

Formal Concept Analysis

Welcome and Organizational Issues

Robert Jäschke
Asmelash Teka Hadgu

FG Wissensbasierte Systeme/L3S Research Center
Leibniz Universität Hannover

Agenda

- 1 Welcome & Socializing
- 2 Applications of FCA
- 3 Organization
- 4 Literature
- 5 Overview
- 6 Homework
- 7 Mathematical Basics

Welcome & Socializing

- courses?
- semesters?
- prior knowledge?
- *goals & expectations*

Welcome & Socializing: Prior Knowledge

- Set
- Intersection
- Union
- Subset
- Superset
- Implication
- Partial Order
- Transitivity
- Lattice
- Isomorphism
- Apriori Algorithm

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History of Formal Concept Analysis

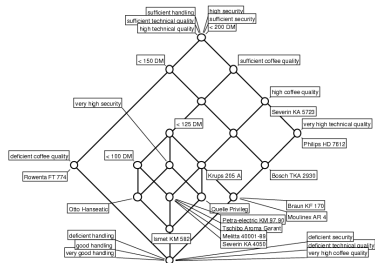
Formal Concept Analysis (FCA) originated in Darmstadt, Germany around 1980 as a mathematical theory that delivers a formalization of the concept of a “concept”.

Since then, FCA spread into different areas of computer science, e.g.,

- data analysis
- knowledge discovery
- software engineering

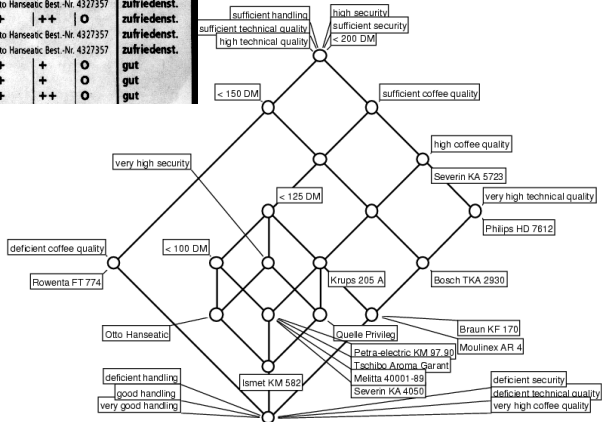
Starting from datasets, FCA derives concept hierarchies. FCA allows you to create and visualize concept hierarchies based on well-grounded mathematical foundations.

STIFTUNG WARENTEST		KAFFEEEMASCHINEN MIT WARMHALTEKANNE (8 bis 10 Tassen)					test Ausgabe: 1998
test		KOMPASS					
	Mittlere Preis in DM ca.	Preis für Ersatzkanne/Gläseinsatz in DM ca.	Kaffeequalität	Technische Prüfung	Sicherheit	Handhabung	test-Qualitätsurteil
Gewichtung			35 %	30 %	10 %	25 %	
Neckermann Best.-Nr. 8628/409	40,-	35,- / □	gut	mit Otto Hanseatic Best.-Nr. 4327357	+	+	zufriedenst.
Otto Hanseatic Best.-Nr. 4327357	40,-	30,- / □	o	+	++	o	zufriedenst.
Quelle Privileg Best.-Nr. 7090720	40,-	24,50 / 17,50	gut	mit Otto Hanseatic Best.-Nr. 4327357	+	+	zufriedenst.
Severin KA 9650	50,-	35,- / 23,-	gut	mit Otto Hanseatic Best.-Nr. 4327357	+	+	gut
Severin KA 4050	80,-	50,- / □	+	+	+	o	gut
Tchibo Aroma Garant Art.-Nr. 48469	80,-	27,50 / 19,50	+	+	+	o	gut
Ismer KM 582 starlight	84,-	47,- / 14,-	+	+	++	o	gut

