Extracting Facets from Lost Fine-grained Categorizations in Dataspaces

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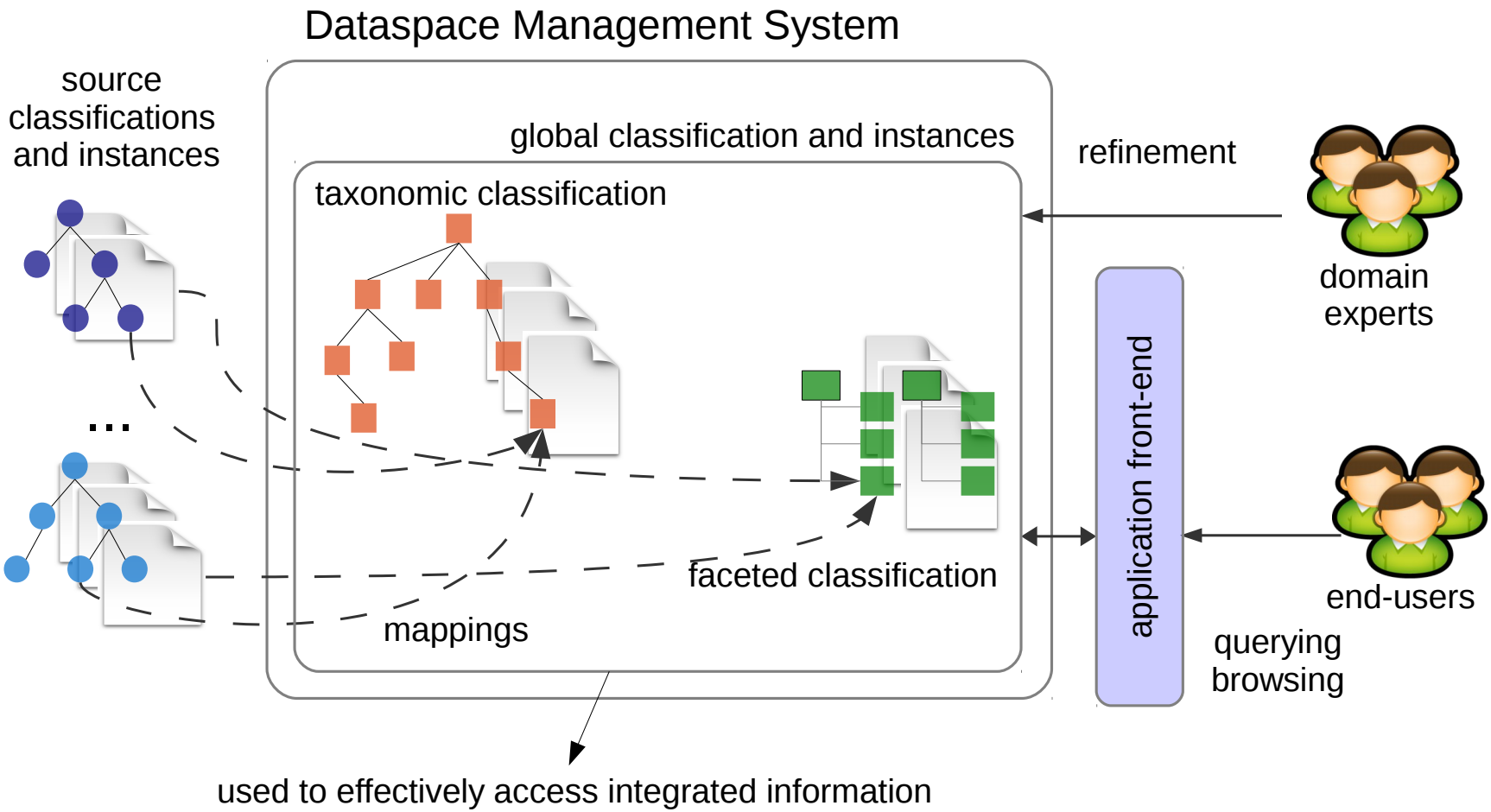
Dataspaces with Multiple Classifications



Taxonomy-based Classification in Price Comparison Engines

Taxonomy: categories organized through a hierarchical structure *(informal)*

Home Page › Giochi e Hobby › Videogiochi › Videogiochi per Console › Videogiochi per PS3

coarse-grained classification helps end-users to recall the "class" of instances

Filtra la ricerca

PREZZO

€ 4,7 - € 1550

MARCA

- Sony (428)
- Electronic Arts (402)
- Activision (262)
- Ubisoft Entertainment (204)
- 2K Games (102)
- Altri(e)...

GENERE

- Azione (1502)
- Sparare (541)
- Sparare in prima persona (FPS) (352)
- Sportivo (332)
- Altro (209)
- Altri(e)...

ETÀ RACCOMANDATA (PEGI)

- 3+ (394)
- 7+ (1...

Risultati: **6025**

Electronic Arts FIFA 14

Scheda tecnica

Videogioco per Sony PlayStation 3, g
ambientazione: realistico. Classificaz

Aggiungi a confronto

Aggiungi a una lista

Rockstar Grand Theft Auto V

Scheda tecnica

Videogioco per Sony PlayStation 3, g
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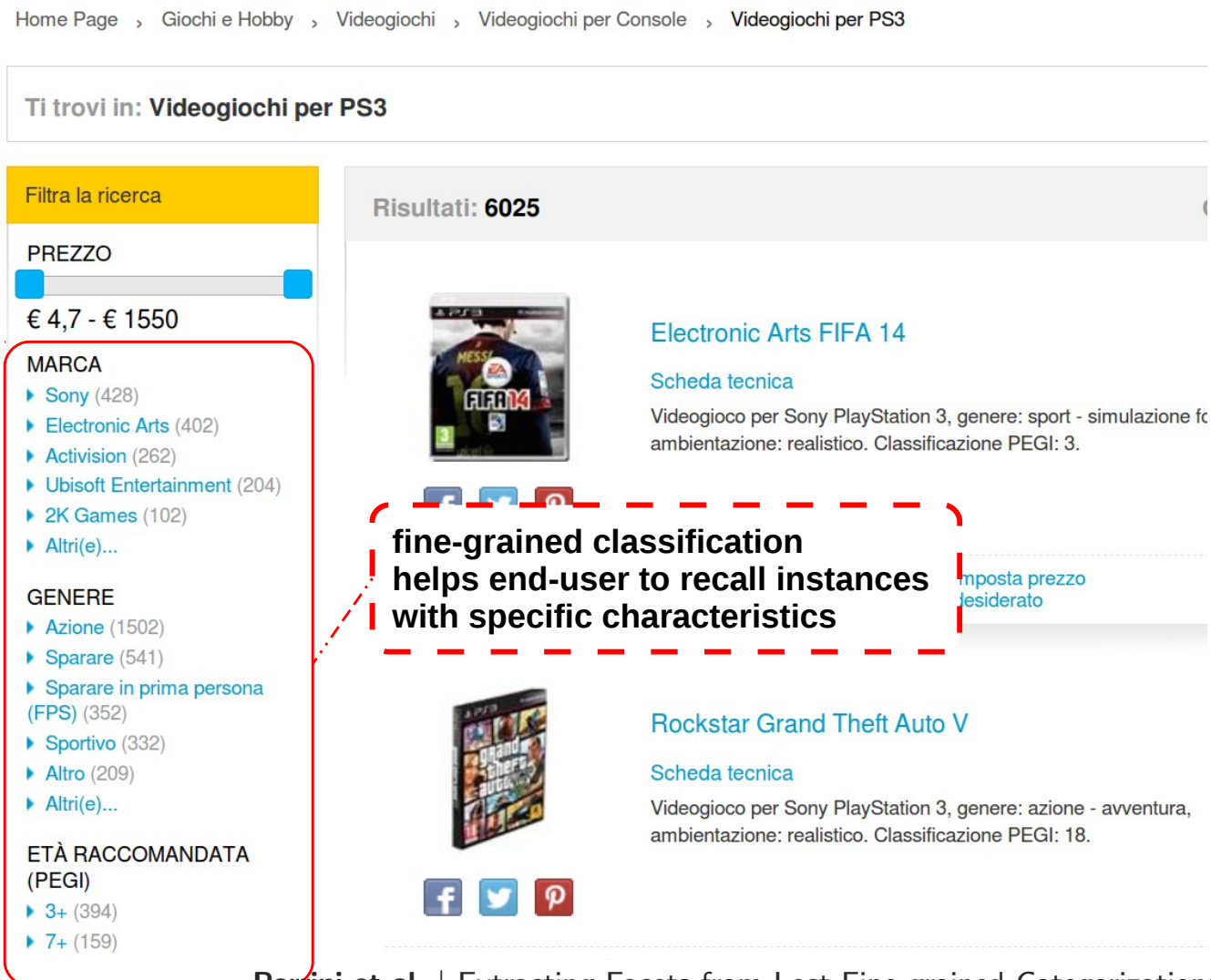
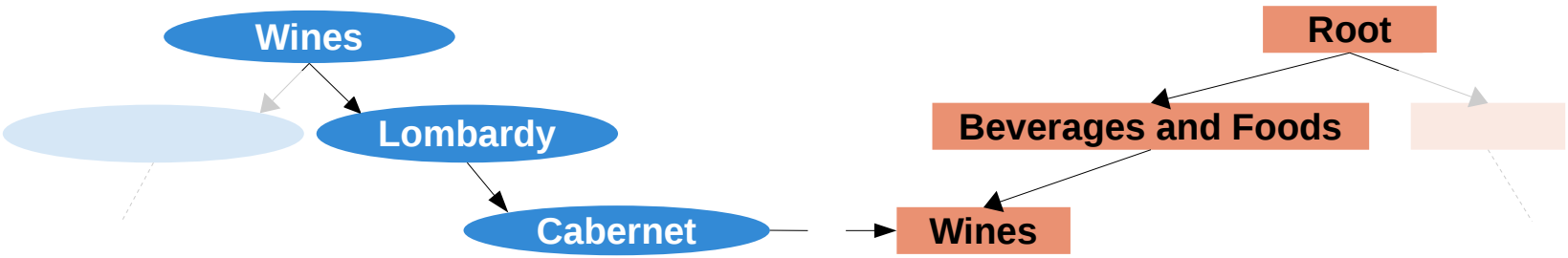
Facet-based Classification in Price Comparison Engines

