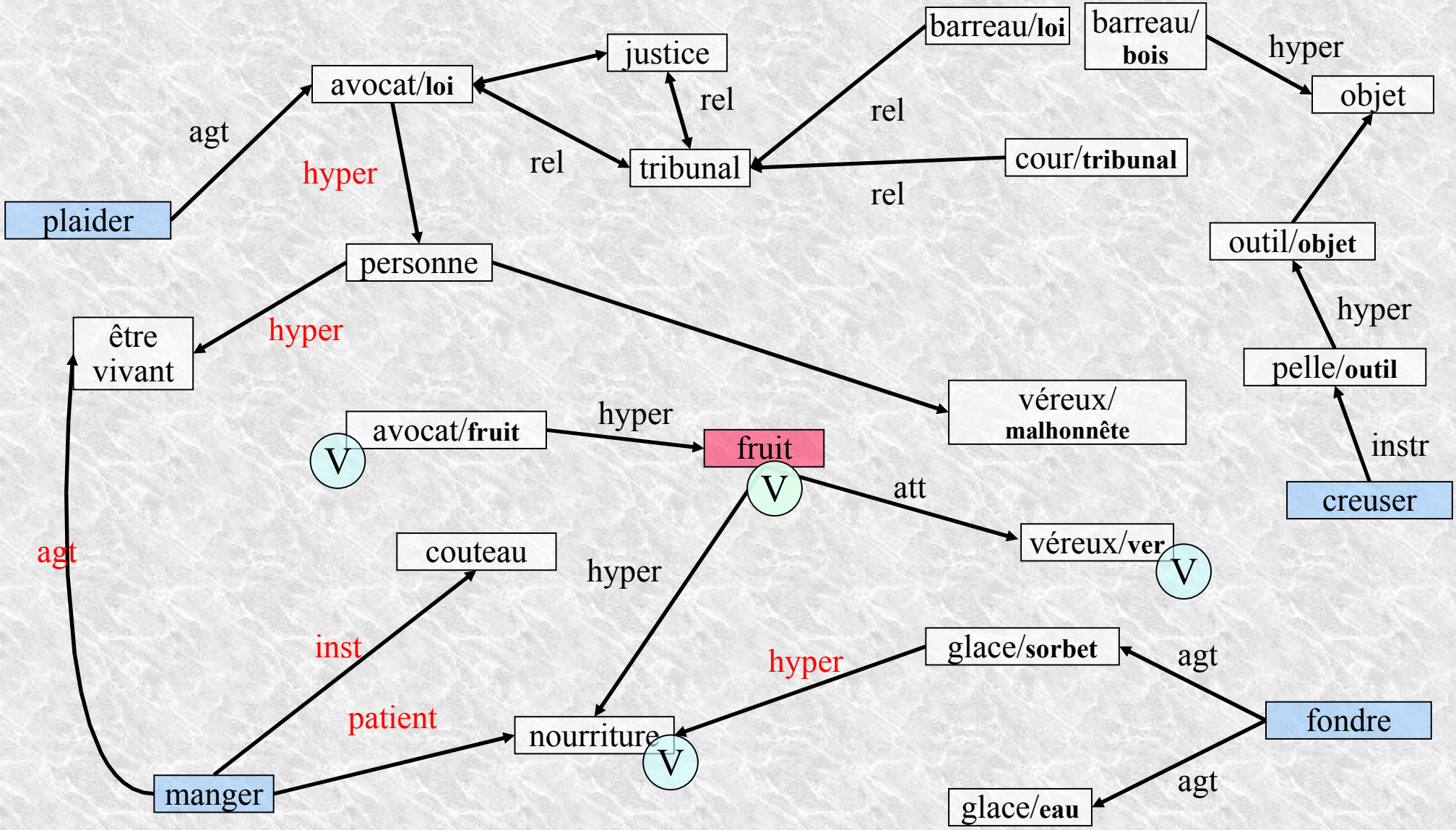
Select k closest neighbours according to D_A

