

Formal Concept Analysis

III Knowledge Discovery

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Agenda

7 Triadic Formal Concept Analysis

- Motivation
- Folksonomies
- Motivation
- Triadic Formal Concept
- Concept-Tri-Lattice
- Visualization of Tri-Lattices
- Iceberg Tri-Lattices
- Computing Tri-Concepts
- Qualitative Evaluation
- Neighborhoods

Motivation: Collaborative Tagging Systems

Sie sind nicht angemeldet Anmelden Hilfe Suchen ▾

Entdecken / Tags / nature

Diashow ▾

Sortieren nach:
Neueste • [Interessanteste](#)

Cluster mit dem Tag nature
Entdecken und filtern Sie diese Liste mit dem Tag nature mit unserem tollen Cluster-Feature!

Dazu passende Tags:
[macro](#) [flower](#) [green](#) [landscape](#)
[trees](#) [sky](#) [water](#) [insect](#) [flowers](#)
[leaves](#)

Ähnliche Inhalte mit
[der Yahoo! Bildersuche suchen](#)

Sponsoren-Links
[PureNature Versand](#)
Hier finden Sie alles für ein gesundes, allergiefreies Leben!
[www.PureNature.de](#)

[Natururlaub in Frankreich](#)
[Natur pur und nachhaltige Konzepte](#)
[de-france-nature.com/natktourismus](#)

The screenshot shows the Flickr homepage with a search bar at the top. Below it, a main heading reads "Entdecken / Tags / nature". A sidebar on the left lists "Sortieren nach" options like "Neueste" and "Interessanteste". Below this, a section titled "Cluster mit dem Tag nature" displays a grid of four images: a close-up of a flower, a landscape with a lake and mountains, a bird perched on a branch, and a close-up of a plant. Each image has a caption below it: "Von andy.v", "Von Tony Reilly1959", "Von Tony Reilly1959", and "Von andy.v" respectively. Further down, another row of four images is shown: a landscape, red flowers, green plants, and a close-up of a flower, each with a caption like "Von Tony Reilly1959", "Von flesh", "Von Giorgio", and "Von Carme M.V.". At the bottom, there are sections for "Sponsoren-Links" featuring "PureNature Versand" and "Natururlaub in Frankreich". The footer contains navigation icons and page numbers.

Motivation: Collaborative Tagging Systems

[flickr](#)
Startseite Di

vimeo

Join [vimeo](#)

Log In Explore Help

Entdecke

Sortieren nach:
Neueste • [Interessant](#)

Cluster mit de
Entdecken und filtern mit dem Tag natürlich tollen Cluster-Finder

Dazu passende Tags:
[macro](#) [flower](#) [nature](#) [trees](#) [sky](#) [water](#) [leaves](#)

Ähnliche Inhalte
[der Yahoo! Bildergalerie](#)

Sponsoren
PureNature [Vegetarian](#)
Hier finden Sie alles gesundes, allergenfreies [www.PureNature.de](#)

Natururlaub in der Natur [pur und natürlich](#) [de-franceguide.com](#)

Videos tagged: nature

Videos 1-12 of 12,812

Show me [newest](#) [videos in](#) [thumbnail](#) [format](#)

Human Nature Explained
The breakthrough world-transforming explanation of the human condition
[www.WorldTransformation.com/](#)

Sponsored Links

Visit Lapland
Watch the Polar Lights From the Untouched Wilderness
[www.HemavanTarnaby.se](#)

Time
2 hours ago



Flies
2 hours ago



Nurture
4 hours ago



Vimeo + a
Vim

Do more with tags
Hey, did you know you can add all these videos to your account? Just click on the "Subscribe" button below each video to never miss a video again.

Motivation: Collaborative Tagging Systems

flickr
Startseite Di

Entdecken

Sortieren nach:
Neueste • Interes

Cluster mit de
Entdecken und fil mit dem Tag nat tollen Cluster-Fea

Dazu passende macro flower trees sky water leaves

Ähnliche Inha der Yahoo! B

Sponsore

PureNature Ve Hier finden Sie al gesundes, allerg www.PureNature

Natururlaub in Natur pur und na de franzmueller

vimeo

Videos tagged

Videos 1-12 of 12,812

Show me newest

Human Nature Explained
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Time
2 hours ago

delicious Home Bookmarks People Tags

Recent nature Bookmarks

Recent | Popular

See popular nature bookmarks.

Tags > nature > Type another tag

10 JUL 10 yosemitedithphoto's Photos- powered by SmugMug SAVE

penb

The Point Magazine SAVE

lucas3850 art read writing zines magazine ch essay essays periodical friends phil

Albino Alligator Photo, Animal Wallpaper – National Geographic Photo of the Day SAVE

jody.nelson animals images photography

Educating, Counseling and Healing With Nature: Ecopsychology In Action SAVE

pippamatt ecopsychology sustainability education resources environment

Yosemite and the Invention of Wilderness - NYTimes.com SAVE

What she found was a view of nature, expressed in writing and photographs, that did not fit in with what she wrote, is how Americans have come to think of the natural world. There is a small white house in Yosemite Valley and the area near Lake Tenaya were home to the Ahwahneechee Indians, whose future beckoned, and Indians did not fit in.

Motivation: Collaborative Tagging Systems

The screenshot shows the BibSonomy homepage. At the top, there's a search bar with the placeholder '(Robert Jäschke) CV'. Below it, a navigation bar includes links for 'home', 'myBibSonomy', 'add post', 'groups', and 'popular'. On the right, there are language options 'EN DE' and user status 'logged in as jaeschke' with a 'logout' link. The main content area is divided into two sections: 'BOOKMARKS (1141)' on the left and 'PUBLICATIONS (726)' on the right. Each section lists items with small icons, titles, URLs, and dates. The right section also features a sidebar titled 'concepts' with a list of tags and their counts.

BOOKMARKS (1141)

- Twitter Calendar
http://statuscalendar.cs.washington.edu/
17 hours and 29 minutes ago by jaeschke
- information named entity ner calendar twitter e...

PUBLICATIONS (726)

- The Wiki way: quick collaboration on the Web
Bo Leuf, and Ward Cunningham. Addison-Wesley, London, (March 2002).
7 days ago by jaeschke
- collaboration wiki management web knowledge

Feature of the week: CSL via REST-API
http://blog.bibsonomy.org/2013/01/feature-of-week-csl-via-rest-a...
3 days and an hour ago by jaeschke- bibsonomynews fotw csl bibsonomy rest

prisma.de: It Might Get Loud
http://www.prisma.de/fm/2008_it_might_get_loudfernsehen.html
4 days ago by jaeschke as private- program tv music

ORCID: Robert Jäschke
http://orcid.org/0100-0003-3271-9653
7 days ago by jaeschke- orcid science myown research publication

BibSonomy
http://www.bibs.uni-hannover.de/~jaeschke/bibsonomy/
7 days ago by jaeschke- tagging collaborative social bookmarking bibso...

concepts
(show all | hide all)

- author ← newman
- conference ← ecal emcipd gvd lccs icdm icfca recsys
- folsonomy ← bookmarking tagging
- geo ← gps map utm
- howto ← manual reference tutorial
- location ← anhalt berlin bittfeld bled celle dagstuhl dresden europe frankfurt hannover hessen kaisers lassel london magdeburg ort saarland sachsen sachsen_anhalt toulouse tübingen wadern wittenberg würzburg
- ort ← location
- programming ← ada c fortran java lisp perl prolog python ruby
- protocol ← ftp http smtp
- researcher ← devadze shannon turing
- science ← chemistry math
- software ← apache beagle cocoon debian eclipse firefox haystack nextstep photoshop protege thunderbird weka wine word x11 zope

- manage your web bookmarks and publication references
- open for the public since beginning of 2006, > 5 000 active users
- developed and operated at L3S Research Center