Facet: a clearly defined, mutually exclusive, and collectively exhaustive aspect, property, or characteristic of a class or specific subject [Ta04]



Mappings

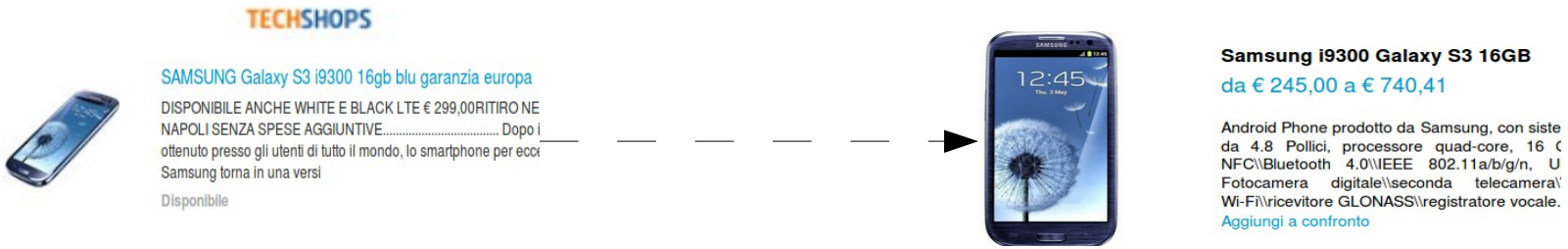
category mapping



source taxonomy

global taxonomy

instance mapping



source instance

global instance

Motivation

Faceted classification bootstrapping

- time and effort consuming
- requires detailed knowledge about dataspace instances

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- source taxonomies usually provide much more granular classification
- this granular information is lost when mapping specific source categories to generic global ones

How about extracting facets from those lost fine-grained source taxonomies?

Problem Statement

Facet F^g

a finite set of values $v_1, \ldots, v_n$ associated with a label used to describe a characteristic of the objects belonging to a global category g

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given a global leaf category g, a set of mappings M from source categories $s_1, \ldots, s_n$ to g in the form $g \leftarrow s_1, \ldots, g \leftarrow s_n$, extract a set $\mathcal{F}^g$ of facets F^g , each one associated with a label

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Wines

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Wines

Winery Country of Origin

- USA
- China
- Australia
- Italy

Wine Alcohol By Volume

- ☐ Under 10%
- ☐ 10% to 12%
- ☐ 12% to 14%
- ☐ 14% & Up

Grape Variety

- ☐ Blend - White
- ☐ Blend - Other
- ☐ Fruit
- ☐ Muscadine
- ☐ Cabernet Sauvignon
- ☐ Pinot Noir
- ☐ Chardonnay

Wine Bottle Volume

- ☐ 375 mL
- ☐ 500 mL
- ☐ 750 mL

Specialty Wine Type

- ☐ Sustainable
- ☐ Small Lot
- ☐ Kosher
- ☐ Gluten-Free

Wine Vintage

- ☐ 2011
- ☐ 2010
- ☐ 2009
- ☐ 2008
- ☐ 2007

Challenges

Source taxonomies are:

- **many**
  3900 within the TrovaPrezzi italian price comparison engine

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  type > white > by vine > chardonnay > producer > firriato
  wines > white wines > greco di tufo