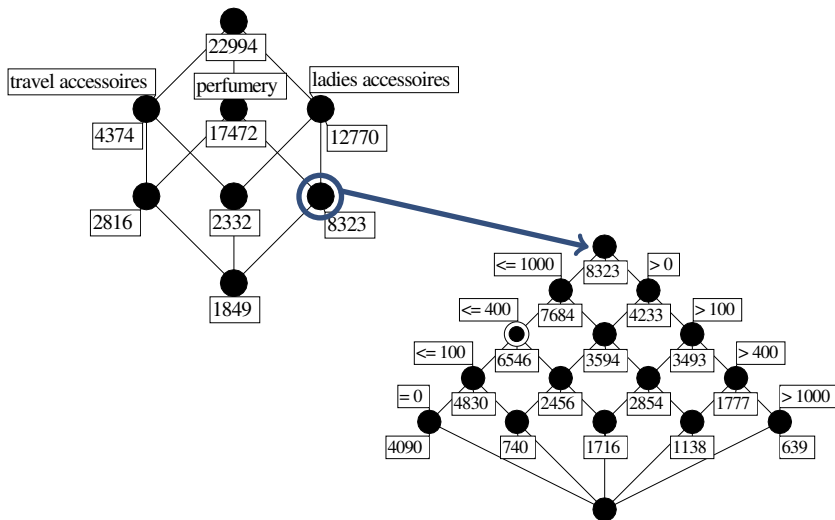


Example: Comparison of Coffee Machines

STIFTUNG WARENTEST test		KAFFEEMASCHINEN MIT WARM- HALTEKANNE (8 bis 10 Tassen)					test Ausgabe 12/98
	Mittlerer Preis in DM ca.	Preis für Er- satzkanne/ Glaseinsatz in DM ca.	Kaffee- qualität	Techni- sche Prü- fung	Sicher- heit	Hand- ha- bung	test- Qualitätsurteil
Gewichtung			35 %	30 %	10 %	25 %	
Neckermann Best.-Nr. 8628/409	40,-	35,- ¹⁾ / □					zufriedenst.
Otto Hanseatic Best.-Nr. 4327357	40,-	30,- ²⁾ / □	○	+	++	○	zufriedenst.
Quelle Privileg Best.-Nr. 7030720	40,-	24,50 / 17,50		baugl. mit Otto Hanseatic Best.-Nr. 4327357			zufriedenst.
Severin KA 9660	50,-	35,- / 23,-		baugl. mit Otto Hanseatic Best.-Nr. 4327357			zufriedenst.
Severin KA 4050	80,-	50,- / □	+	+	+	○	gut
Tchibo Aroma Garant Art.-Nr. 48469	80,-	27,50 / 19,50	+	+	+	○	gut
Ismet KM 582 starlight	84,-	47,- / 14,-	+	+	++	○	gut



Database Marketing at Jelmoli AG, Zurich¹

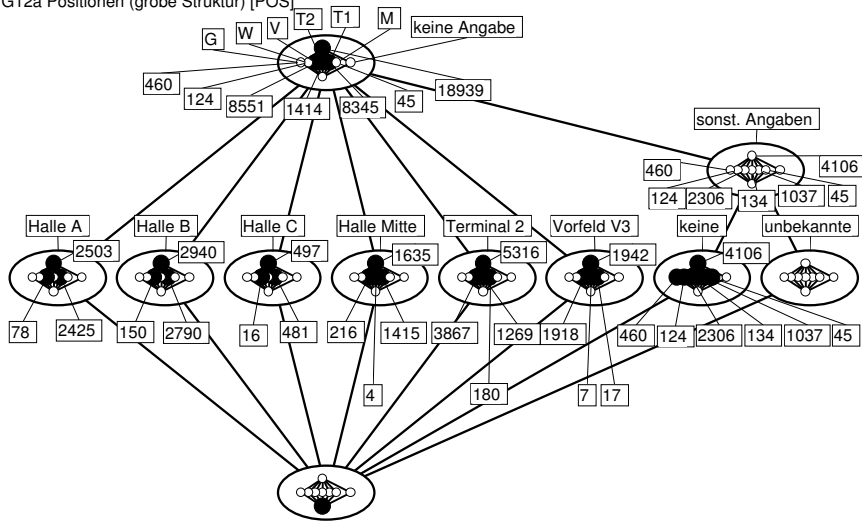


¹ J. Hereth, G. Stumme, R. Wille, and U. Wille. Conceptual knowledge discovery and data analysis. In *Proc. ICCS 2000*, volume 1867 of *LNCS*, pages 421–437. Springer, Berlin/Heidelberg, 2000.

