

Knowledge Engineering for Software Development

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Prof. Tatiana Gavrilova

Education: 1975 - MSc, St.Petersburg State Railway University

1986 - Ph.D in computer science at St. Petersburg State Polytechnic

1996 - Doctor of Science Degree in Artificial Intelligence at the same University

Research area: Knowledge Management, Cognitive Modelling, Human-Computer Interaction, Intelligent Information Systems in management.

Experience: 2007-present: Head of Information Technologies in Management Dpt., Graduate School of Management, Saint-Petersburgh State University

1996 - present: Full Prof. in Intelligent Computer Technologies Dpt at St.Petersburg State Polytechnic University, free-lance consultant and trainer.

Working abroad: HEC (France), Qatar, Univ. of Pittsburgh (USA), Penn State (USA), First Independent Univ. in Warsaw and Politechnica Gdanska (Poland), Univ.of Milano (Italy), Univ of Espoo (Finland), Tartu Univ. (Estonia).

Membership: IEEE, ACM, IAKM, Head of St. Petersburg Division of Russian Association for Artificial Intelligence, Member of editorial board of journal "AI & Decision making", chairman of Program Committee of Int. conference KESW (Knowledge Engineering and Semantic Web), member of St. Petersburg Scientific Union.

Publications: More than 200 (97 in English)

International co-operation: More than 10 international research projects and visiting 42 countries.

Outline

- Knowledge Engineering for Big Data Age
- Visual Knowledge Models for Knowledge Mapping
- Training for Analysts
- Applications: E-business - Software Development - E-government - Teaching – Research

This express-training introduces students to the practical application of knowledge structuring tools into innovating processes. It will give insight and experience in key issues of knowledge processing in companies. The stress will be put at visual methods as mind mapping and concept-mapping.