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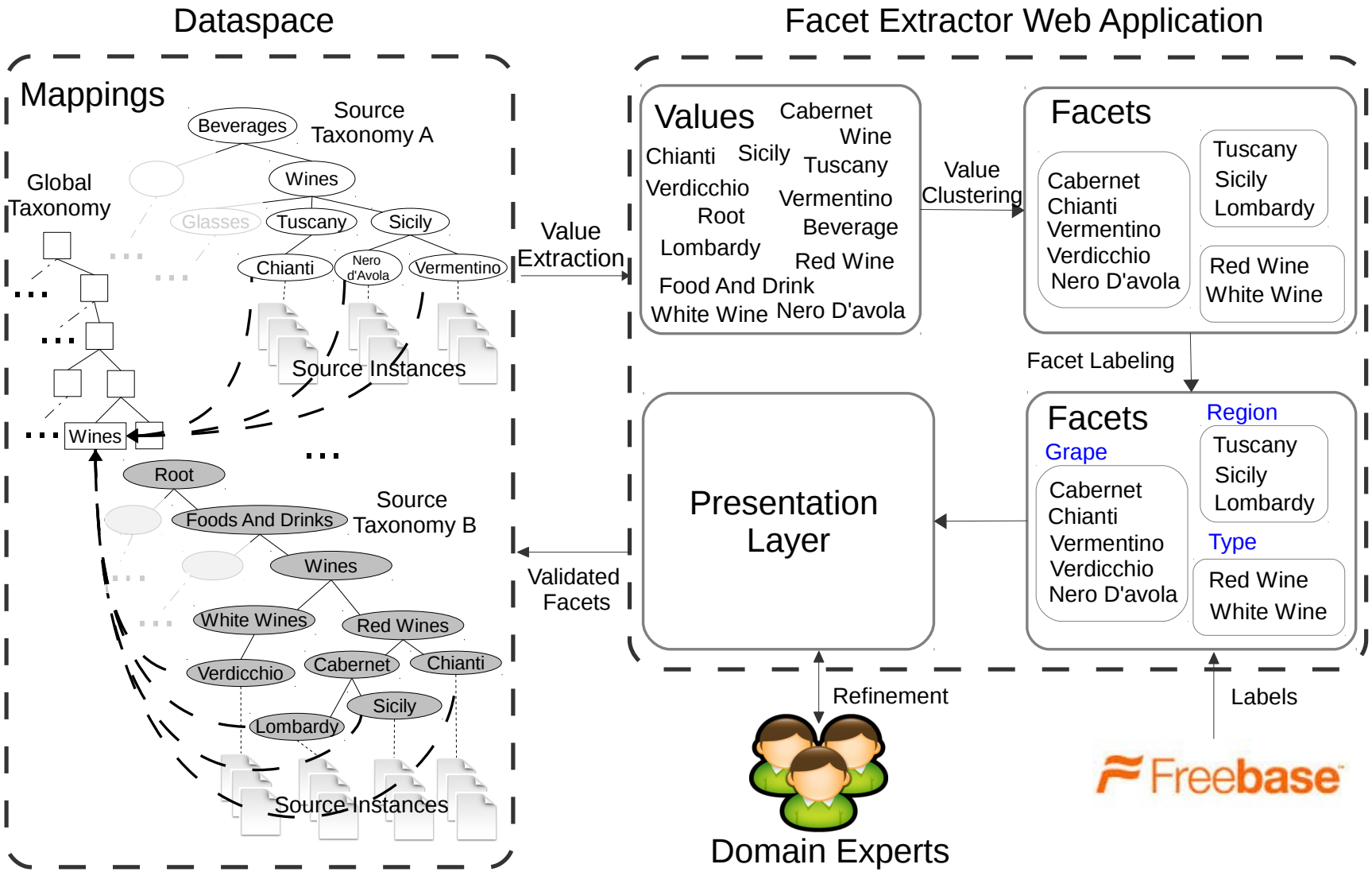
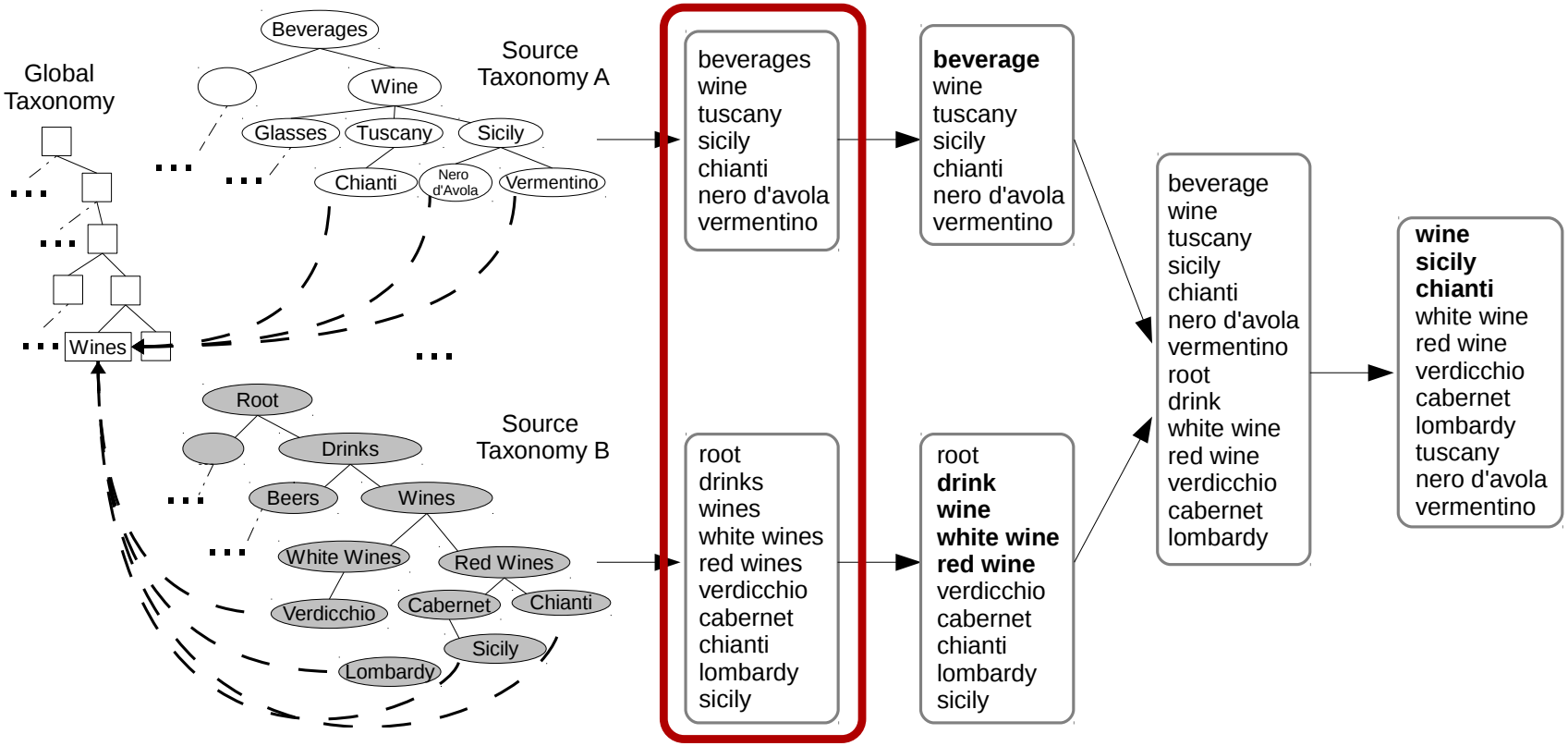
  3900 within the TrovaPrezzi italian price comparison engine
- **noisy**
  type > white > by vine > chardonnay > producer > firriato
- **heterogeneous**
  type > white > by vine > chardonnay > producer > firriato
  wines > white wines > greco di tufo
- **ambiguous** different semantics for different contexts
  red is a wine type for wines
  and a color for shirts