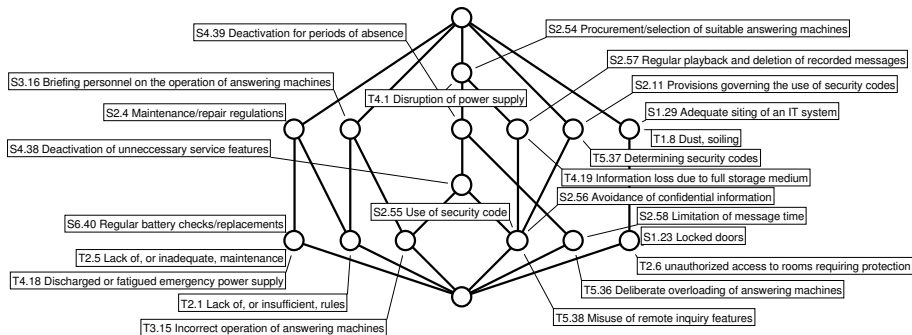
Analysis of Plane Movements at Frankfurt Airport²

O12 Ort der benötigten Staubahn [SBE]

G12a Positionen (grobe Struktur) [POS]

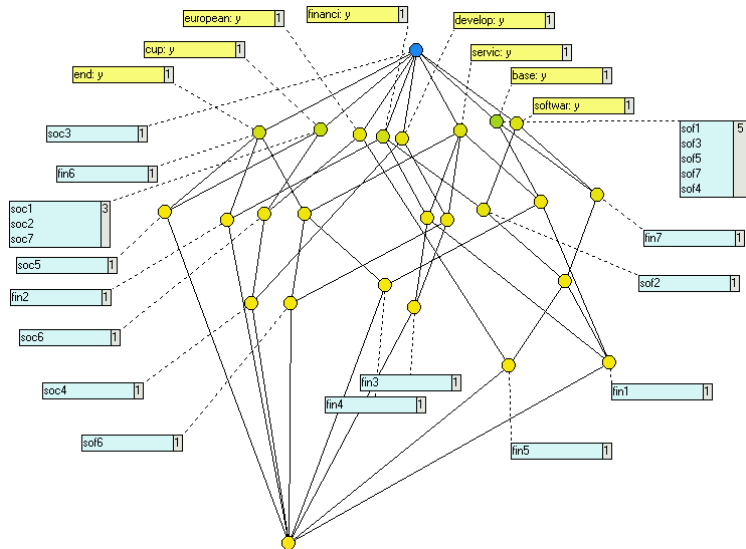


² G. Stumme, R. Wille, and U. Wille. Conceptual knowledge discovery in databases using formal concept analysis methods. In *Proc. PKDD*, volume 1510 of *LNCS*, pages 450–458. Springer, Berlin/Heidelberg, 1998.



³K. Becker, G. Stumme, R. Wille, U. Wille, and M. Zickwolff. Conceptual information systems discussed through an it-security tool. In Rose Dieng and Olivier Corby, editors, *Knowledge Engineering and Knowledge Management Methods, Models, and Tools*, volume 1937 of *LNCS*, pages 352–365. Springer, Berlin/Heidelberg, 2000.

Text Clustering⁴



⁴ A. Hotho, S. Staab, G. Stumme. Ontologies improve text document clustering. In *Proc. ICDM*, pages 541–544, 2003.

Concept Email Manager

list of referees: ICCS-2000 - ICCS2000 - Netscape-Ordner

Datel Bearbeiten Ansicht Gehe Nachricht Communicator Hilfe

Nachr. abr. Neue Nachr. Antwort Antwort an alle Weiterleiten Ablegen Nächste Drucken Löschen Stop

Name	Ungelesen	Insgesamt
Drafts		
Templates		
Sent		1651
Trash	2	1639
AIFB		94
AUSTRALIA	???	
cole.richard		26
eklund.peter		73
groh.bernd	???	
martin.philippe	???	
CALLFORPAPERS		17
Conferences	1	
ECAI02-Workshop		26
ECML01...orkshop	1	262
mailingaktion	???	
antworten	???	
lesenswert	???	
ICCS2000	1	187
CAMER**\$M.SUM	???	
CAMER**MIB	???	