Compute and apply a repulsive vector with a $1/d^2$ rule

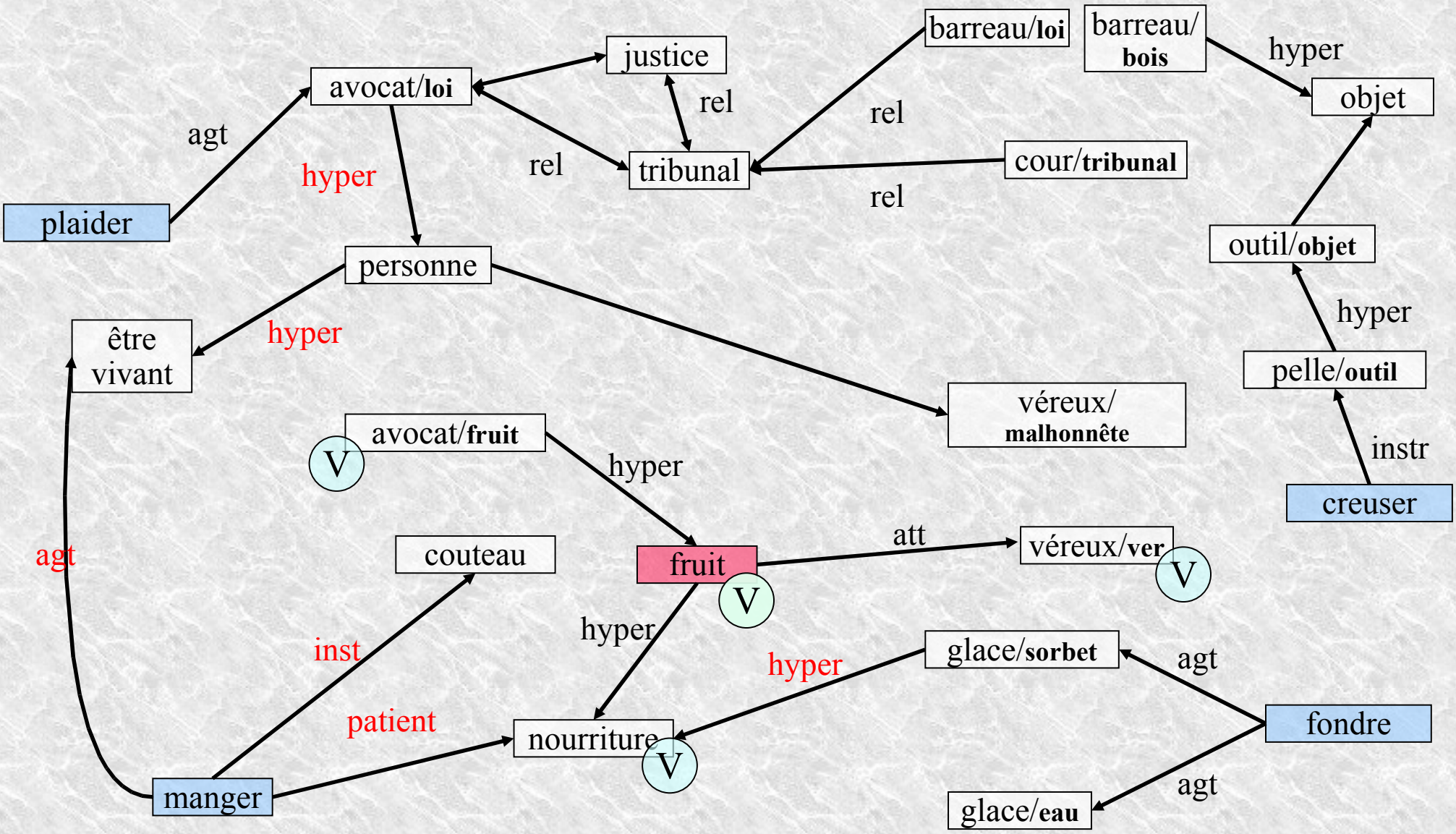
Conceptual Vectors Construction



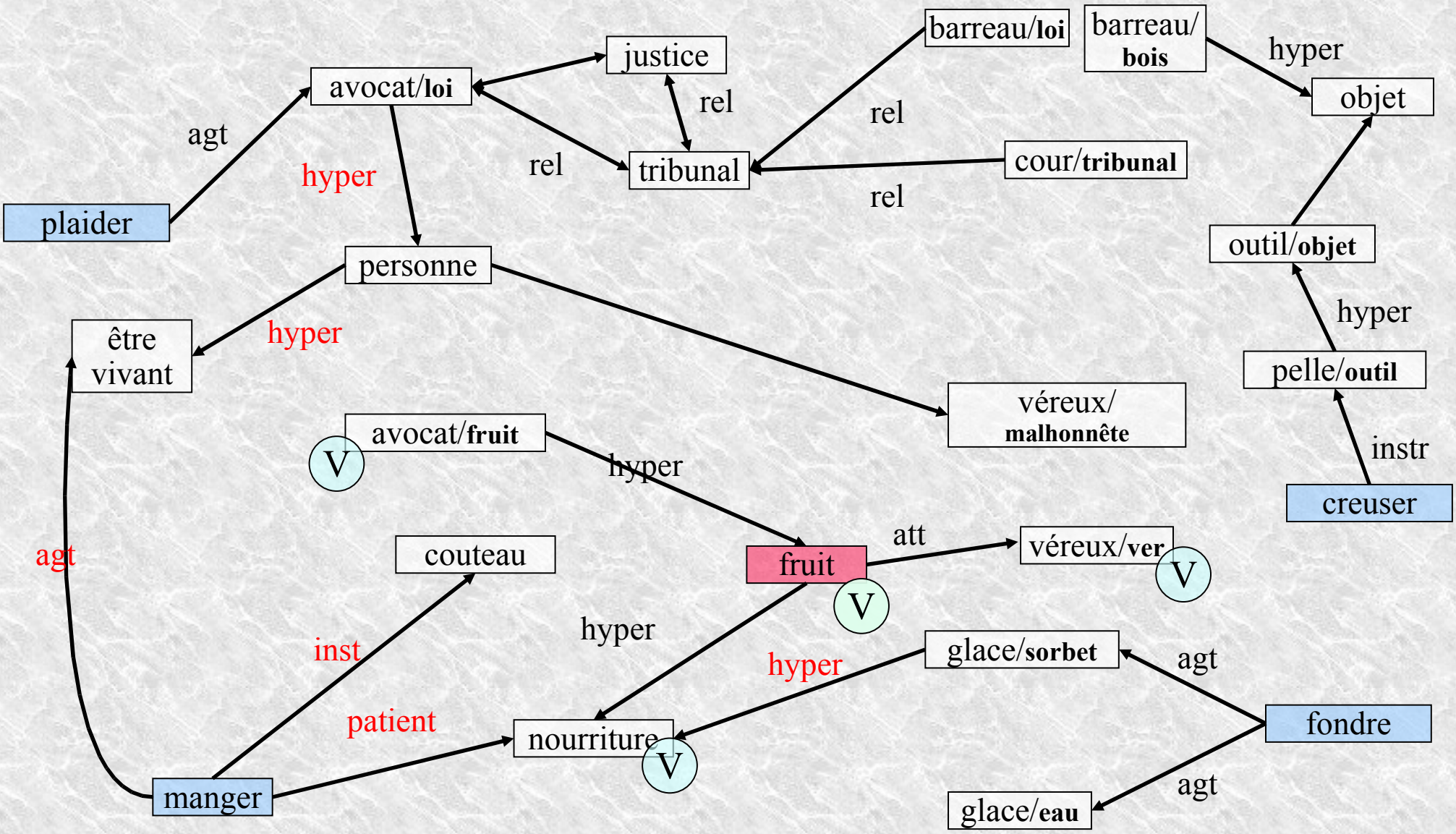
Conceptual Vectors Construction



Conceptual Vectors Construction



Conceptual Vectors Construction



Ant algorithm More...

Production ratio between ant castes

Adjustment through rewards => increase if successfully
=> decrease toward equiprobability with time

Self termination

Internal factors (≠ simulated annealing)

«freezing ants» - narrow the gap between min and max of pheromones on a given arc

Produced when a stability is perceived locally => contamination

Inhibition

«killing ants» - alert pheromone –
kill foe ant, compromising the durability of their anthill