Language independent facet extraction

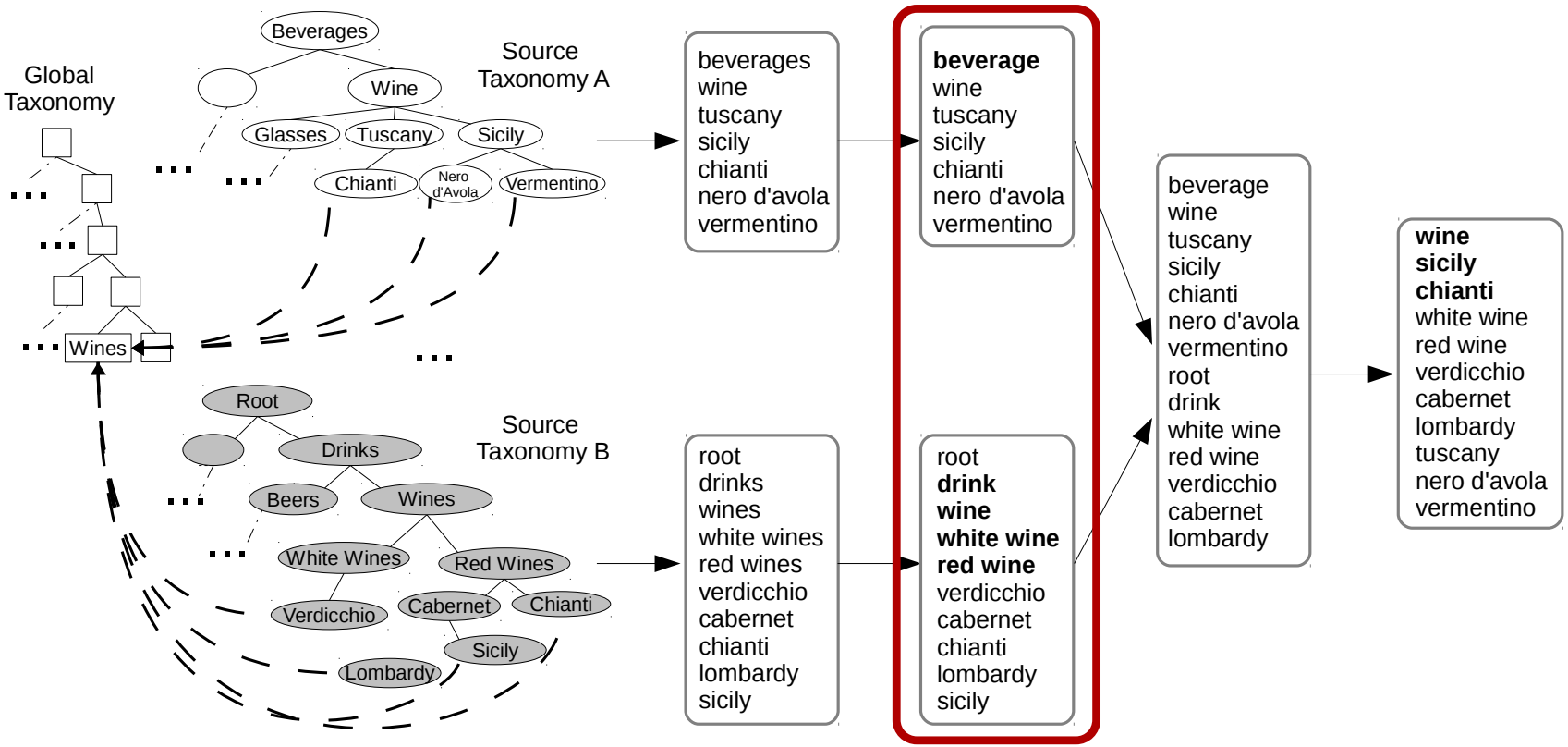


Value Extraction



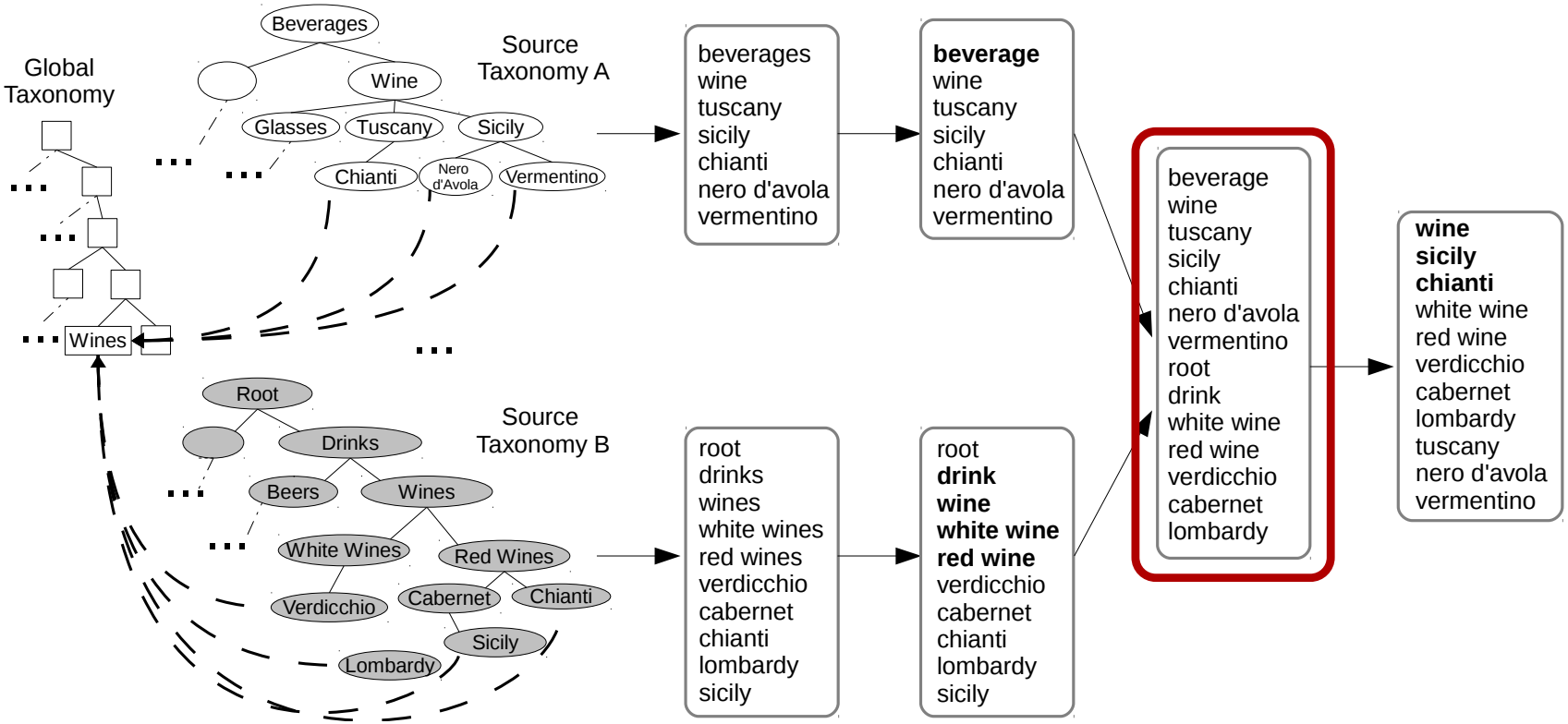
$$V_S^g = \{s \mid \exists\ g \leftarrow s \text{ or } \exists\ g \leftarrow s', \text{ with } s \in S \text{ and } s' \text{ is a descendant of } s\}$$