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Folksonomies

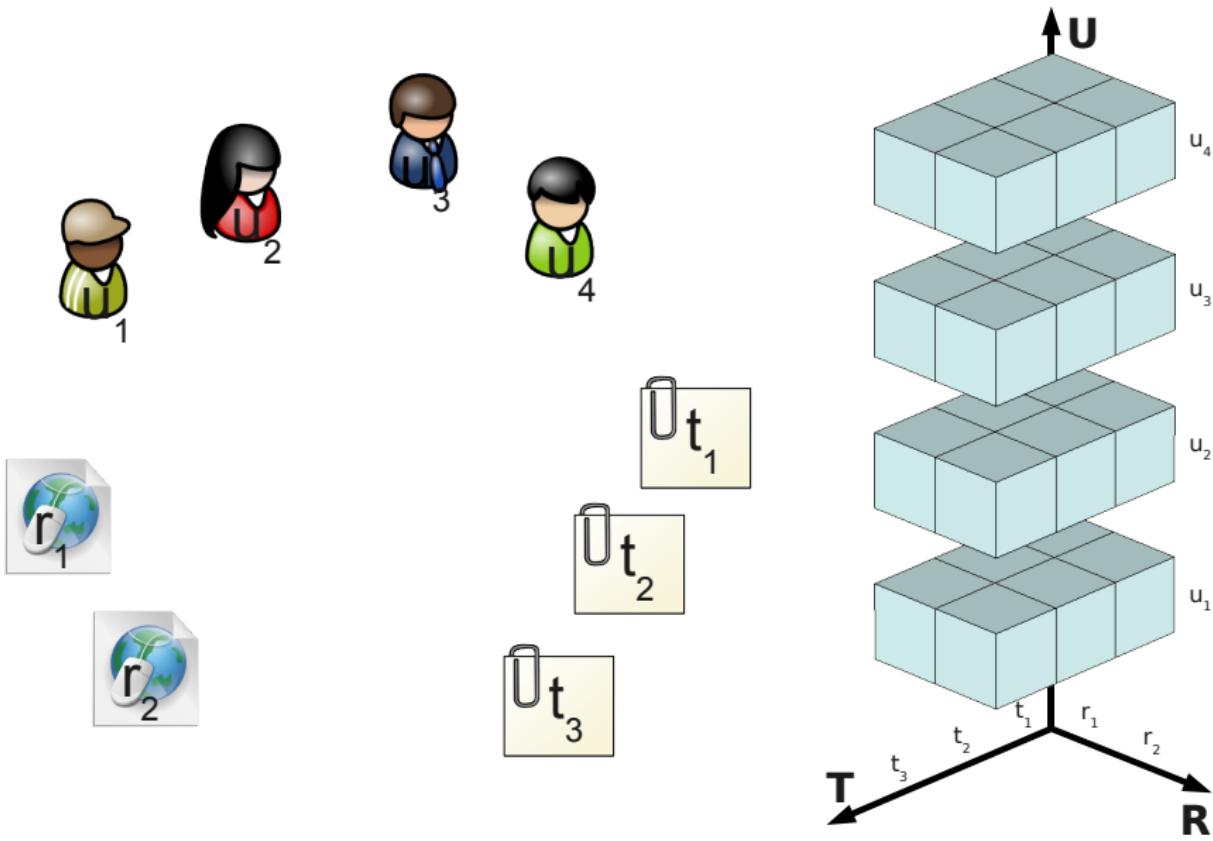
- data structure of collaborative tagging systems
- connects users, tags, and resources
- conceptual structure created by the people



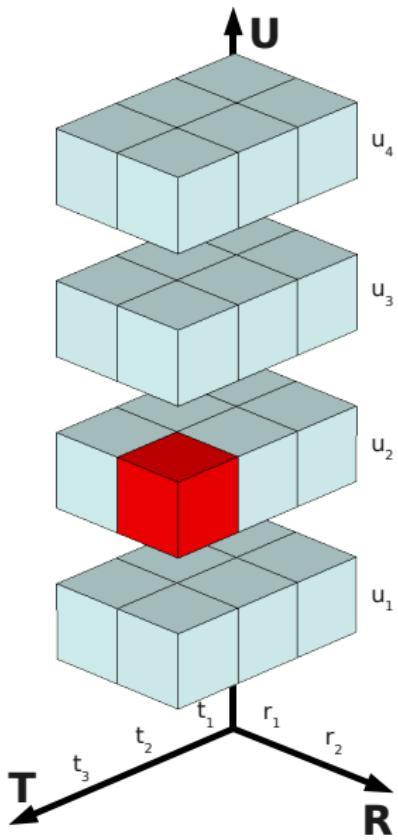
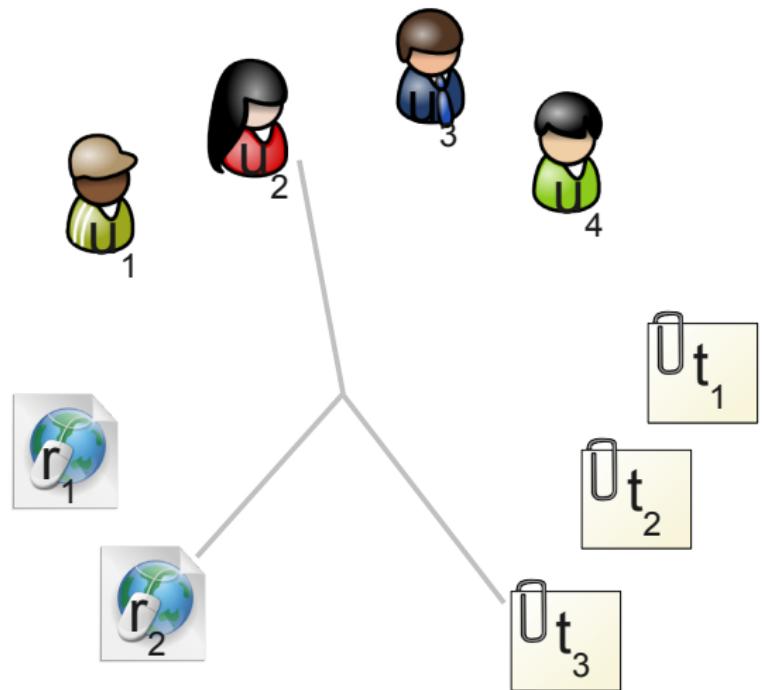
The screenshot shows a folksonomy interface. At the top right is a blue rounded rectangle containing the text "Forschungszentrum L3S" and "Wissenschaft & Forschung in den Schlüsselbereichen Wissen, Information und Lernen". Below this is a tag cloud with various tags like "science", "research", "hannover", etc. To the right of the tag cloud is a detailed view of a tag labeled "forschungszentrum l3s". This view includes the tag's URL ("to science l3s center hannover research"), the date it was created ("by jaeschke and 1 other person on 2006-01-27 10:39:07"), and links to "edit" and "delete".



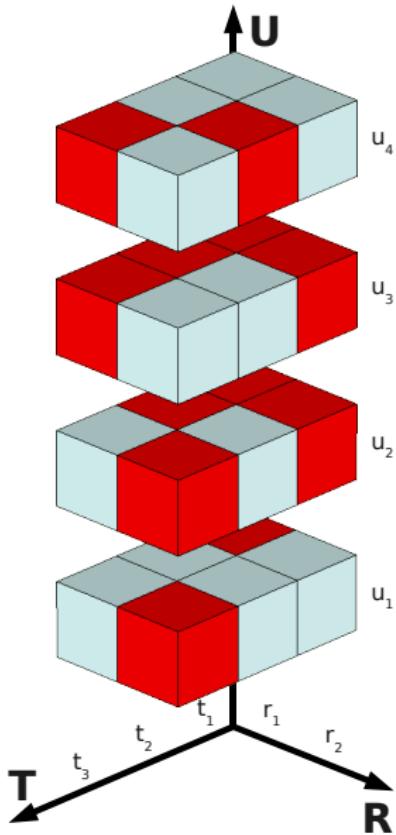
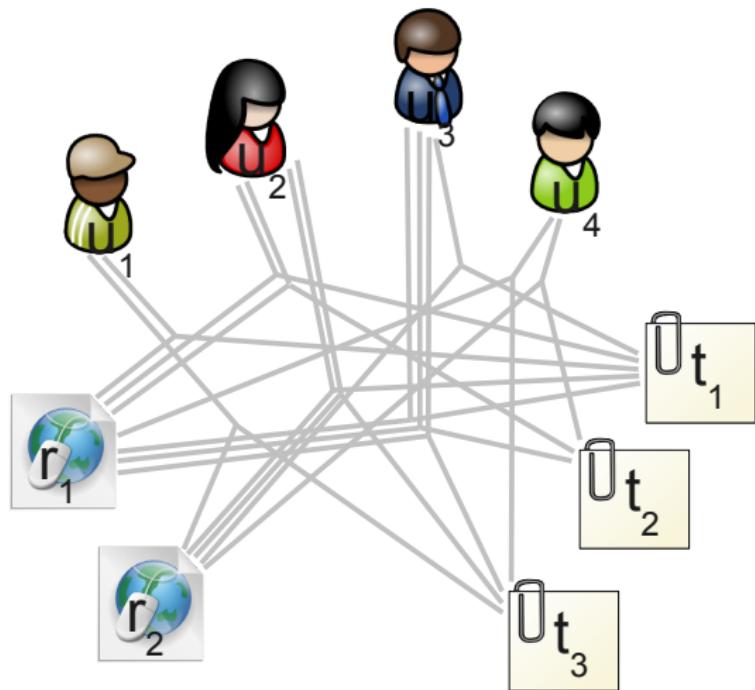
Folksonomies: Hypergraph, Tensor