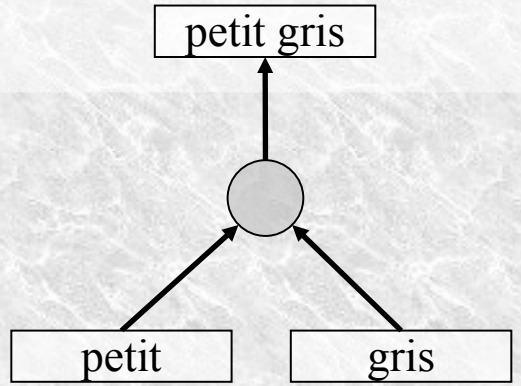
Outline

Semantic Analysis	What to look at? – Applications
Casting	Conceptual Vectors – Analysis Trees – Lexical Network
Ant algorithm	Principles - Without lexical network - With lexical network
Ressource Production	Lexical Network - Conceptual Vectors
Future directions	Toward holistic analysis: syntax + semantic

Future directions

Taking into account frequent schemas

Prepositional phrase attachment [gala, lafourcade]



Acceptation distribution

over the general domain

over a specific domain

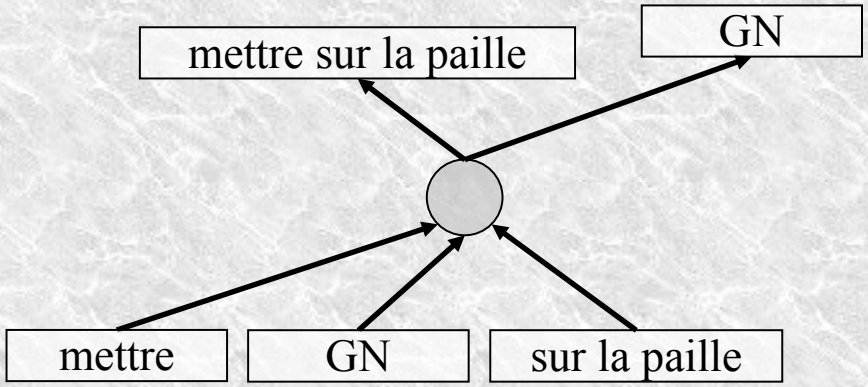
a squirrel – a paintbrush
a mushroom
a snail
a commuter train

Frequency for conpound terms meanings

petit gris - serpent de mer - ...