Value Extraction



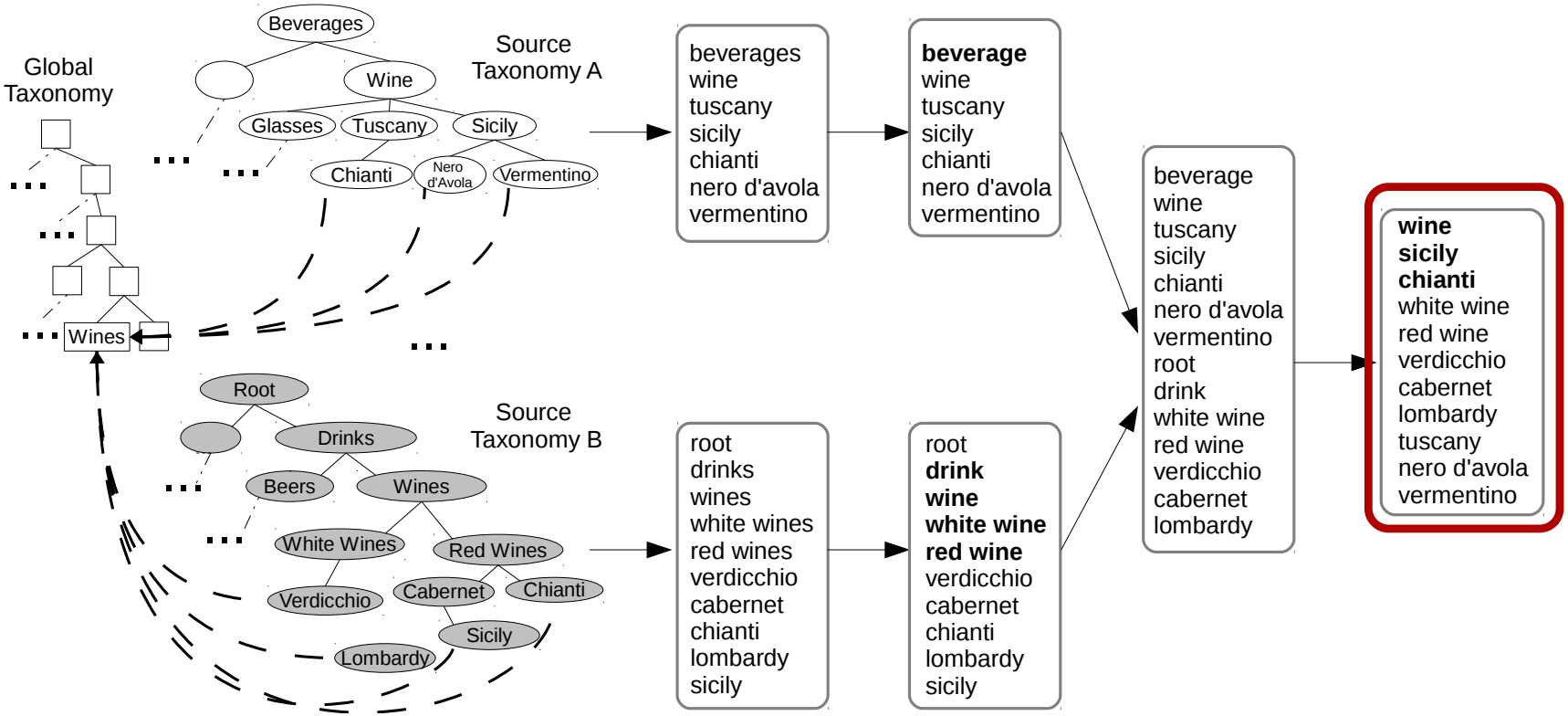
Normalization and stemming

Value Extraction



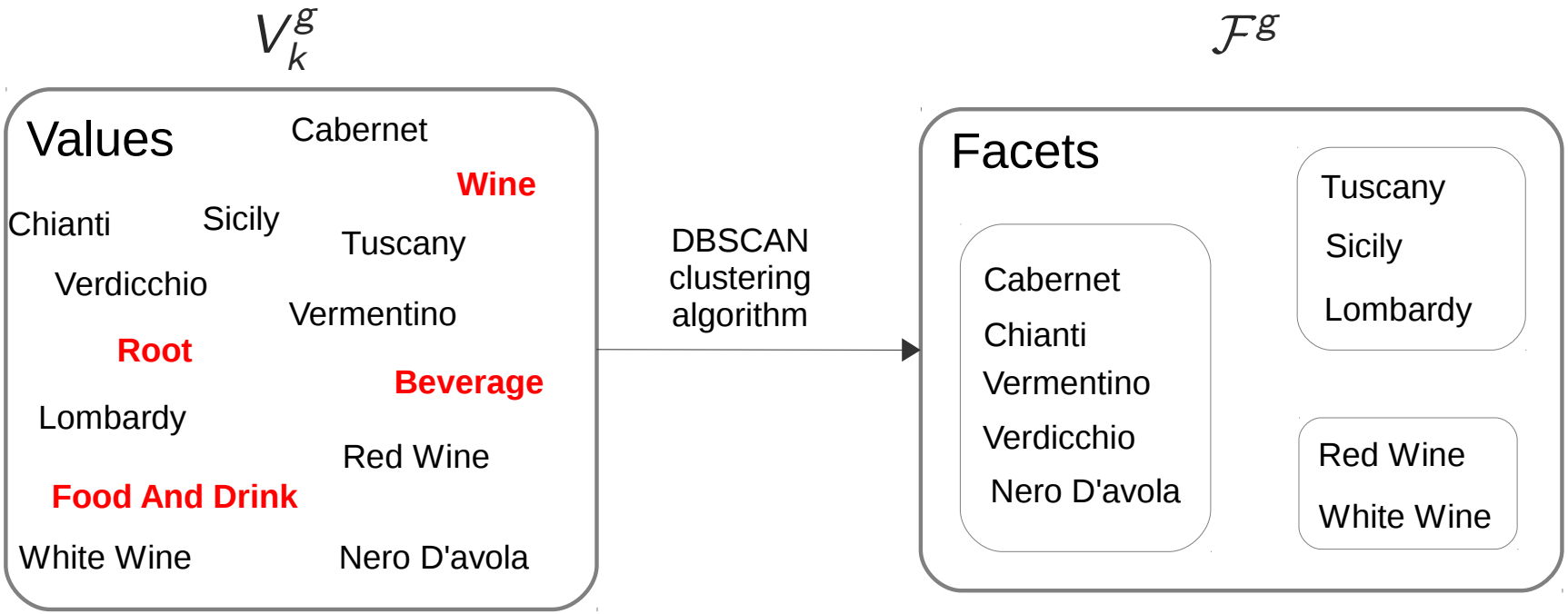
$$V^g = \bigcup_{i=1}^{n} V^g_{S^i}$$

Value Extraction



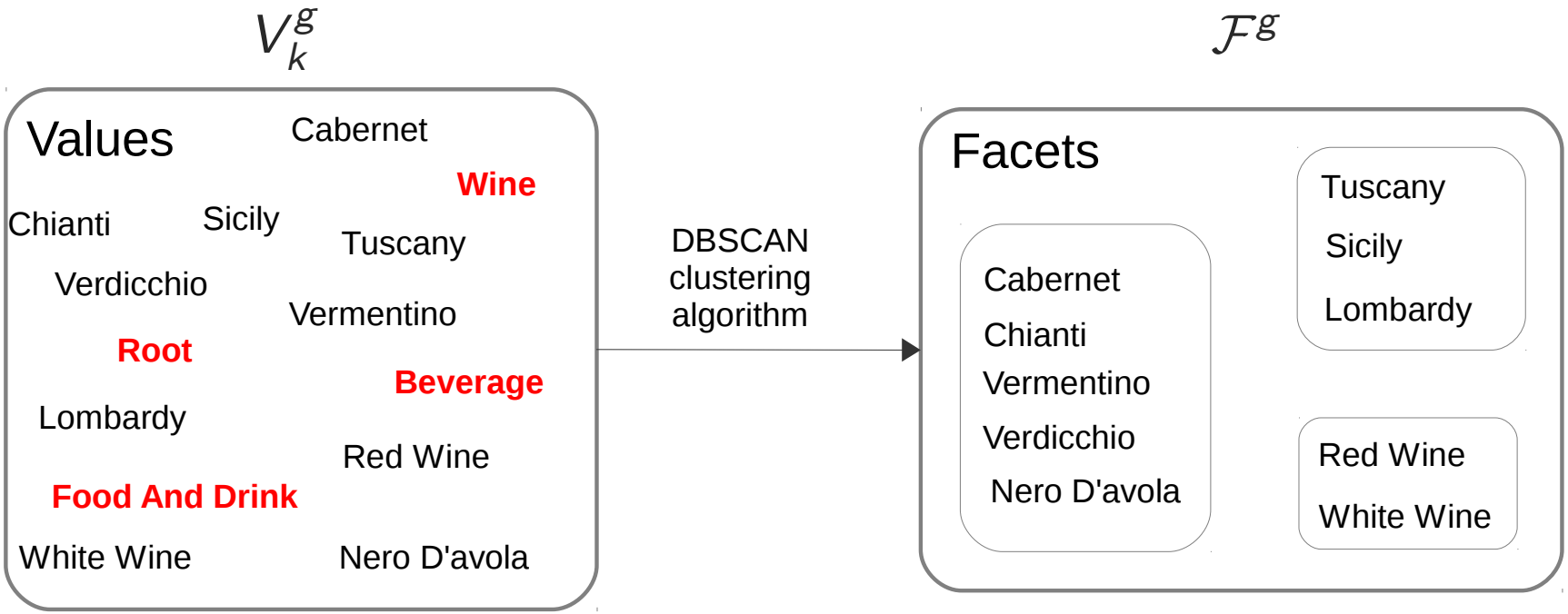
Set V_k^g of the top k frequent values over all $V_{S^i}^g$

Value Clustering



DBSCAN [Es96] Density based clustering

Value Clustering



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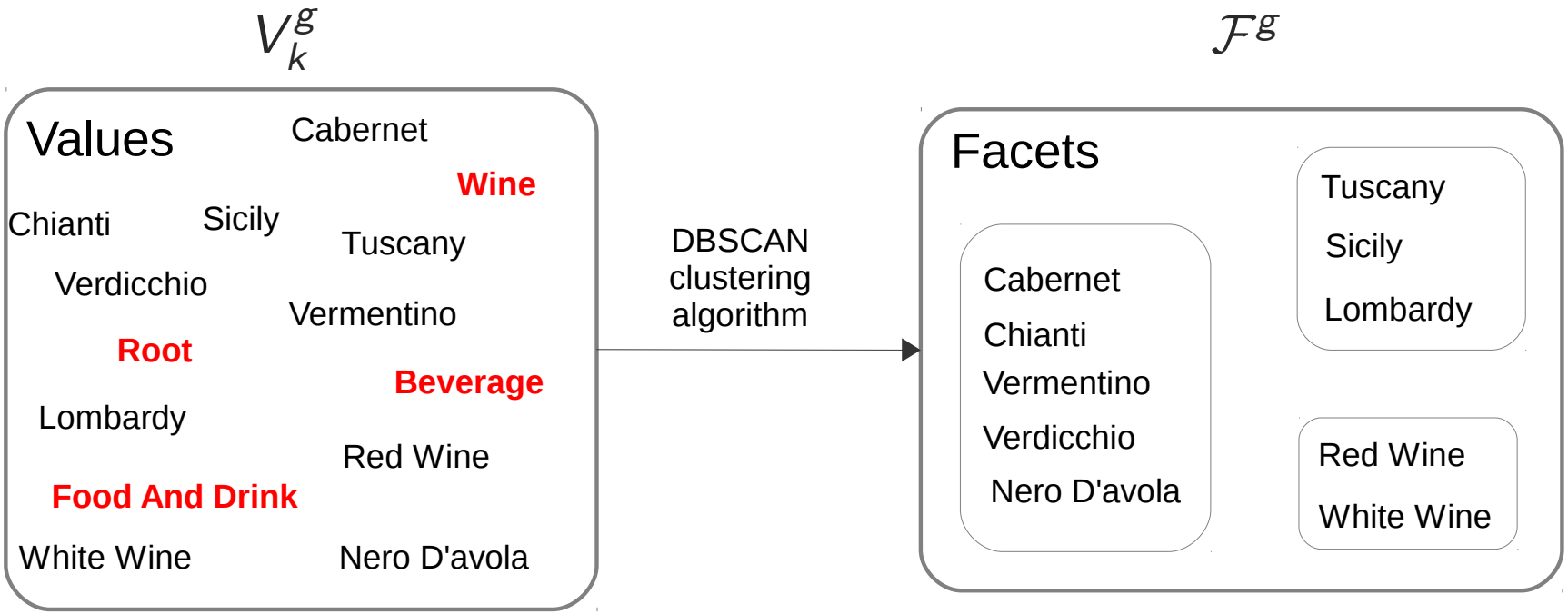


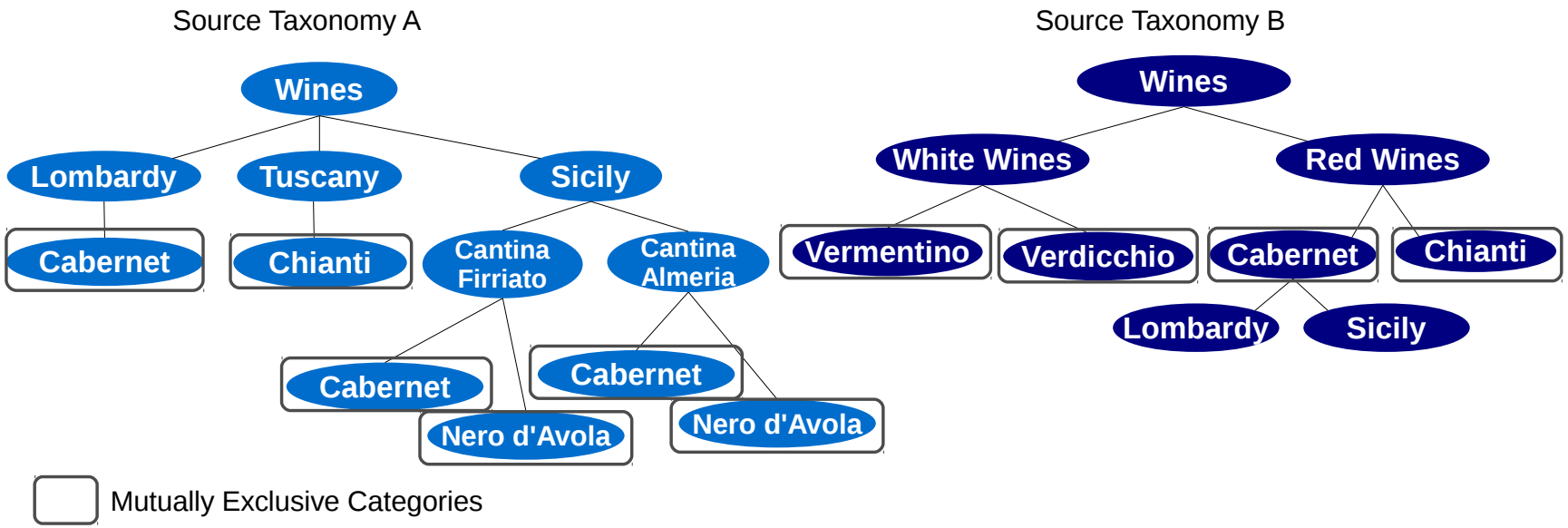
DBSCAN [Es96] Density based clustering

- incorporates the concept of *noise*
- number of clusters (i.e., facets) not known a priori