How the customer explained it



How the Project Leader understood it



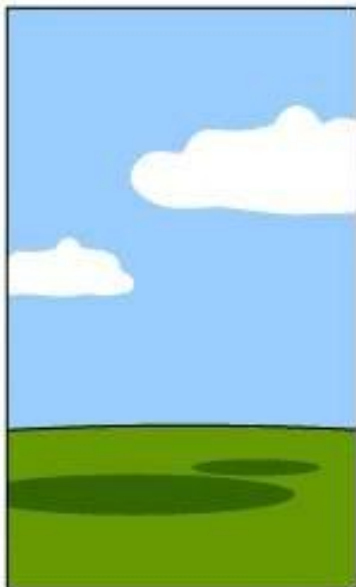
How the Analyst designed it



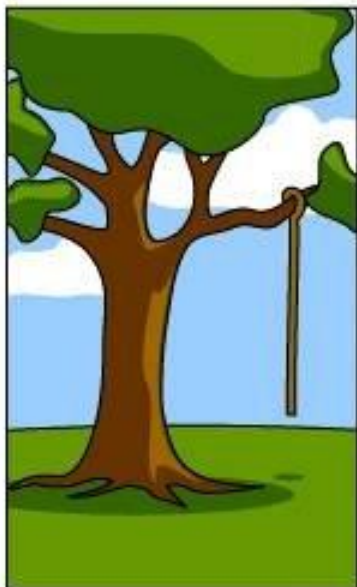
How the Programmer wrote it



How the Business Consultant described it



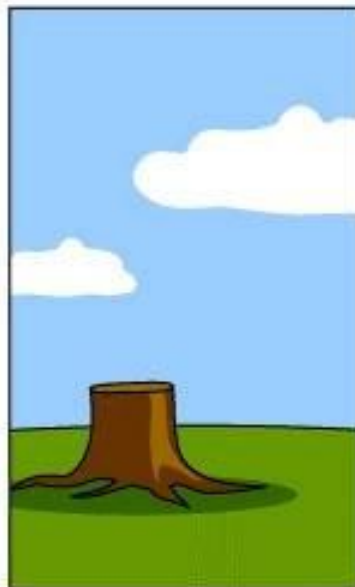
How the project was documented



What operations installed



How the customer was billed



How it was supported

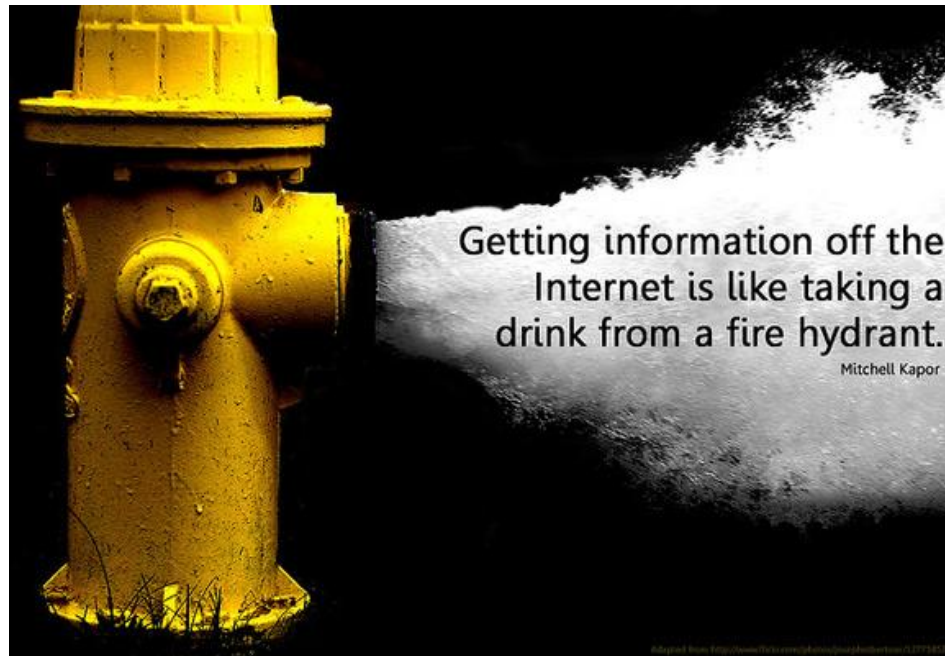


What the customer really needed

Foreword

- Nearly 2 millennia ago, the Roman philosopher Seneca wrote, "What is the use of having countless books and libraries whose titles their owners can scarcely read through in a whole lifetime? **The learner is not instructed but burdened by the mass of them.**"
- The quantity of information produced today is unprecedented. According to the study "How Much Information?" from the University of California-Berkeley, the amount of information produced in the world **increases by about 30% every year.**
- Nowadays, business information environment worldwide is very complex and **over-complicated.**
- Companies need to make use of its entire human and intellectual capital. Most successful companies are the ones which wisely manage what they **know.**

Information Overload (IO)