Folksonomies: Hypergraph, Tensor



Folksonomies: Hypergraph, Tensor

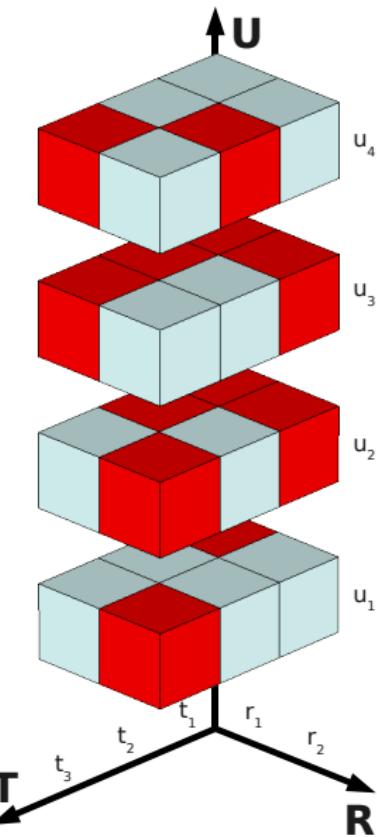
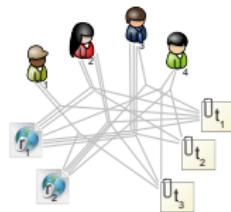


Folksonomies

Definition (Folksonomy)

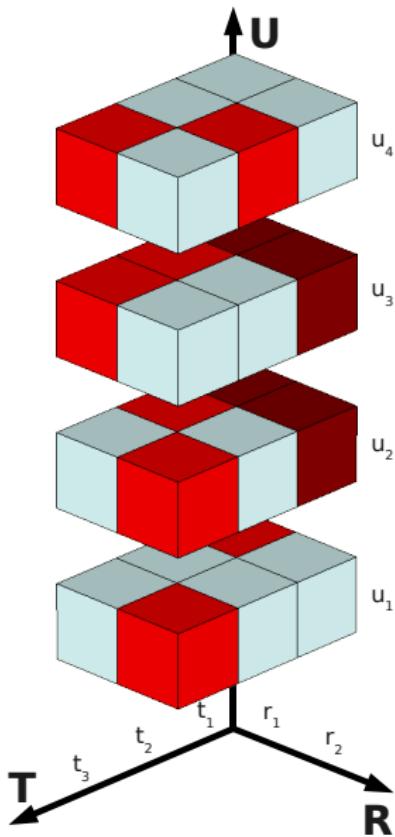
$\mathbb{F} := (U, T, R, Y)$ with

- U, T, R finite sets of users, tags, and resources, resp.
 - $Y \subseteq U \times T \times R$ ternary relation
-
- tripartite hypergraph
 - boolean 3-dimensional tensor
 - triadic formal context



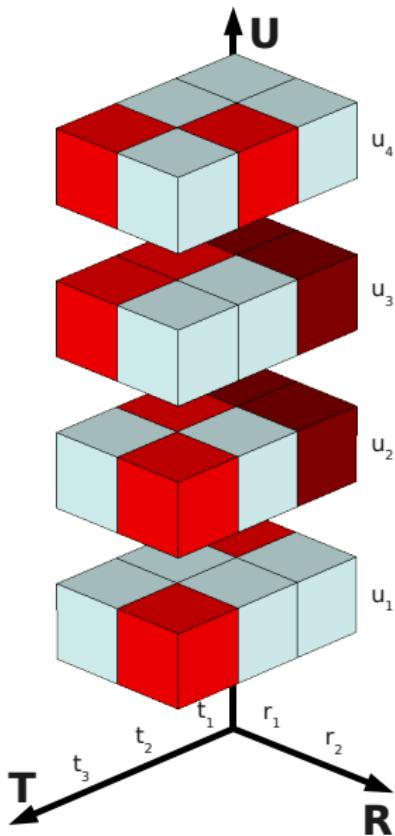
Motivation

- conceptual clustering of folksonomies
 - find interesting concepts/clusters
 - support browsing, community detection, recommendations
 - get an overview into the structure of a folksonomy

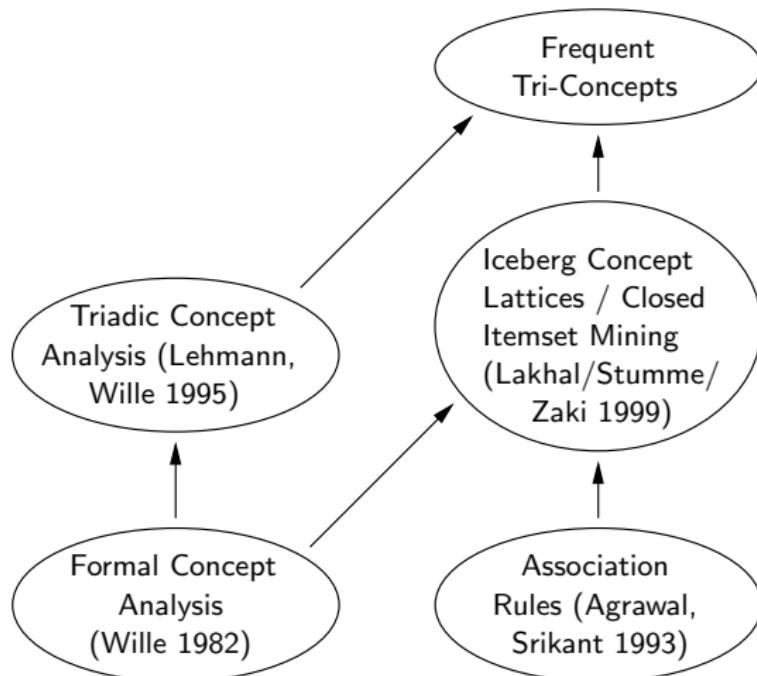


Motivation

- conceptual clustering of folksonomies
 - find interesting concepts/clusters
 - support browsing, community detection, recommendations
 - get an overview into the structure of a folksonomy
- *tri-concept* $(A, B, C) \subseteq U \times T \times R$: maximal cuboid in which every user from A has tagged every resource from C with all tags from B
→ shared conceptualization



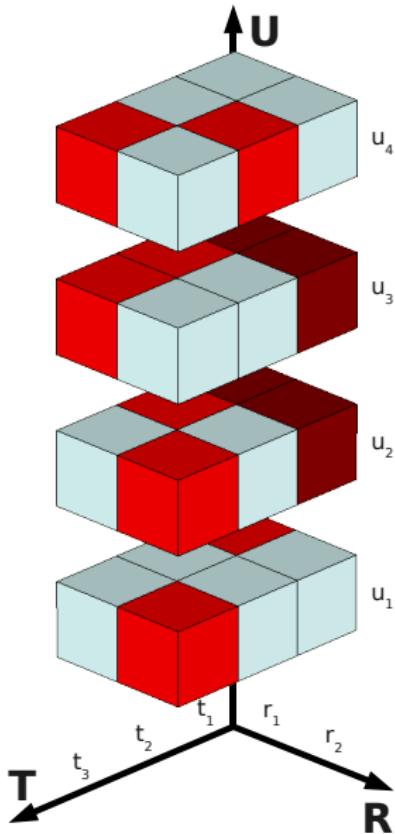
Motivation



Motivation

We regard $\mathbb{F} = (U, T, R, Y)$ as *triadic formal context*.

In general, the elements of U , T and R are then called *objects*, *attributes* and *conditions* and $(u, t, r) \in Y$ is read as “*object u has the attribute t under condition r* ”.



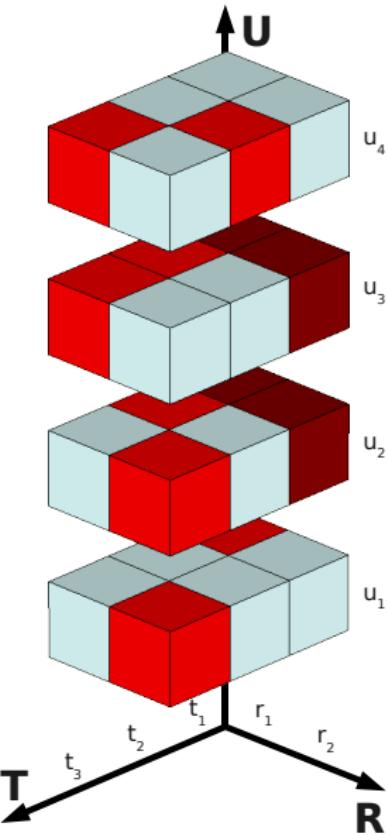
Triadic Formal Concept

Definition (tri-concept)

triple (A, B, C) with $A \subseteq U$, $B \subseteq T$, $C \subseteq R$ and $A \times B \times C \subseteq Y$, such that none of the three components can be enlarged without violating the condition $A \times B \times C \subseteq Y$.