Betreff	Absender	Datum	Priorität
final notification	Guy Mineau	25.05.2000 16:37	
ICCS2000	Janos Sarbo	26.05.2000 15:20	
Re: Returned mail: Host u...	Alex Borgida	26.05.2000 17:40	
status of all papers	Guy Mineau	29.05.2000 16:50	
expenses covered to go t...	Guy Mineau	29.05.2000 20:22	
Re: Confirmation ICCS2000	Galia Angelova	30.05.2000 08:29	
additional reviewer for ICC...	Harry Delugach	30.05.2000 21:30	
list of referees: ICCS-2000	Guy Mineau	30.05.2000 21:32	
other referees: reminder	Guy Mineau	30.05.2000 21:59	
list of referees: ICCS...	Peter Eklund	31.05.2000 11:...	
Additional reviewers	Ulrike Sattler	31.05.2000 11:46	
Re: List of Referees	Pavel Kocura	31.05.2000 12:40	
Re: ICCS 2000	Deborah L. McGuinness	31.05.2000 20:38	
Please help with accomo...	Guy Mineau	31.05.2000 21:20	

Betreff: list of referees: ICCS-2000
Datum: Wed, 31 May 2000 11:01:11 +0200 (MEST)
Von: [Peter Eklund <Peter.Eklund@sophia.inria.fr>](mailto:Peter.Eklund@sophia.inria.fr)
An: stumme@mathematik.tu-darmstadt.de
CC: ganter@math.tu-dresden.de

Richard
Bernd C

Nachrichten insgesamt: 187 Ungelesene Nachrichte

*Conferences/ICCS2000
vs.
AUSTRALIA/eklund.peter*

conventional e-mail programs store mails in a tree structure
→ only one search path exists which must already been set when saving the mail

Concept Email Manager

The screenshot displays the Concept Email Manager (CEM) application window. The interface includes a menu bar (File, Lattice, View), a toolbar with icons for file operations, and a hierarchical tree view on the left for organizing emails. The main area shows a list of emails with columns for count, status, and keywords. A callout box highlights that emails can be tagged with multiple keywords. The right pane shows the content of a selected email from Gerd Stumme.

Callout: In CEM an e-mail can be tagged with several keywords.

From	Count	Status	Keywords
From Friends	185	+	+
From Organisation	1878	✓	+
From Griffith Uni	1431	✓	+
From KVO Members	937	+	+
From Darmstadt Group	308	✓	+
From Rudolf Wille	0	+	+
From Jo Hereth	10	+	+
From Gerd Stumme	298	✓	+
from Gerd	298	✓	+
from stumme@	286	+	+
From g.stumme@	12	✓	+
From Darmstadt	46	+	+
From Mailing List	2617	+	×
CG Mailing List	329	+	×
To Hermes	2117	+	×
To Hermes Elec	427	+	×
To Hermes Chat	893	+	×
To Hermes Joke	736	+	×
Text Retrieval List	171	+	×
Conferences	143	✓	+

Email Content (Selected):