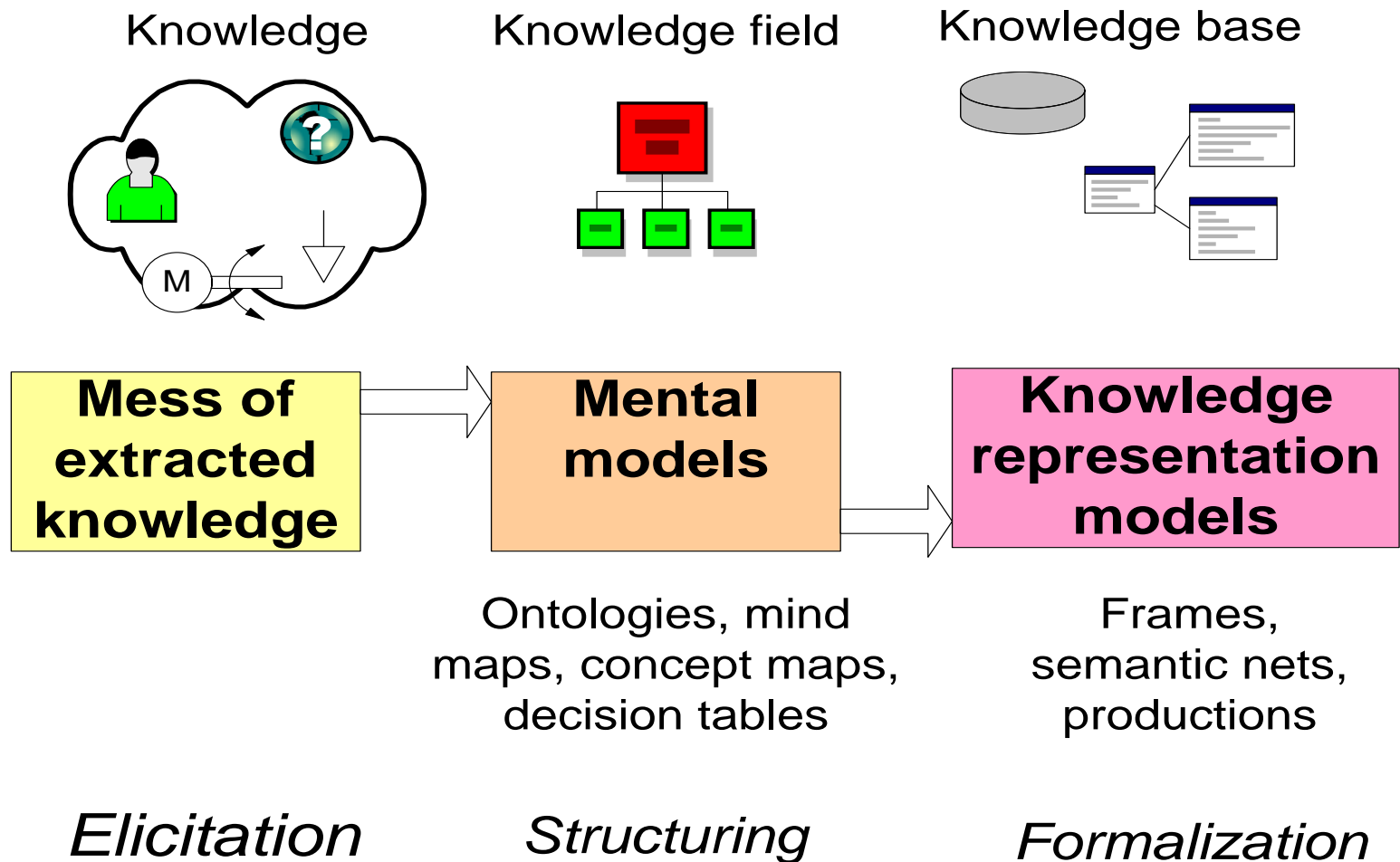


- IO decreases efficiency as individuals and organizations waste time managing it.
- IO is not only about too much data but also about the different types of it. All non-essential information adds to the clutter and ends up as – garbage in...garbage out.

Knowledge engineering

is a science about data and knowledge acquisition, structuring and formalizing methods and technologies for effective knowledge management and/or information systems' development.

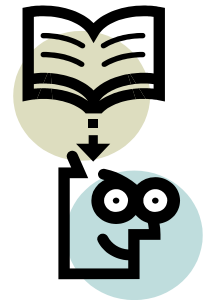
Knowledge Processing and Transformation



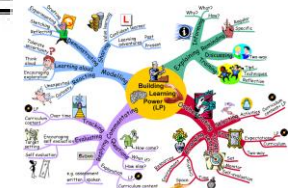
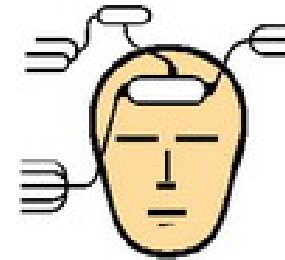
KE structure

Knowledge Engineering

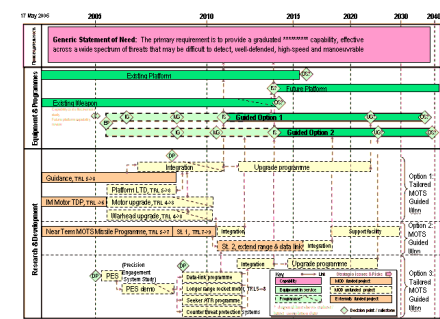
Elicitation



Structuring



Codification



Knowledge Engineering

Knowledge Elicitation (Capture) : is the process of acquiring knowledge from its source/ expert/ group of experts/literature (books, documents, papers).

Knowledge structuring is the process of organizing the acquired knowledge into the knowledge fields.
Knowledge fields shows the main concepts of the domain and relationship between them.

Knowledge Formalizing is the process of transformation of knowledge fields into knowledge bases, which are expressed in knowledge representation languages.