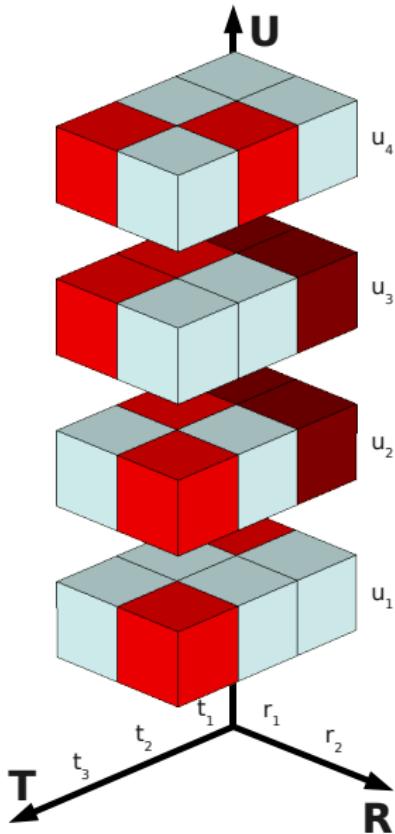
We call A the *extent*, B the *intent* and C the *modus* of the formal tri-concept.

→ natural extension of formal concepts



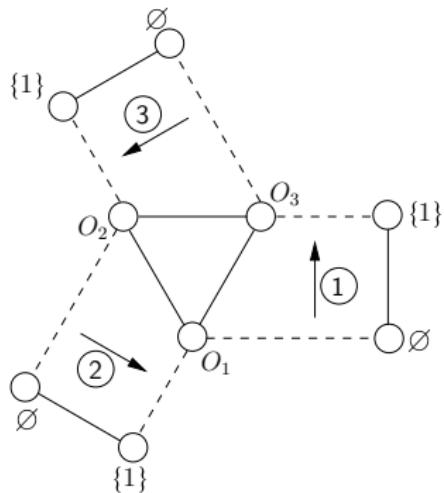
Concept-Tri-Lattice

- three quasi orders $\lesssim_1, \lesssim_2, \lesssim_3$:
 $(A_1, A_2, A_3) \lesssim_i (B_1, B_2, B_3)$
 $\Leftrightarrow A_i \subseteq B_i$, for $i = 1, 2, 3$.
- *not antisymmetric*, i. e. from
 $(A_1, A_2, A_3) \lesssim_i (B_1, B_2, B_3)$ and
 $(B_1, B_2, B_3) \lesssim_i (A_1, A_2, A_3)$ does not follow $(A_1, A_2, A_3) = (B_1, B_2, B_3)$
- *concept tri-lattice* $\mathfrak{B}(\mathbb{K})$ of the triadic context \mathbb{K}
- not a real (mathematical) lattice!

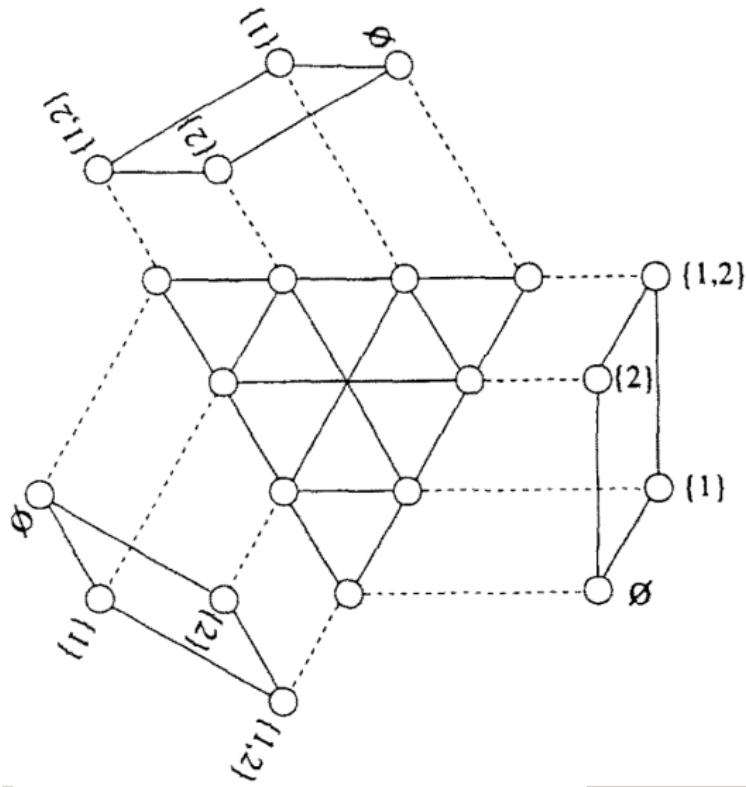


Visualization of Tri-Lattices

- Since it is not really a lattice, we can not draw a lattice diagram
- Alternative:
 - every quasi-order is written along the edge of a virtual triangle
 - the tri-concepts are drawn into the triangle
- example to the right: smallest non-trivial tri-lattice
 $\mathfrak{B}_3 = \mathfrak{B}(\{1\}, \{1\}, \{1\}, \emptyset)$
- visualization not always possible
 - satisfied tetrahedron condition
 - violated Thomson condition

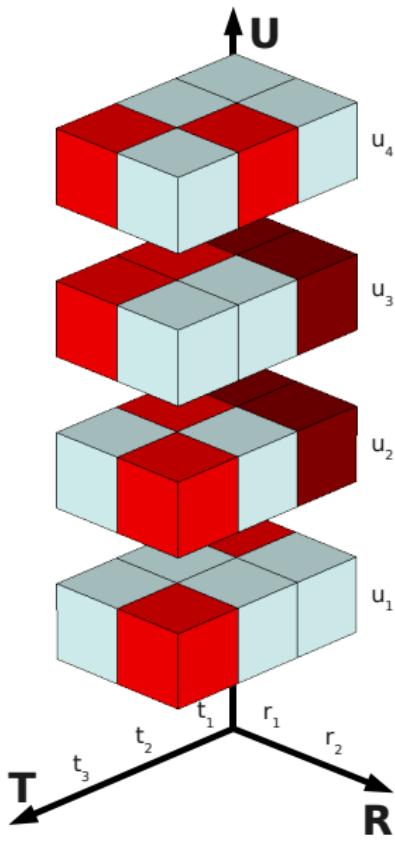


Visualization of Tri-Lattices



Iceberg Tri-Lattices

- Given support constraints τ_u, τ_t, τ_r :
tri-concept (A, B, C) frequent
 $\Leftrightarrow |A| \geq \tau_u, |B| \geq \tau_t$, and $|C| \geq \tau_r$
 \rightarrow *iceberg tri-lattice*

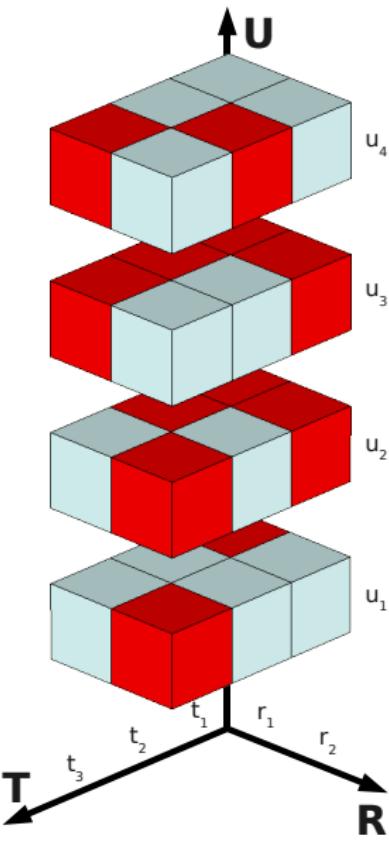


Computing Tri-Concepts

- Given
 - sets U, T, R
 - ternary relation $Y \subseteq U \times T \times R$
 - support constraints τ_u, τ_t, τ_r
- Find (A, B, C) with
 - $A \subseteq U, B \subseteq T, C \subseteq R$
 - $|A| \geq \tau_u, |B| \geq \tau_t, |C| \geq \tau_r$
 - $A \times B \times C \subseteq Y$
 - such that none of the sets A, B or C can be enlarged without violating the former condition