Blank | Navig

From: Gerd Stumme

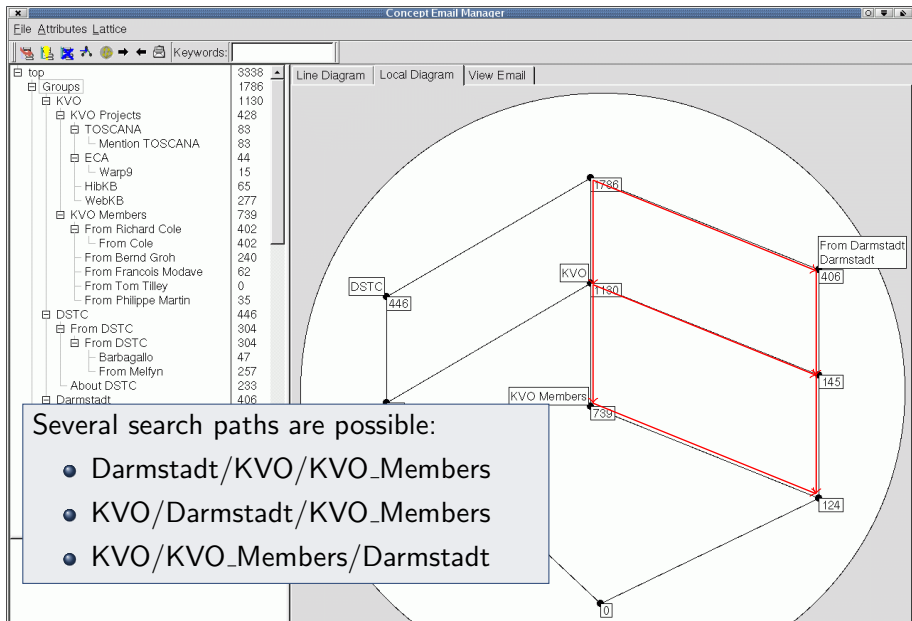
Subject: Paper

to: "r.cole@gu.edu.au" <r.cole@gu.edu.au>
<stumme@mathematik.tu-darmstadt.de>
from: "Gerd Stumme" <g.stumme@gu.edu.au>
Subject: Paper

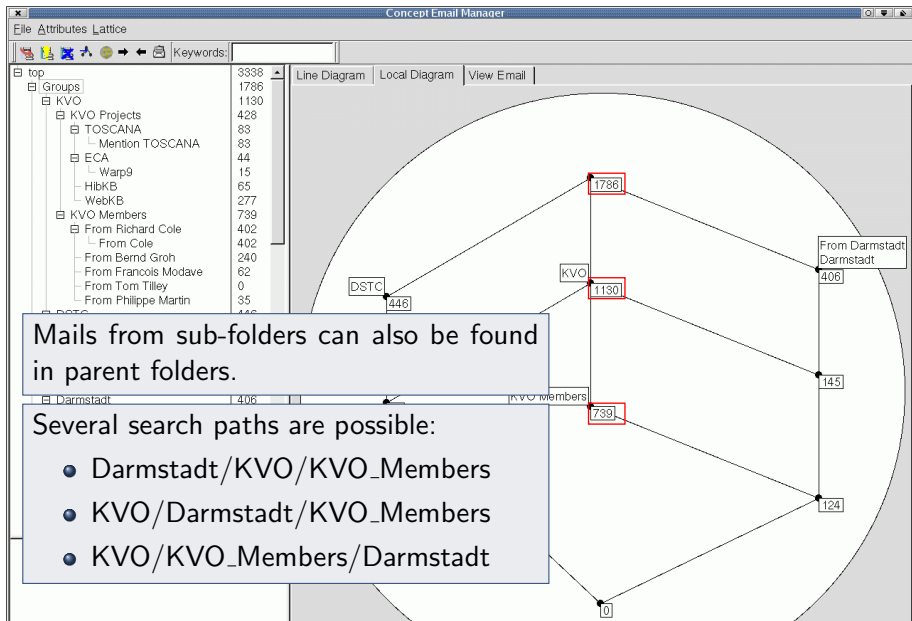
Hi Richard,

here's the Tex-File of our paper. :
lincs.cls, please have a look at it
follow the links to the Springer Au