Information

```
graph TD; Information --> Knowledge; Information --> Data; Information --> Content;
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KNOWLEDGE

- The body of truths and principles obtained by mankind from study or investigation (Random House Dictionary) ;
- Rules, concatenating the data and obtained from experience.

DATA

- Factual material used as a basis (Webster);
- Instances and facts characterizing object's, processes and their properties

CONTENT

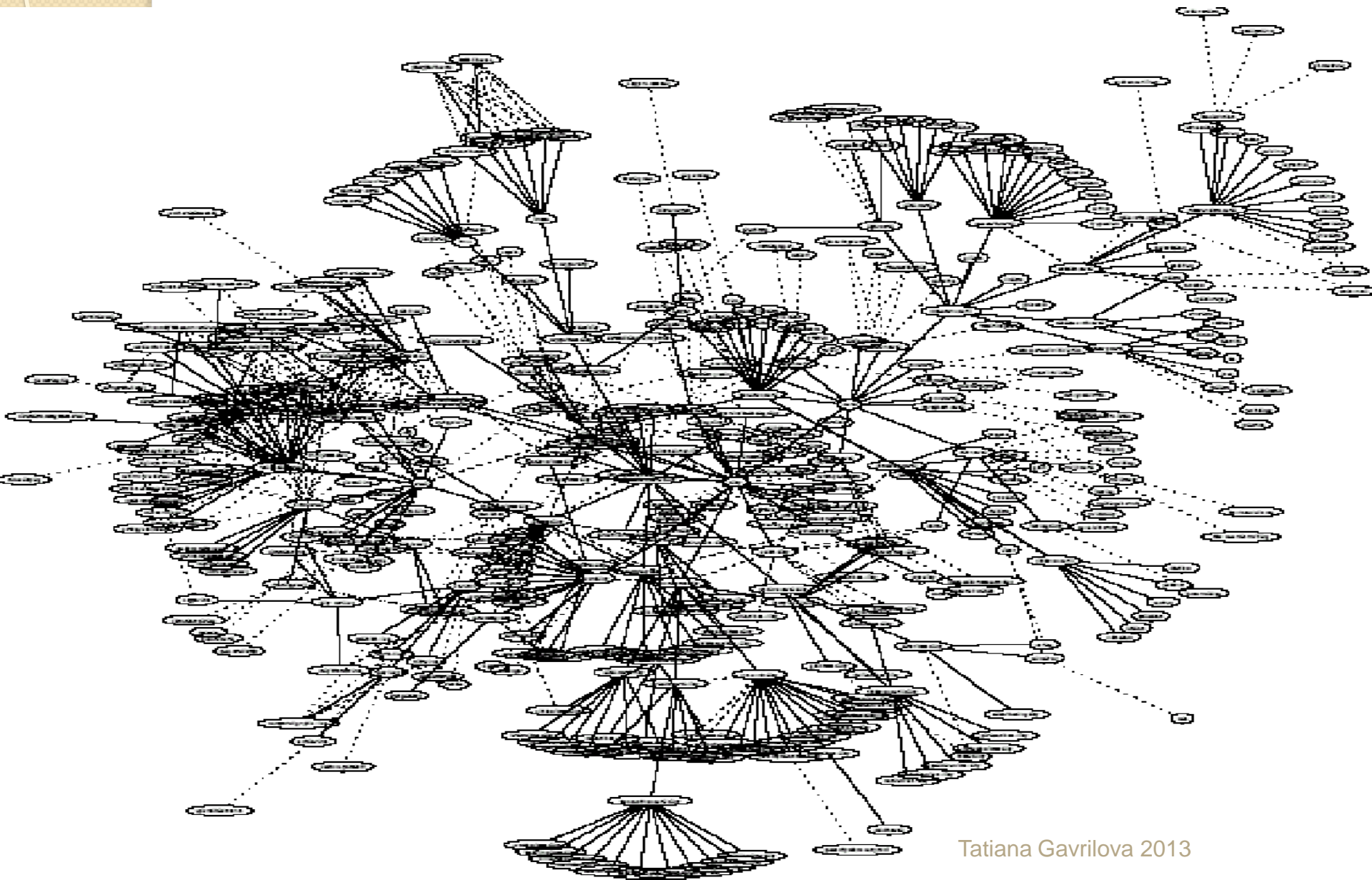
Unstructured pieces of information :
letters, images, audio, video

Knowledge