Computing Tri-Concepts

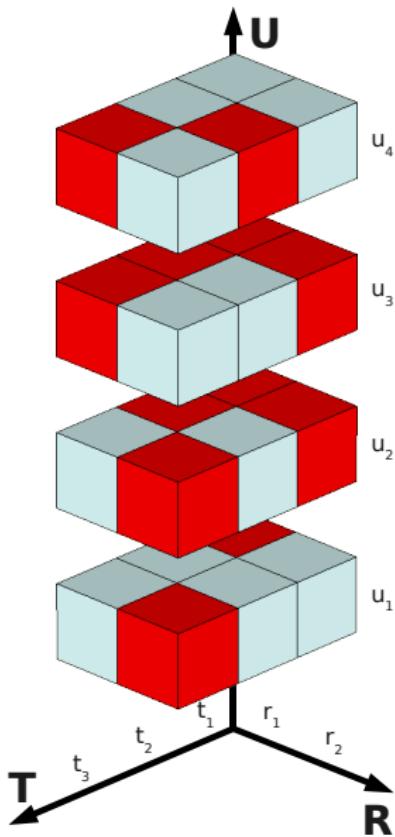
computes the iceberg tri-lattice of a triadic formal context



Computing Tri-Concepts

computes the iceberg tri-lattice of a triadic formal context

Algorithm

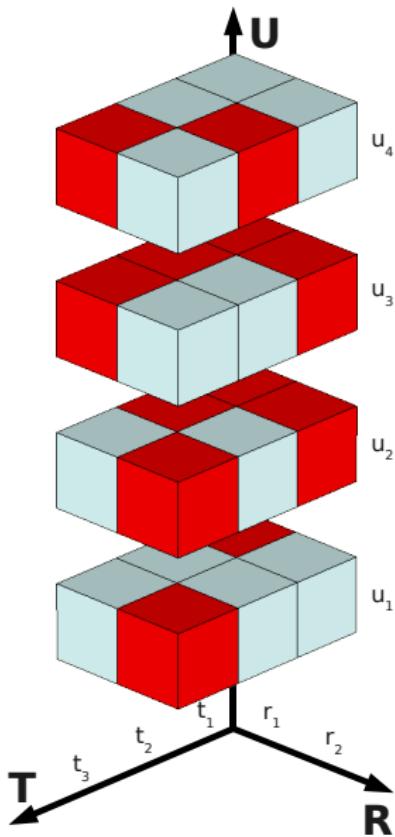


Computing Tri-Concepts

computes the iceberg tri-lattice of a triadic formal context

Algorithm

- Let $\tilde{Y} := \{(u, (t, r)) \mid (u, t, r) \in Y\}$

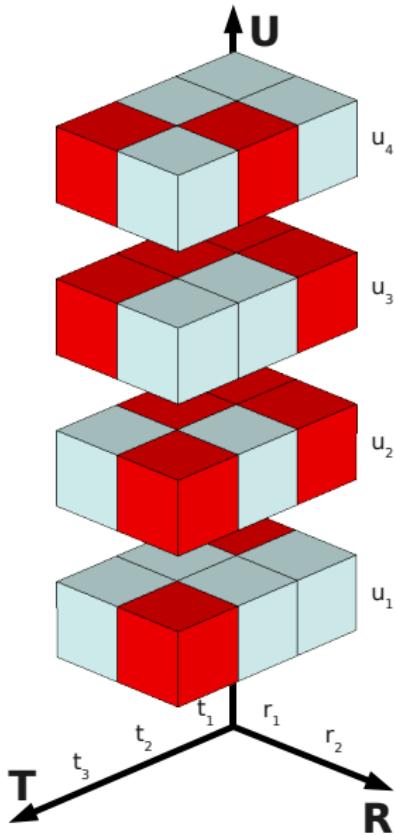


Computing Tri-Concepts

computes the iceberg tri-lattice of a triadic formal context

Algorithm

- Let $\tilde{Y} := \{(u, (t, r)) \mid (u, t, r) \in Y\}$
- Loop: Find (frequent) concepts (\mathbf{A}, I) in $(U, T \times R, \tilde{Y})$



Computing Tri-Concepts

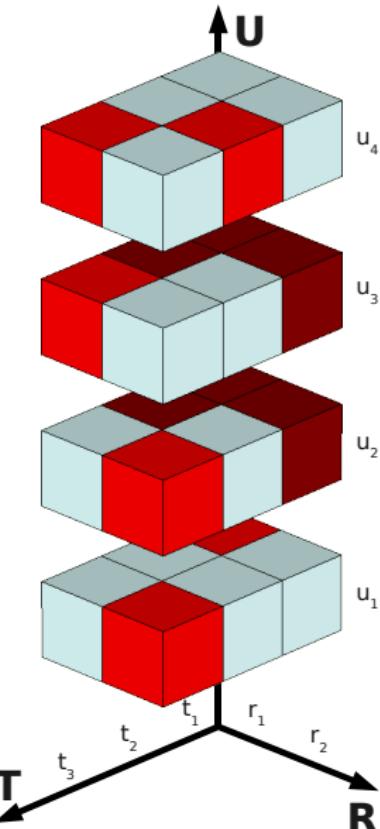
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In the example:

$$(A, I) = (\{u_2, u_3\}, \{(t_1, r_1), (t_1, r_2), (t_2, r_1)\})$$



Computing Tri-Concepts

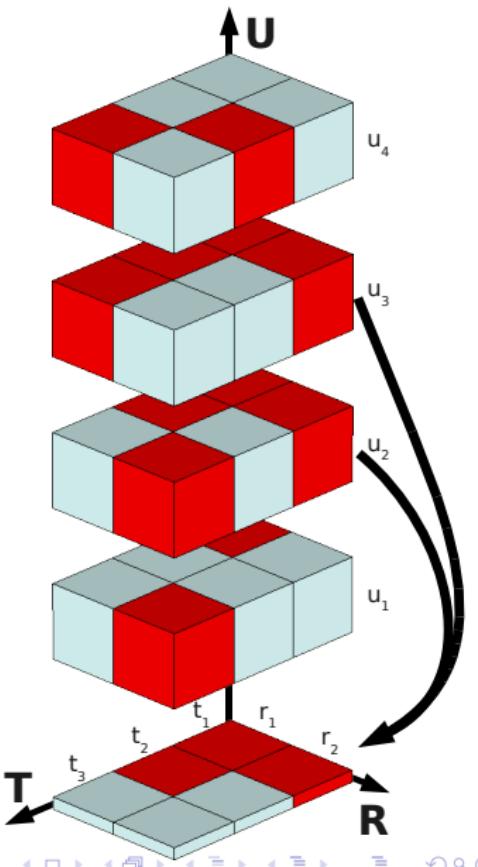
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 - ▷ Loop: Find (frequent) concepts (\mathbf{B}, \mathbf{C}) in (T, R, I)

In the example:

$$(T, R, I) = (T, R, \{(t_1, r_1), (t_1, r_2), (t_2, r_1)\})$$



Computing Tri-Concepts

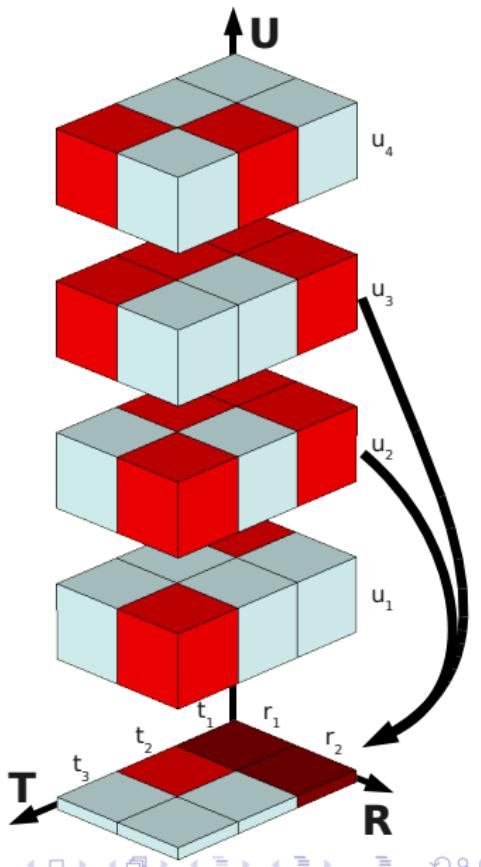
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In the example:

$$(\mathbf{B}, \mathbf{C}) = (\{t_1\}, \{r_1, r_2\})$$



Computing Tri-Concepts

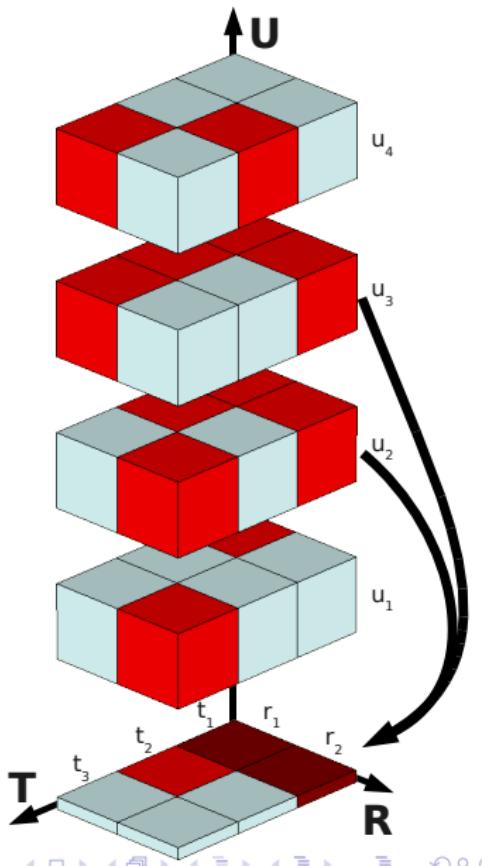
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 - Loop: Find (frequent) concepts (\mathbf{B}, \mathbf{C}) in (T, R, I)
 - If $\mathbf{A} = (\mathbf{B} \times \mathbf{C})^{\tilde{Y}}$, then output $(\mathbf{A}, \mathbf{B}, \mathbf{C})$

In the example:

$$(B \times C)^{\tilde{Y}} = (\{t_1\} \times \{r_1, r_2\})^{\tilde{Y}}$$



Computing Tri-Concepts

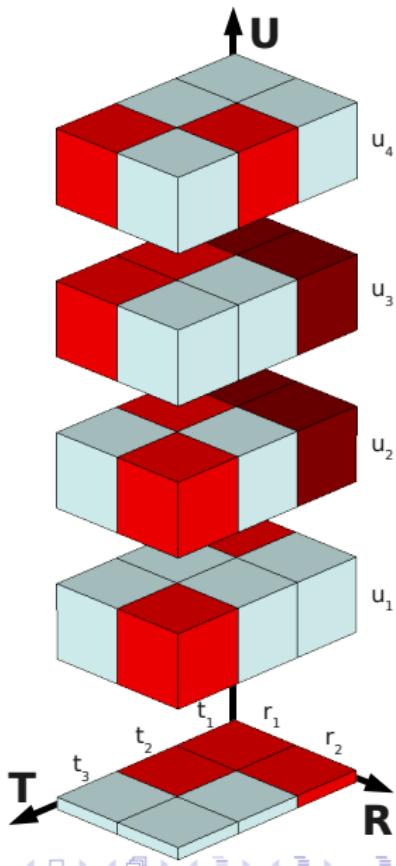
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In the example:

$$\begin{aligned}(B \times C)^{\tilde{Y}} &= (\{t_1\} \times \{r_1, r_2\})^{\tilde{Y}} \\ &= \{u_2, u_3\} = A\end{aligned}$$



Computing Tri-Concepts

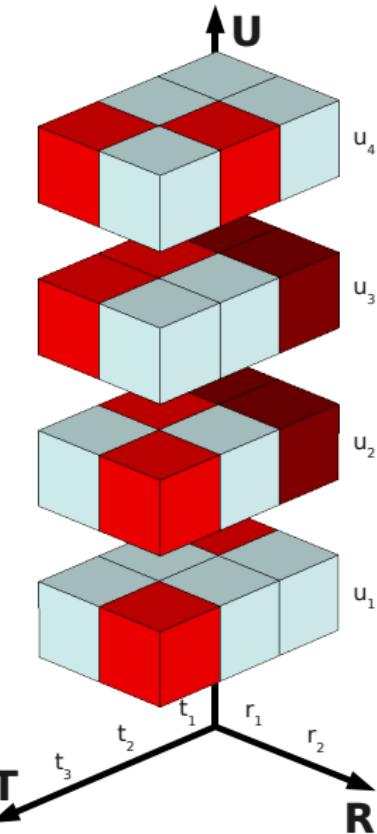
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 - Loop: Find (frequent) concepts (\mathbf{B}, \mathbf{C}) in (T, R, I)
 - ★ If $\mathbf{A} = (\mathbf{B} \times \mathbf{C})^{\tilde{Y}}$, then output $(\mathbf{A}, \mathbf{B}, \mathbf{C})$

In the example:

$$(A, B, C) = (\{u_2, u_3\}, \{t_1\}, \{r_1, r_2\})$$



Computing Tri-Concepts

Require: $U, T, R, Y, \tau_u, \tau_t, \tau_r$

```
1:  $\tilde{Y} := \{(u, (t, r)) \mid (u, t, r) \in Y\}$ 
2:  $(A, I) := \text{FirstFrequentConcept}((U, T \times R, \tilde{Y}), \tau_u)$ 
3: repeat
4:   if  $|I| \geq \tau_t \cdot \tau_r$  then
5:      $(B, C) := \text{FirstFrequentConcept}((T, R, I), \tau_t)$ 
6:     repeat
7:       if  $|C| \geq \tau_r$  then
8:         if  $A = (B \times C)^{\tilde{Y}}$  then
9:           print A,B,C
10:          end if
11:        end if
12:        until not  $\text{NextFrequentConcept}((B, C), (T, R, I), \tau_t)$ 
13:      end if
14:    until not  $\text{NextFrequentConcept}((A, I), (U, T \times R, \tilde{Y}), \tau_u)$ 
```

Computing Tri-Concepts

The *FirstFrequentConcept* method:

Require: $(G, M, I), \tau$

- 1: $A := \emptyset^I$
- 2: $B := A^I$
- 3: **if** $|A| < \tau$ **then**
- 4: $\text{NextFrequentConcept}((A, B), (G, M, I), \tau)$
- 5: **end if**
- 6: **return** (A, B)

Computing Tri-Concepts

the *NextFrequentConcept* method:

Require: $(A, B), (G, M, I), \tau$

```
1: i := max(M)
2: while defined(i) do
3:   A :=  $(B \bullet i)^I$ 
4:   if |A|  $\geq \tau$  then
5:     D := AI
6:     if B <i D then
7:       B := D
8:     return true
9:   end if
10:  end if
11:  i := max(M \ B ∩ {1, ..., i - 1})
12: end while
13: return false
```

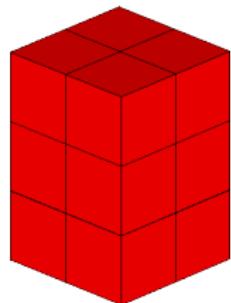
Qualitative Evaluation

BibSonomy Dataset:

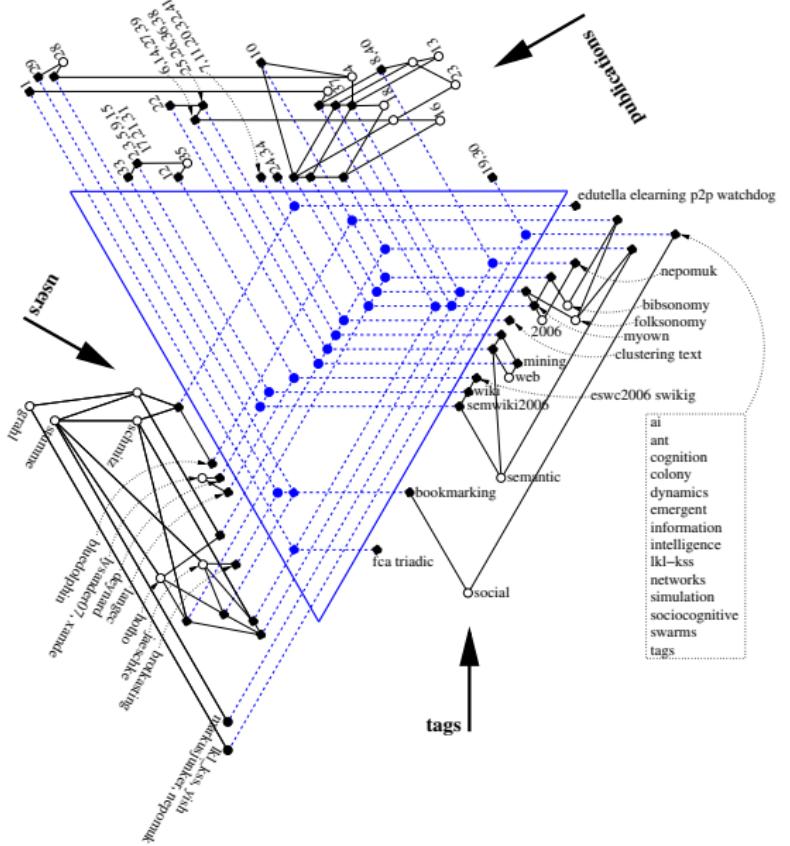
- all publication records until November 23rd, 2006
- removed: DBLP, posts with the tag “imported”
- $|U| = 262$, $|T| = 5\,954$, $|R| = 11\,101$, $|Y| = 44\,944$