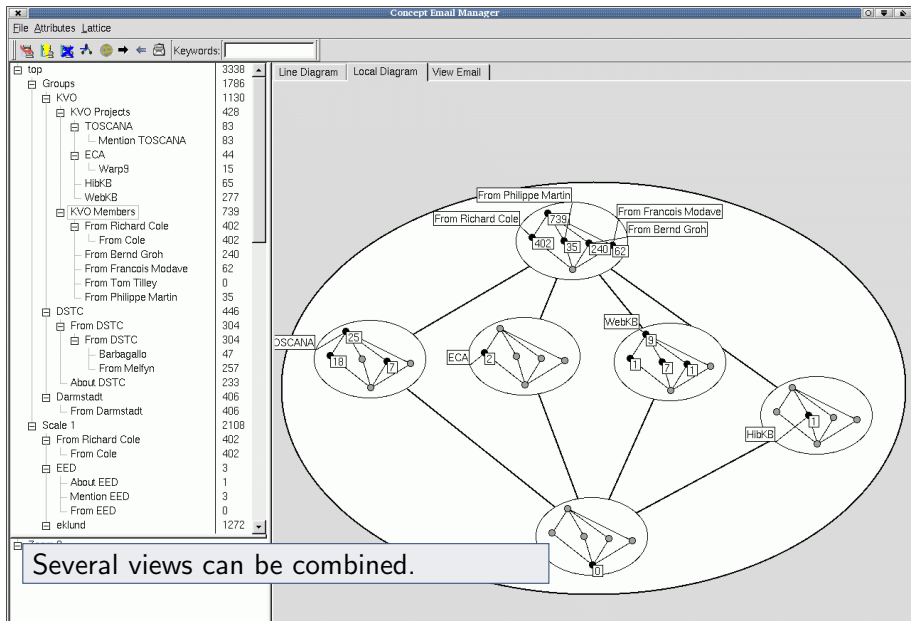
Concept Email Manager



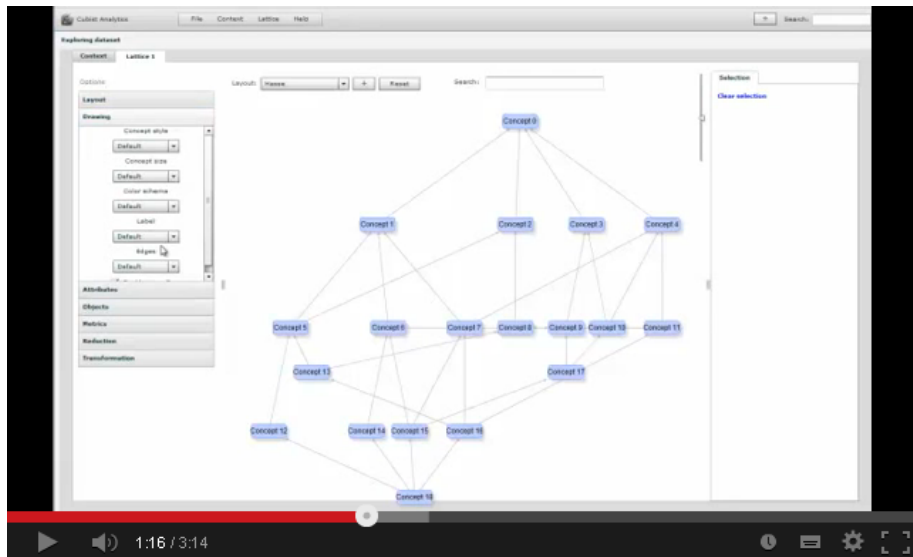
Concept Email Manager



Concept Email Manager



CUBIST Visual Analytics



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Organization

Lectures and Exercises

lecture Tuesday, 14:00 – 15:30, room 235

hands-on exercise Tuesday, 10:00 – 11:30, room 235

Material

overview <http://www2.kbs.uni-hannover.de/fca.html>

slides & exercises [http://www.kbs.uni-hannover.de/
~jaeschke/teaching/2015w/fca/](http://www.kbs.uni-hannover.de/~jaeschke/teaching/2015w/fca/)

Stud.IP <https://elearning.uni-hannover.de/>

Contact

Robert Jäschke jaeschke@l3s.de, room 203, afternoon or scheduled individually

Asmelash Teka Hadgu asmelashtk@gmail.com, scheduled individually

- we experiment with new forms of teaching, learning, and cooperation
- (occasionally) highly interactive lecture
- framework:
 - assuming responsibility
 - lecture is a process, participating actively
 - doing something on your own
- my goal is good teaching which (necessarily) is interactive

How did you understand this?

hands-on exercise means

- *autonomous work* on the practice sheet in small teams of 3-4 students, under supervision
- *no general repetition* of lecture material
- *no general demonstration* of the solution (will be provided later)

necessary for that is

- making notes during the lecture
- performing autonomous follow-up course work *before* the exercise
- bringing the script and your notes to the exercise
- developing own activity

Why this exercise concept?