Knowledge — presents the objective *principles* (foundations, rules, links) of the subject domain, obtained as the *result of the practice*, professional *experience* and *reasoning*. It allows the specialists to set and to solve problems in the arbitrary domains.

Knowledge — is *well-structured data* or data about data or *meta-data*.

Knowledge is well structured Data



Knowledge classifications

by depth

- Deep
- Shallow

by owner

- Personal
- Collective
 - Corporative
 - Family
 - National
- Common

by type

- Explicit
 - Verbal
 - Image
 - Material
 - Published
 - Digital
 - Video
 - Audio
- Tacit
 - Conscious
 - Unconscious

by source

- in person
 - Experiential
 - Theoretical
- with mediator
 - from Books
 - from the Web
 - from Teacher

by application

- Professional
- Everyday
- Cultural

Objectives for Knowledge Structuring

- Systemic terminology management and supervising for better interoperability
- Knowledge sharing in the company
- Development of enterprise vocabulary
- Integration of different conceptual frameworks into innovating process

Knowledge workers:

- Top managers, Chief Information Officer (CIO), Chief Knowledge Officer (CKO)
- Analysts, Problem Originators
- Knowledge Engineers, Cognitive Engineers
- Knowledge Managers, Brokers
- System Architects
- Teachers
- Researchers



The main problem

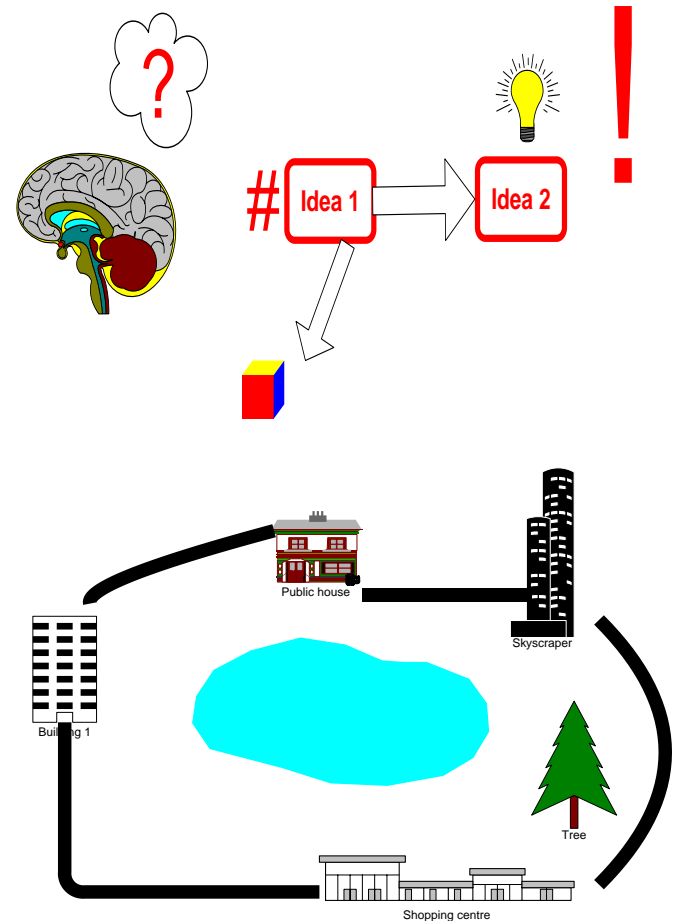
- 99% of research is focused on technology (languages, tools, standards) – it is a problem of HOW present knowledge.