Result:

- 13 992 tri-concepts (75 minutes on a 2 GHz PC)
- with support constraints $\tau_u = 3$, $\tau_t = 2$, $\tau_r = 2$:
 - 21 tri-concepts
 - contain 41 publications, 15 users and 36 tags

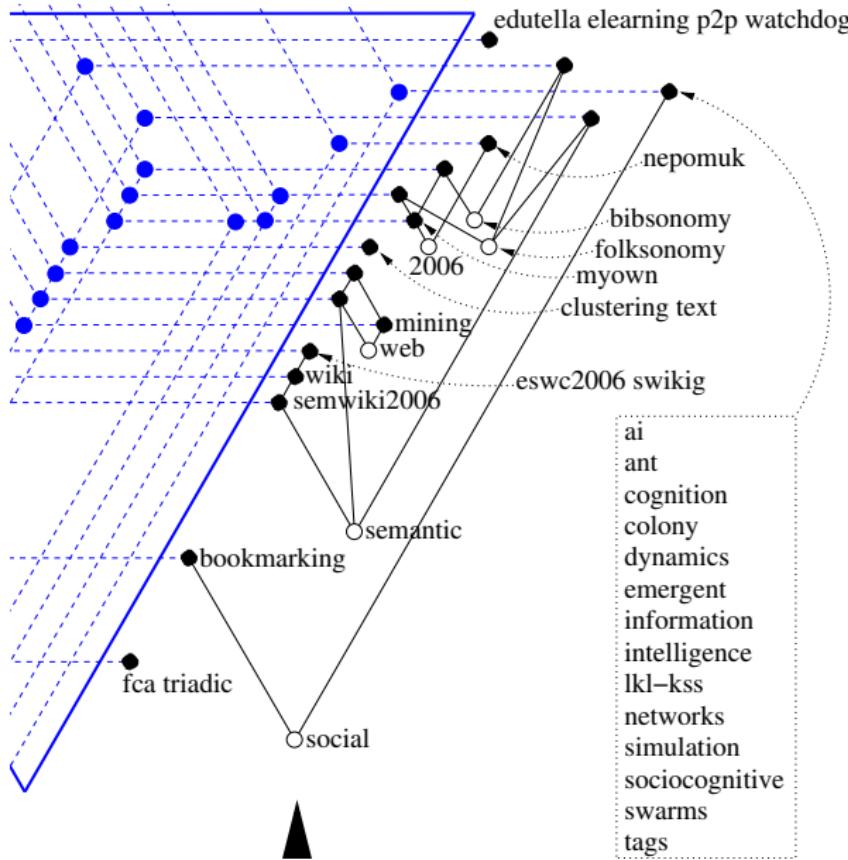


Qualitative Evaluation

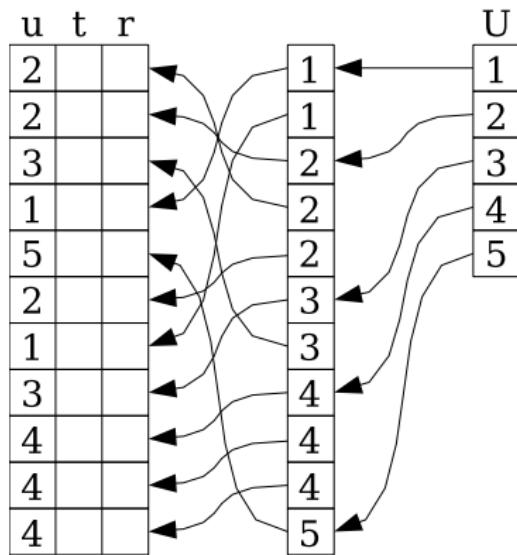


visualisation of the iceberg tri-lattice for $\tau_u = 3$, $\tau_t = 2$,
 $\tau_r = 2$

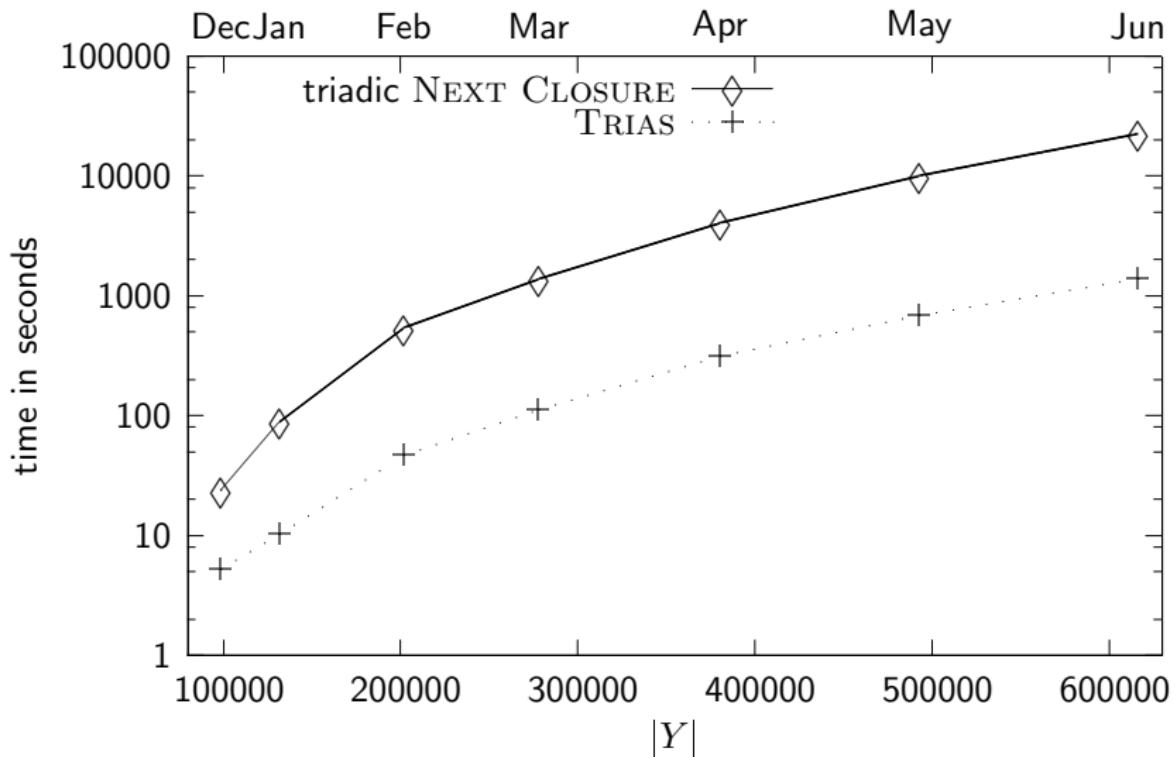
Qualitative Evaluation



Qualitative Evaluation



Qualitative Evaluation

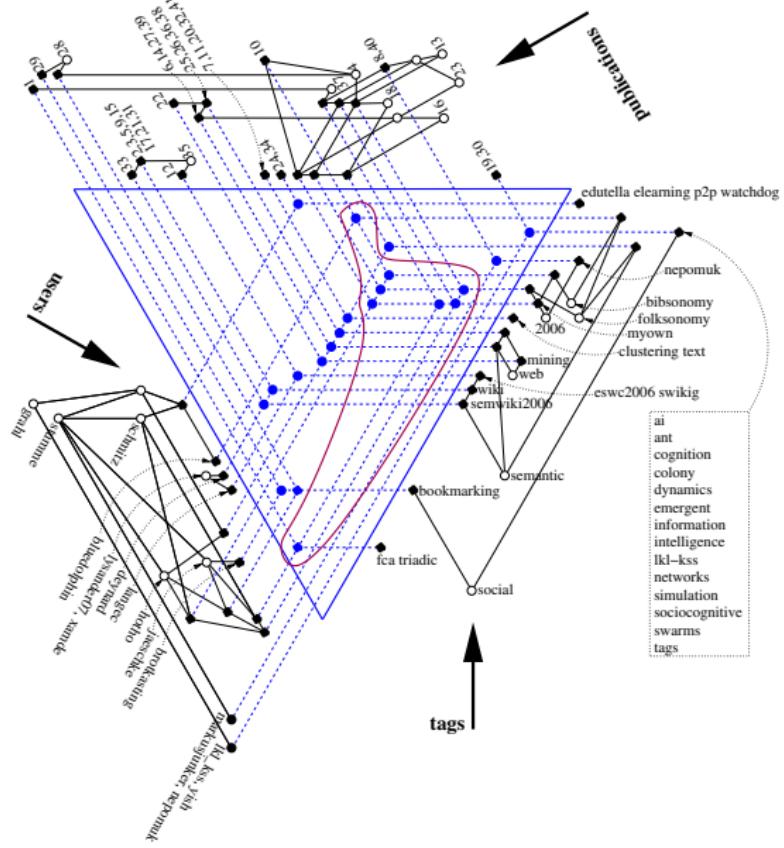


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2	Annotation and Navigation in Semantic Wikis
3	A Semantic Wiki for Mathematical Knowledge Management
4	BibSonomy: A Social Bookmark and Publication Sharing System
5	Bringing the "Wiki-Way" to the Semantic Web with Rhizome
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7	Conceptual Clustering of Text Clusters
8	Content Aggregation on Knowledge Bases using Graph Clustering
9	Creating and using Semantic Web information with Makna
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16	Kollaboratives Wissensmanagement
17	Learning with Semantic Wikis
18	Mining Association Rules in Folksonomies
19	On Self-Regulated Swarms, Societal Memory, Speed and Dynamics
20	Ontologies improve text document clustering
21	Proceedings of the First Workshop on Semantic Wikis – From Wiki To Semantics