Source Category Mutual Exclusivity Principle

SCME principle

the more two values refer to mutually exclusive categories, the more they should be grouped together into the same facet



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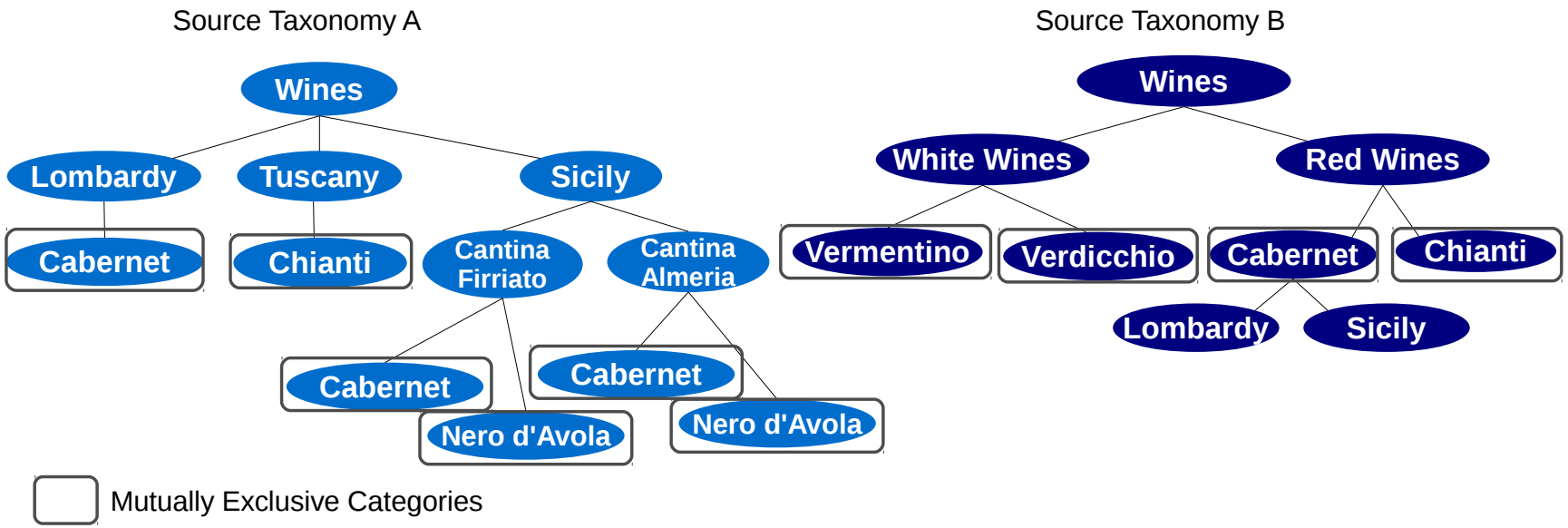
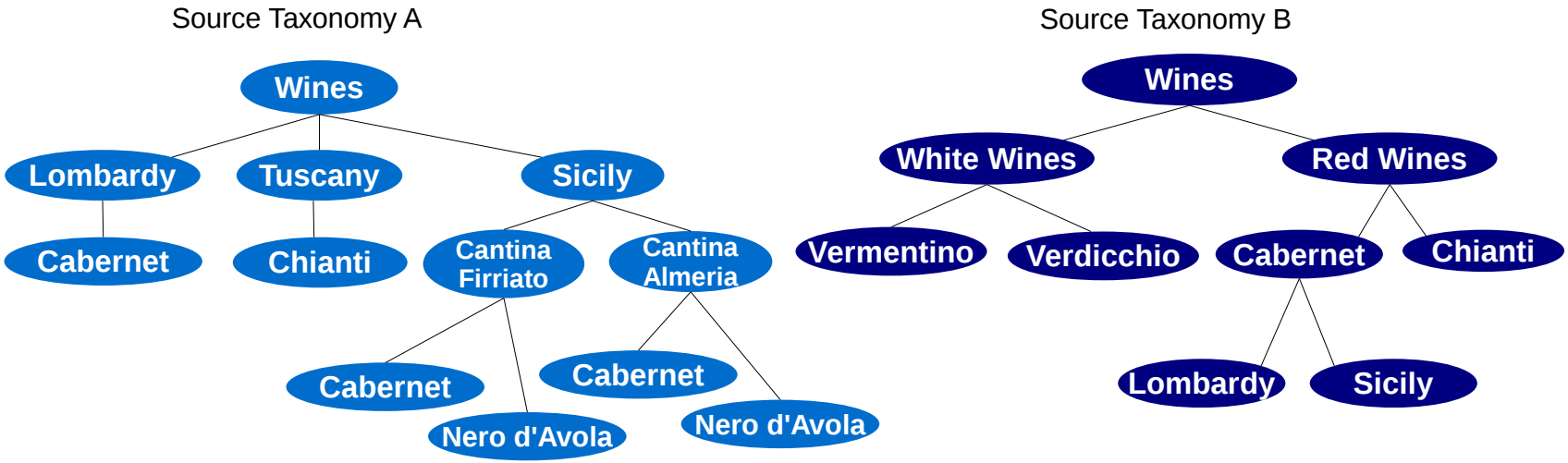


Hint

given two source categories s_1 and s_2, their occurrence as siblings indicates that s_1 and s_2 are mutually exclusive

Taxonomy Layer Distance

captures the **SCME** principle by considering the co-occurrence of categories on a same taxonomy layer



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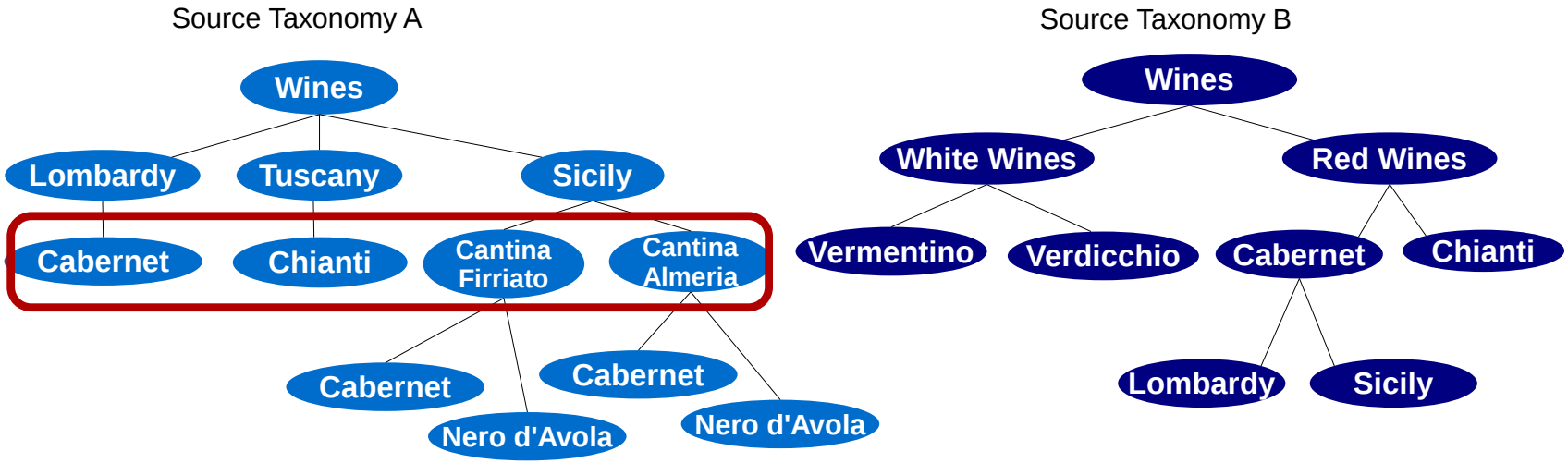