- We are focused on WHAT (what are concepts, relations, content, hidden structures, form, etc.)
- “How” is skill, “what” is art.

Practical problems

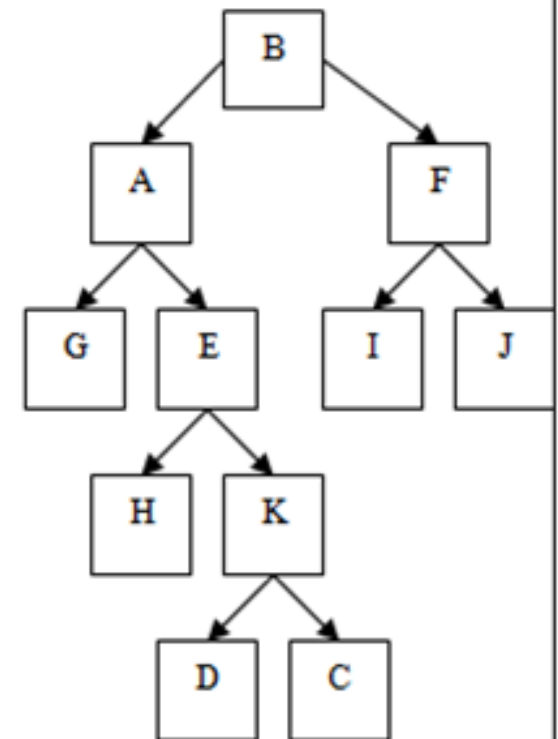
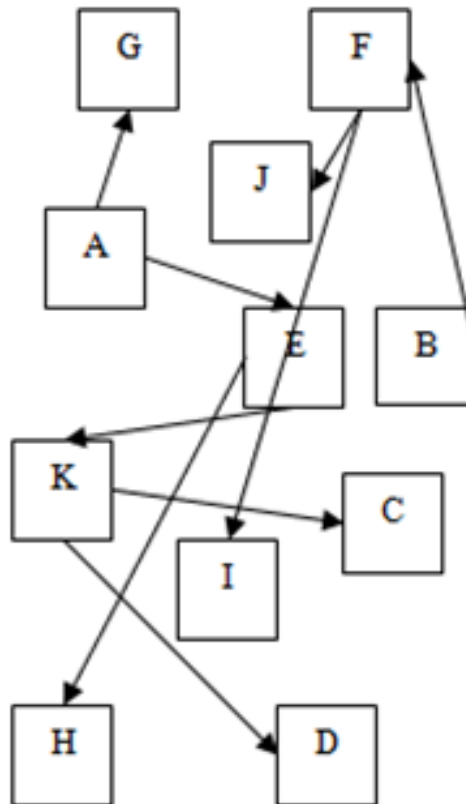
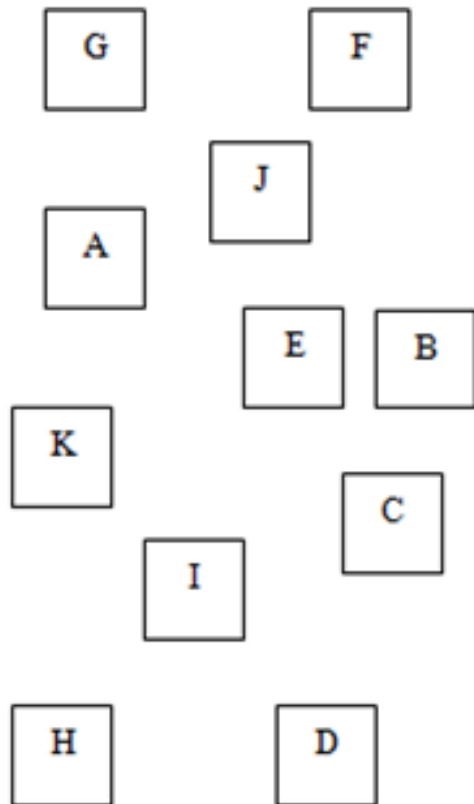
- How to select and **define objects** (concepts, terms)?
- Where to find and how to **name relations**?
- How to **create categories** (meta-concepts)?

Knowledge Mapping

- ✖ K-mapping is as old as the first teacher made the first figure for explanation.
- ✖ People use K-mapping in order to make sense, and to be able to remember and to explain the ideas. That is why people tend to impose a structure in their knowledge.