- active development of the lecture material is more effective
- discovering relationships in the material
- learning structured thinking and autonomous working
- learning team work
- learning to explain things
- exercise for the exams ;-)
- *You have finished your study of . . . Your personal strengths include pro-activity and team work, you are communicative and willing to cooperate.* (typical job advertisement)


Organization: Exams


- oral exam at the end of the semester
- you can choose a topic to start with
- you are generating exam questions:
 - after every lecture each of you devises two questions
 - ask yourself *“Which question should I ask my fellow students to see if they really understood what today’s lecture was about?”*
 - answer the two questions by yourself
 - write down the answer+question
 - at the beginning of the next lecture, one question+answer is presented and all other questions are collected
 - promise: we will take some of the questions for the exam


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 Bernhard Ganter.
Diskrete Mathematik: Geordnete Mengen.
Springer, Berlin/Heidelberg, 2013.

 Bernhard Ganter and Rudolf Wille.
Formal Concept Analysis: Mathematical Foundations.
Springer, Berlin/Heidelberg, 1999.

 Robert Jäschke, Andreas Hotho, Christoph Schmitz, Bernhard Ganter, and Gerd Stumme.
Discovering shared conceptualizations in folksonomies.
Web Semantics: Science, Services and Agents on the World Wide Web, 6(1):38–53, February 2008.

 Gerd Stumme, Rafik Taouil, Yves Bastide, Nicolas Pasquier, and Lotfi Lakhal.
Computing iceberg concept lattices with TITANIC.
Data & Knowledge Engineering, 42(2):189–222, August 2002.

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Organization

I Contexts, Concepts, and Concept Lattices

- ① Concept Lattices
- ② Multi-valued Contexts and Conceptual Scales

II Closure Systems and Implications

- ③ Closure Systems
- ④ Implications

III Knowledge Discovery

- ⑤ Attribute Exploration
- ⑥ Rule Exploration
- ⑦ Attribute Exploration with Background Knowledge

IV Extensions of FCA

- ⑧ Triadic Formal Concept Analysis

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Homework

The next lecture

- will be highly interactive
- requires careful preparation by each one of you

Prepare for the next lecture

Read the following works about concepts and conceptual modelling

- <http://www.alleydog.com/glossary/definition.php?term=Concept>
- <http://general-psychology.weebly.com/how-are-concepts-formed.html>
- Walter Edelmann *Lernpsychologie*, 6. Auflage, 2000. Kapitel 4.2 (Seiten 116-130, insbesondere Kapitel 4.2.1 zu “Eigenschaftsbegriffen” und “klassischer Theorie”)

Identify the most important and common ideas and concepts and write them down. You need them in the next lecture, where we will try to mathematically formalize the concept of “concept”.


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On the blackboard:

- definition of partial order
- definition of total order
- examples

 On the blackboard:

- lower bound, upper bound
- infimum (join, \wedge), supremum (meet, \vee)
- Def. (complete) lattice (V, \leq)
- $0_V, 1_V$

Mathematical Basics: Vacuous Truth

Logic: a statement about elements of the empty set

Example

- $P :=$ all cell phones in the room are turned off
- $Q :=$ all cell phones in the room are turned on
- $P \wedge Q$

What if there are no cell phones in the room?

A statement $P \Rightarrow Q$ is *vacuously true*, if P is known to be false.

- $\forall g : P(g) \Rightarrow Q(g)$ is always true when $\forall g : \neg P(g)$
- $\forall g \in A : Q(a)$ is always true when ...?
- $\forall g \in A : (g, m) \in I$ is always true when ...?
- $\{m \in M \mid \forall g \in A : (g, m) \in I\}$ for $A = \emptyset$ is equal to ...?