A taxonomy *layer* l^S of S is the set of all categories that are at the same distance from the taxonomy root

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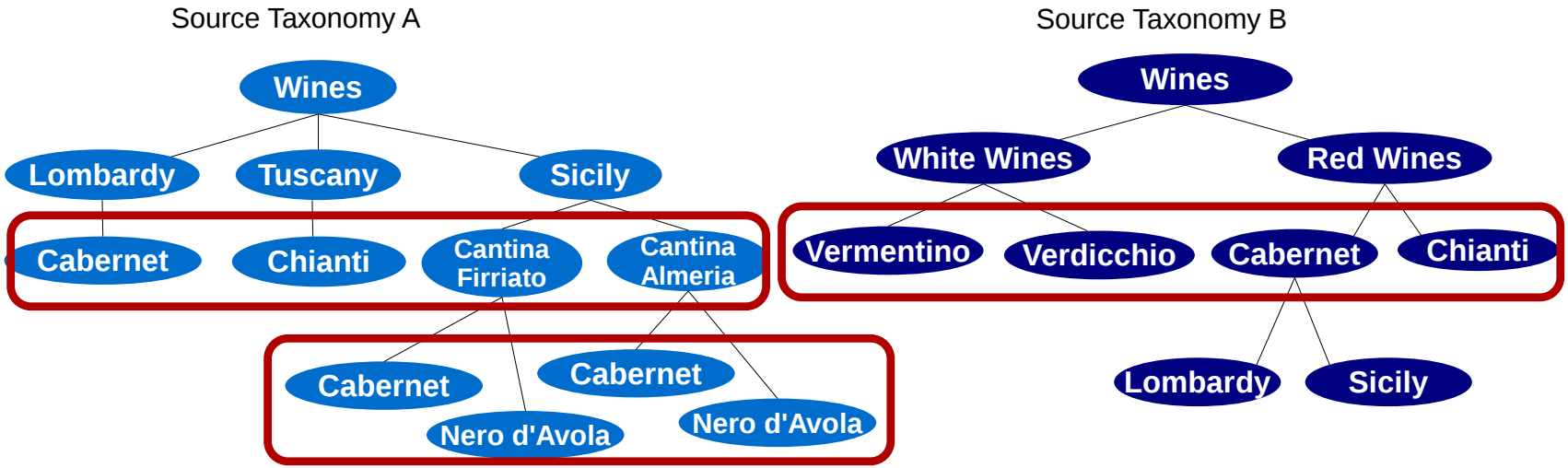

A value v is represented by the set $L_v = \bigcup_{i=1}^{n} L_v^{S^i}$ of layers containing v for each source taxonomy S, where $L_v^S = \{I^S \mid v \in I^S\}$ is the set of layers containing v in the source taxonomy S

Taxonomy Layer Distance

$$\mathrm{TLD}(v_1, v_2) = 1 - \frac{|L_{v_1} \cap L_{v_2}|}{|L_{v_1} \cup L_{v_2}|}$$

Jaccard Distance between the two sets of taxonomy layers where two values v_1 and v_2 occur

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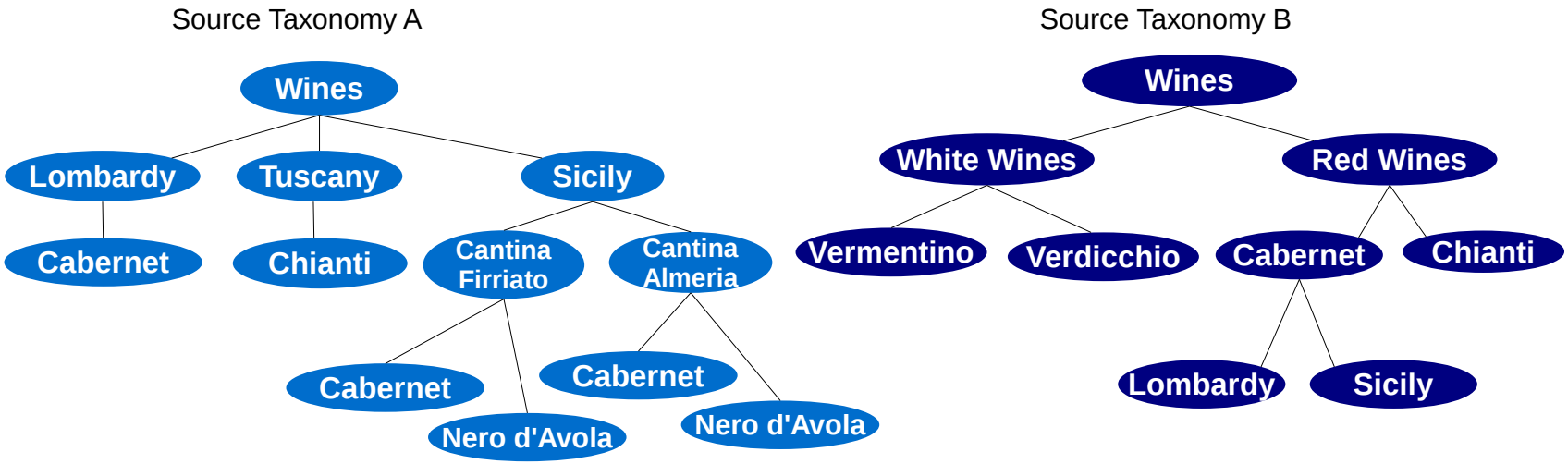

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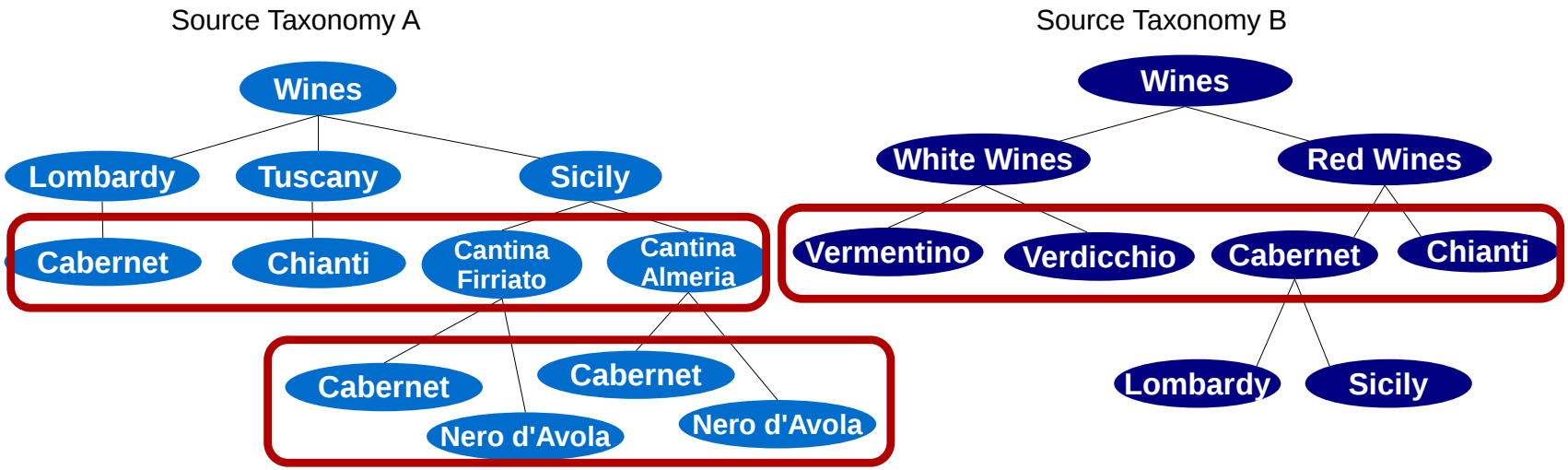