Frequency for locution meanings

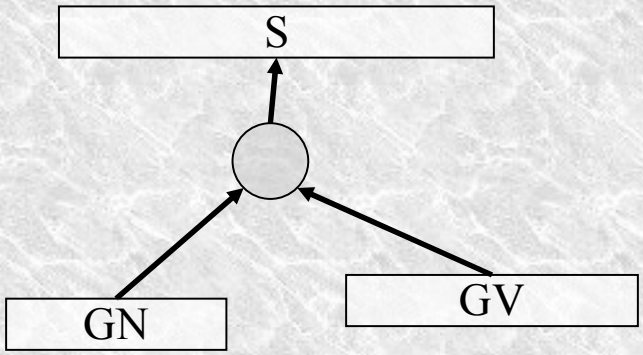
mettre *x* sur la paille

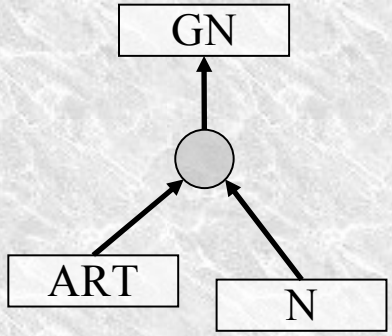


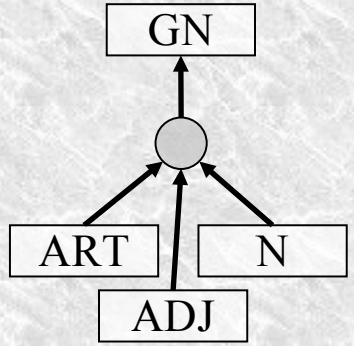
to ruin/bankrupt x
to put x on the hay

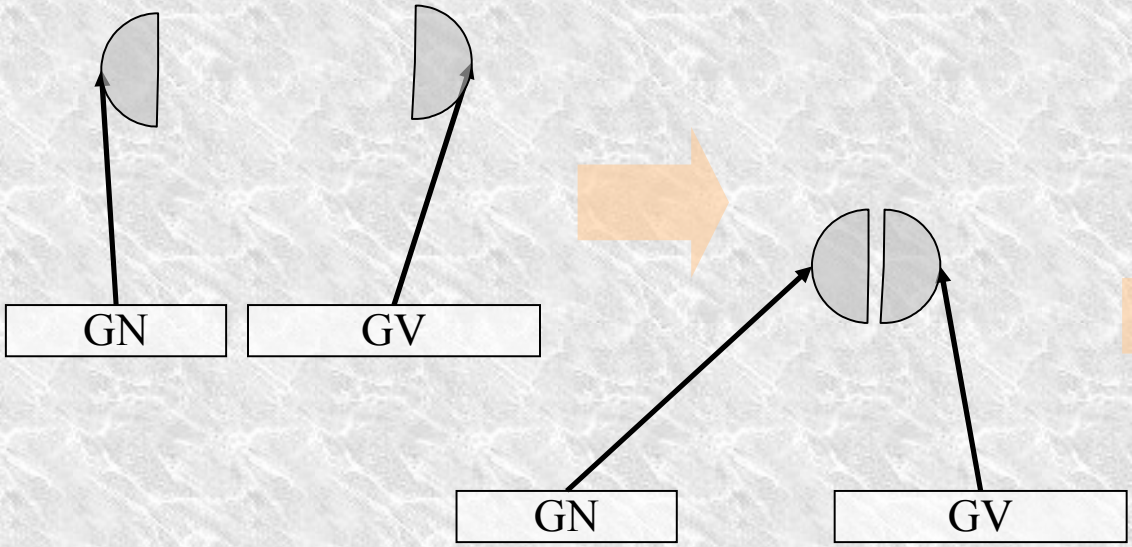
Future directions holistic analysis

Syntactic schemas in the lexical network









Future directions holistic analysis

All nodes

- produce information
- request information
- Produce agents for these tasks

Information

- Deduced from the lexical network
- Symbolic (MAS, SING, V, GV, ...)
- Vectors (different types according to network relation labels)

Ants as agents

- Information carriers
- Structure builders

Conclusion

Holistic analysis

<= what is important and when?

Emergence of some solutions through errors

<= perfect ants would produce nothing

Coordination problem facilitated

<= no central control but population control

Generic and extensible architecture

<= adding new information type is (relatively) easy

Tuning is difficult => can be assessed through experiment