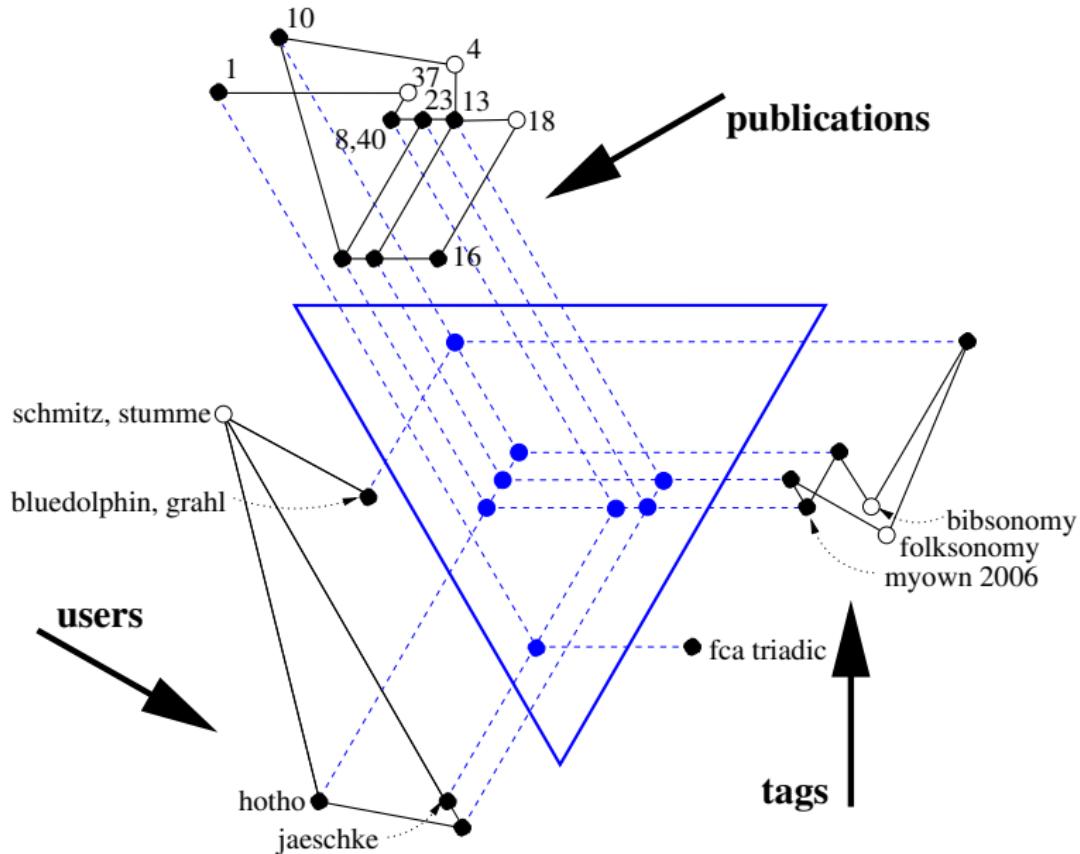
22	Proc. of the European Web Mining Forum 2005
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24	Semantic Resource Management for the Web: An ELearning Application.
25	Semantic Web Mining
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37	TRIAS - An Algorithm for Mining Iceberg Tri-Lattices
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40	Wege zur Entdeckung von Communities in Folksonomies
41	WordNet improves text document clustering

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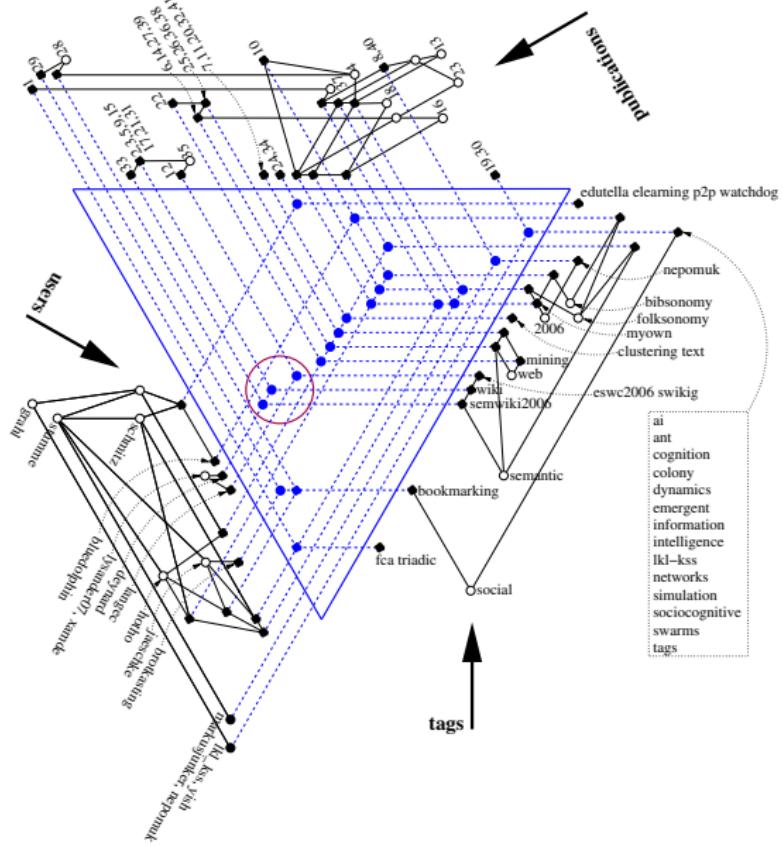
Qualitative Evaluation



Qualitative Evaluation



Qualitative Evaluation



Qualitative Evaluation



publication 33: "'The ABCDE Format Enabling Semantic Conference Proceedings'"

Neighborhoods

The visualization of tri-lattices is . . .

- at the moment manual work,
- time-intensive and pretty complicated,
- or even impossible (cf. *tetrahedron condition* and *Thomson condition*).

Thus: easier visualization option desireable

Neighborhoods

Idea:

- We regard tri-concepts as nodes in a graph.
- We connect two tri-concepts with an edge, when they contain the same tags, users, or resources.

More formally:

- Two tri-concepts (A_1, A_2, A_3) and (B_1, B_2, B_3) are *neighbors*, if for an $i \in \{1, 2, 3\}$ it holds $A_i = B_i$.
- neighbor relation $\sim \subseteq (\underline{\mathcal{B}}(\mathbb{F}) \times \underline{\mathcal{B}}(\mathbb{F}))$
- The *neighborhood graph* then is $(\underline{\mathcal{B}}(\mathbb{F}), \sim)$.

Neighborhoods

neighborhood graph for the tri-concept

($\{jaeschke, schmitz, stumme\}$, $\{fca, triadic\}$, $\{1, 37\}$)

bluedolphin, grahl, schmitz, stumme
bibsonomy, folksonomy
4, 10



hoho, schmitz, stumme
2006, bibsonomy, myown
4, 10

hoho, schmitz, stumme
2006, folksonomy, myown
4, 13, 16, 18

hoho, schmitz, stumme
2006, myown
4, 10, 13, 16, 18, 23

jaeschke, schmitz, stumme
2006, myown
4, 8, 13, 18, 23, 37, 40

hoho, jaeschke, schmitz, stumme
2006, folksonomy, myown
4, 13, 18

hoho, jaeschke, schmitz, stumme
2006, myown
4, 13, 18, 23

jaeschke, schmitz, stumme
fca, triadic
1, 37