cabernet

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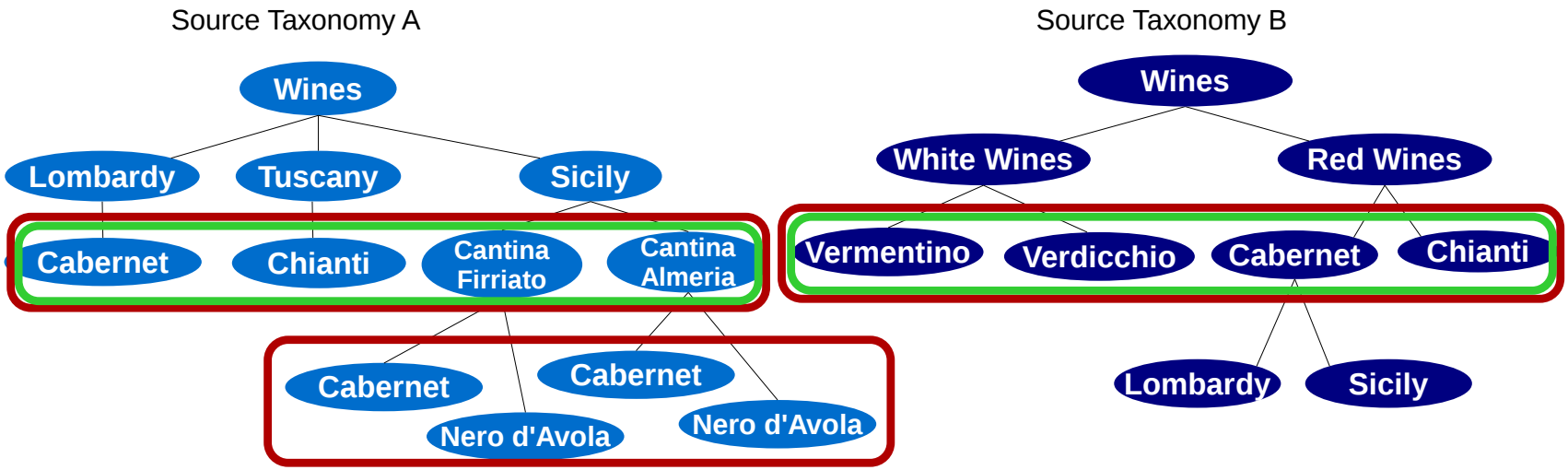

cabernet *chianti*

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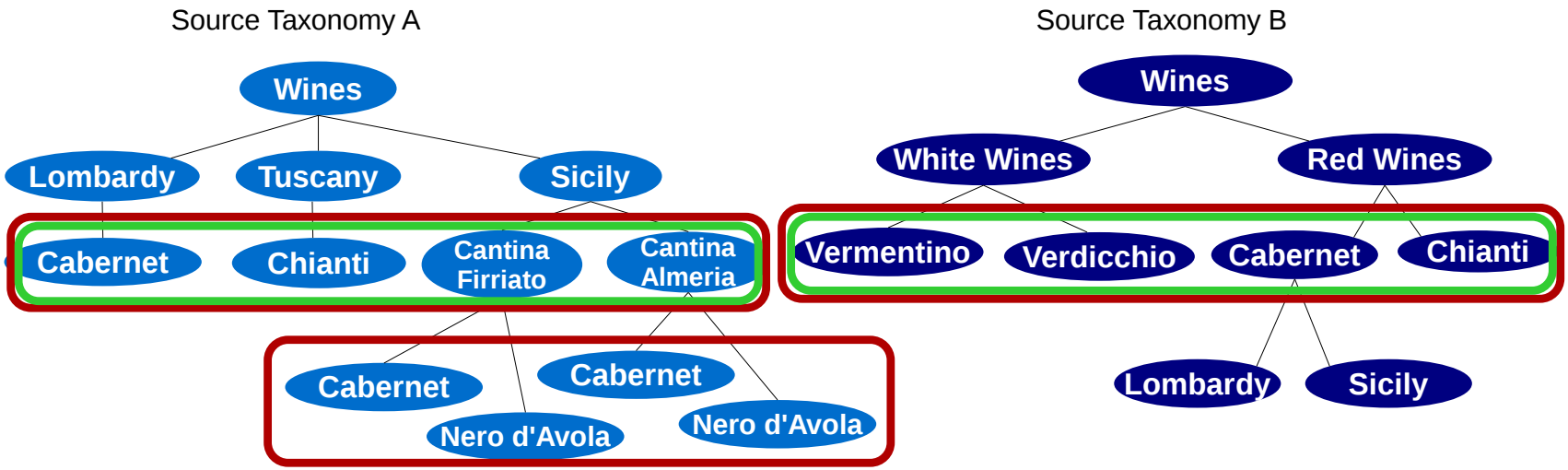

cabernet *chianti*

$$\mathrm{TLD}(\mathit{cabernet}, \mathit{chianti}) = 1 - \frac{|L_{\mathit{cabernet}} \cap L_{\mathit{chianti}}|}{|L_{\mathit{cabernet}} \cup L_{\mathit{chianti}}|} = 1 - \frac{2}{3} = \frac{1}{3}$$

Facet Labelling

Reconcile the values of each facet F^g to the Freebase knowledge base

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- pick the most frequent type

Evaluation

Goal

show that TLD effectively captures the SCME principle and supports domain experts in facets definition

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Comparison with:

- Leacock and Chodorow (LC) similarity [Le98]
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Evaluation using real world data from the italian PCE TrovaPrezzi

- 10 global categories
- 688 source taxonomies
- 22594 leaf mappings
- ran the extraction phase
- values manually grouped in facets by domain experts

Evaluation - Metrics

State-of-the-art evaluation campaign [Do11, Ka12]

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- **Value Clustering Effectiveness:** Purity (P^*), Normalized Mutual Information (NMI^*), Entropy (E^*), FMeasure (F^*)
- **Overall quality:** aggregates facet value precision P, facet value recall R and clustering F-measure F^*

$$PRF^* = \frac{3 * P * R * F^*}{R * P + P * F + P * R}$$

Evaluation - Results

	Value Effectiveness			*Clustering Effectiveness*				*Quality*
	P	R	F_1	F^*	NMI^*	Purity	E^*	PRF^*
LC	0.394	0.953	0.537	0.666	0.709	0.220	0.685	0.531
WP	0.377	**0.984**	0.525	0.682	0.714	0.210	0.744	0.520
TLD	**0.416**	0.901	**0.541**	**0.719**	**0.746**	**0.286**	**0.416**	**0.558**

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- TLD more effective in finding relevant facet values and discarding noisy ones (high F_1)
- TLD more effective in clustering homogeneous values (high *clustering effectiveness*)

Evaluation - Results

LC	F_1^g = {Wine, Red Wine, White Wine, . . . , Piedmont, Lombardy, . . . , Sicily, Donnafugata, Cusumano, . . . , Alessandro di Camporeale, . . . , France} (98)
WP	F_1^g = {Wine, Red Wine, White Wine, . . . , Piedmont, Lombardy, . . . , Sicily, Donnafugata, Cusumano, . . . , France} (100)
TLD	F_1^g = { Piedmont, Tuscany, Sicily, , . . . , France } (14) F_2^g = { Red, White, Rosé } (3) F_3^g = { Red Wine, White Wine, Rosé Wine } (3) F_4^g = { Moscato, Chardonnay, . . . , Merlot } (13) F_5^g = { Tuscany Wine, Sicily Wine} (2) F_6^g = { Donnafugata, Cusumano, . . . , Principi di Butera } (27)
Gold Standard	F_1^g = { Piedmont, Lombardy, . . . , Sicily } (21) F_2^g = { Red Wine, White Wine, . . . , Rosé Wine } (14) F_3^g = { Donnafugata, Cusumano, . . . , Alessandro di Camporeale} (12)

Conclusions

- semi-automatic, language independent approach to facets extraction from heterogeneous taxonomies within dataspaces

Future work

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- improvement of the labelling phase (e.g., reconciliation with known Semantic Web ontologies)
- integration of evidence coming from additional input (e.g., user queries)

Thank You

Questions?

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http://rporrini.info

Backup

Related Work

Facet extraction

- *document corpora* [St07, Da08, We13, Me13]
  focus on faceted hierarchies - specific for unstructured data
- search engines' *query logs* and *documents* [Li09, Pa09, Po11]
  user search queries as a primary source of information
- search engines' *query results* [Ya10, Do11, Ka12, Ko13]
  integrate and rank facets already present in web documents

Similarity-Relatedness between taxonomy categories

- Leacock and Chodorow similarity [Le98]
- Wu and Palmer similarity [Wu94]
- ...
  not designed for heterogeneous taxonomies

Evaluation - Number of discovered facets

	$\lvert\mathcal{F}_*^g\rvert$	LC	WP	TLD
Dogs and Cats Food	3	1	1	7
Grappe, Liquors, Aperitives	1	1	1	6
Wines	3	1	1	6
Beers	2	6	3	14
DVD Movies	2	2	1	3
Rings	4	1	2	7
Blu-Ray Movies	2	2	2	5
Musical Instruments	6	1	1	5
Ski and Snowboards	1	1	1	7
Necklaces	8	2	3	11

References

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[Ta04] Taylor et al. Wynars introduction to cataloging and classification. *Libraries Unlimited*, 2004

[Da08] Dakka et al. Automatic extraction of useful facet hierarchies from text databases. *ICDE*, 2008

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