- ✖ We understand concepts through their relationship to other concepts.



k-model

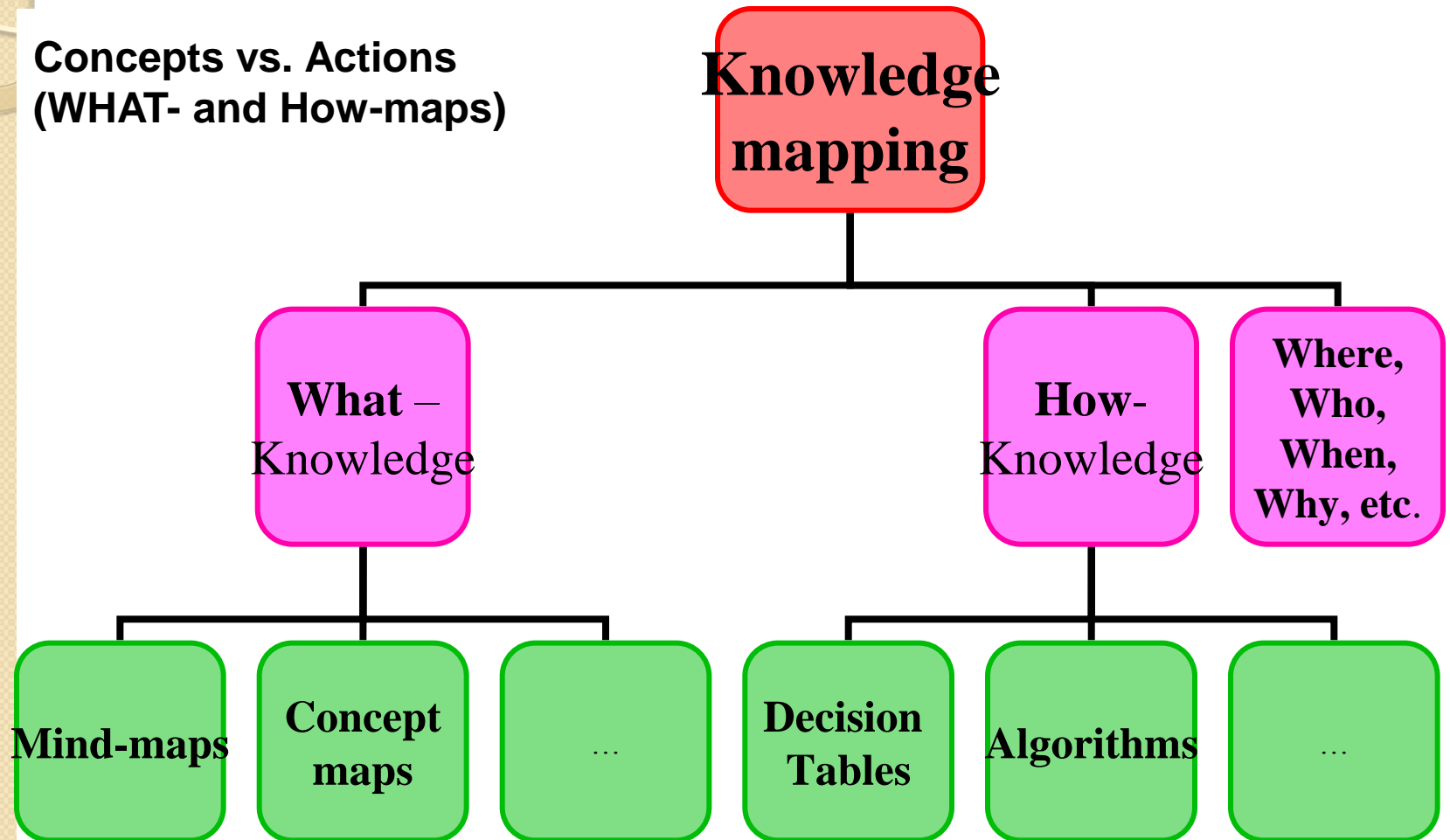


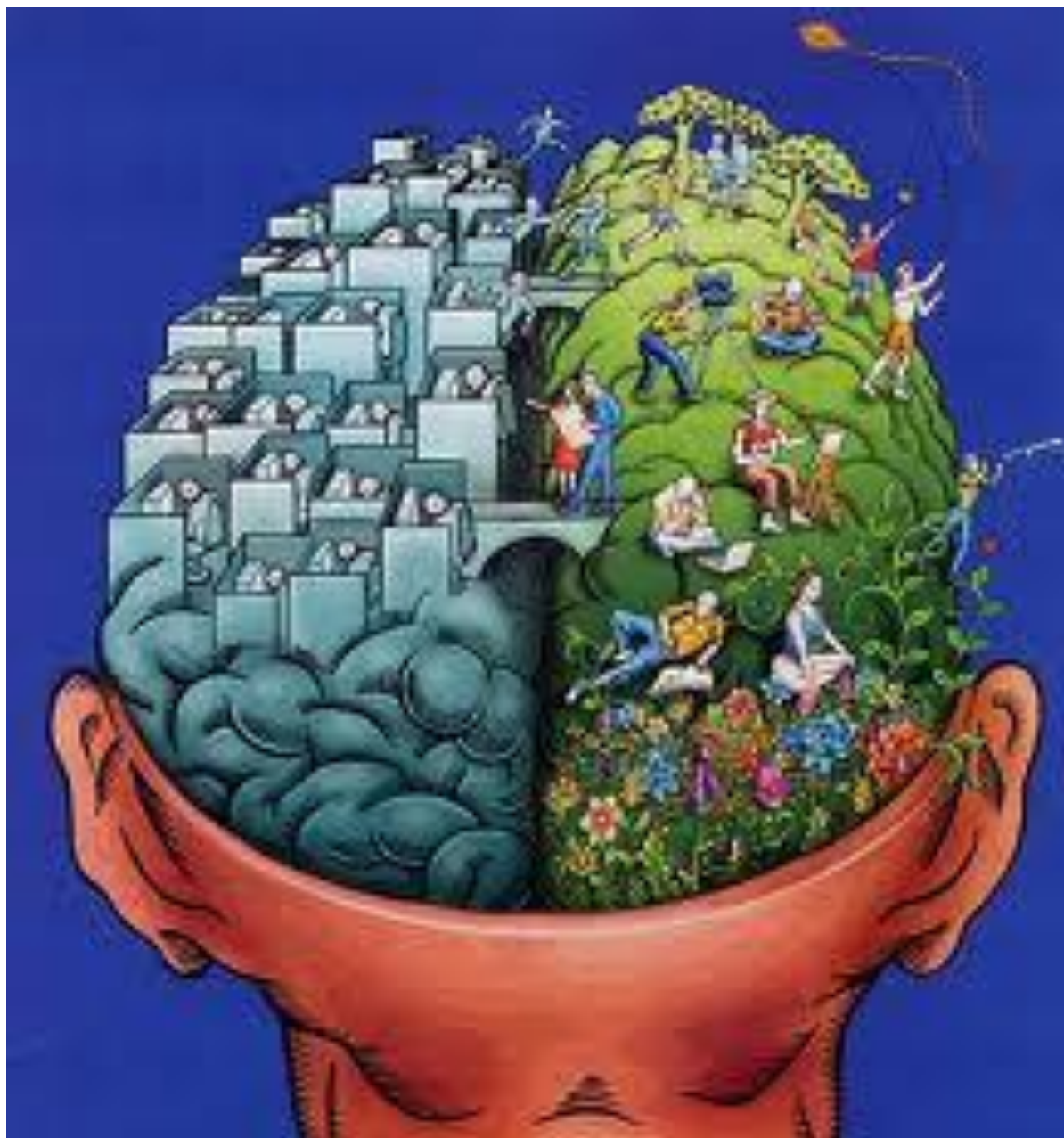
K-mapping traditional techniques

- Graphs, maps, plots, charts
- Figures
- Block-schema of Algorithms
- Wienn set diagrams
- Business Process Modeling Schema
- ERD-diagrams, etc.

How to do: Visual Thinking (Brain mapping)

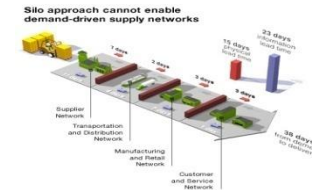
Concepts vs. Actions
(WHAT- and How-maps)





3 knowledge stages

«Harder knowledge gives more profit»



«Hard»



«Liquid»



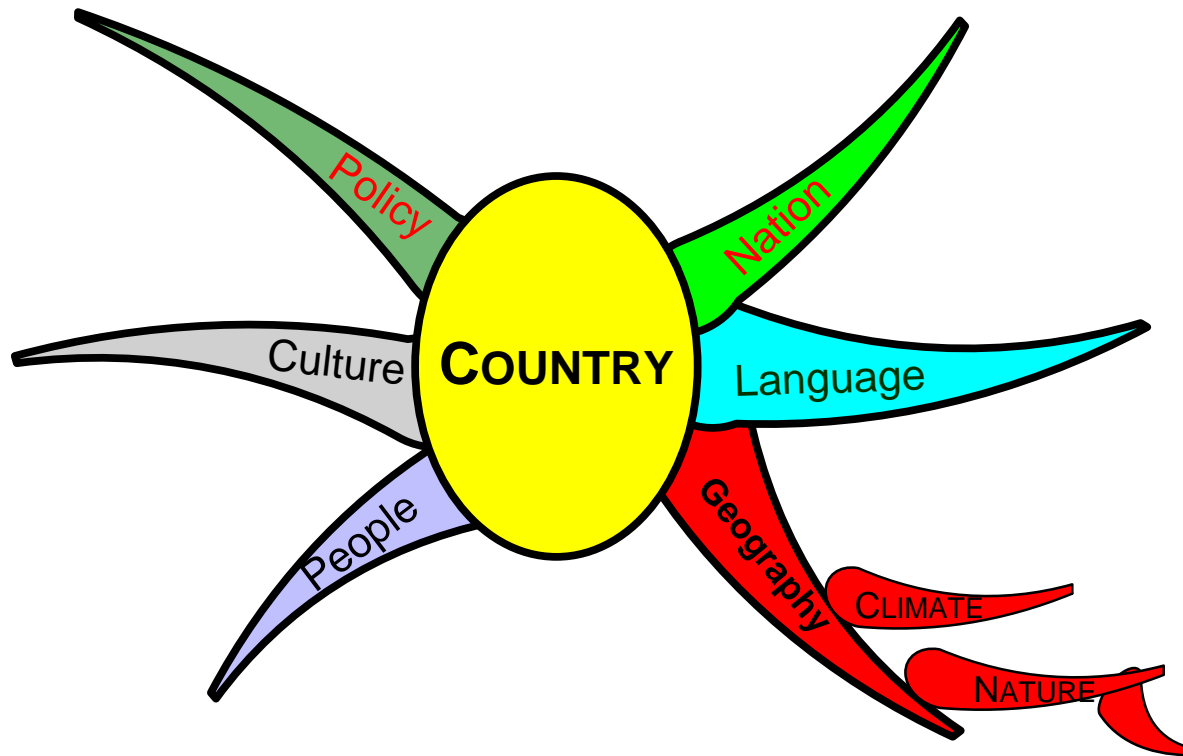
«Gaz»

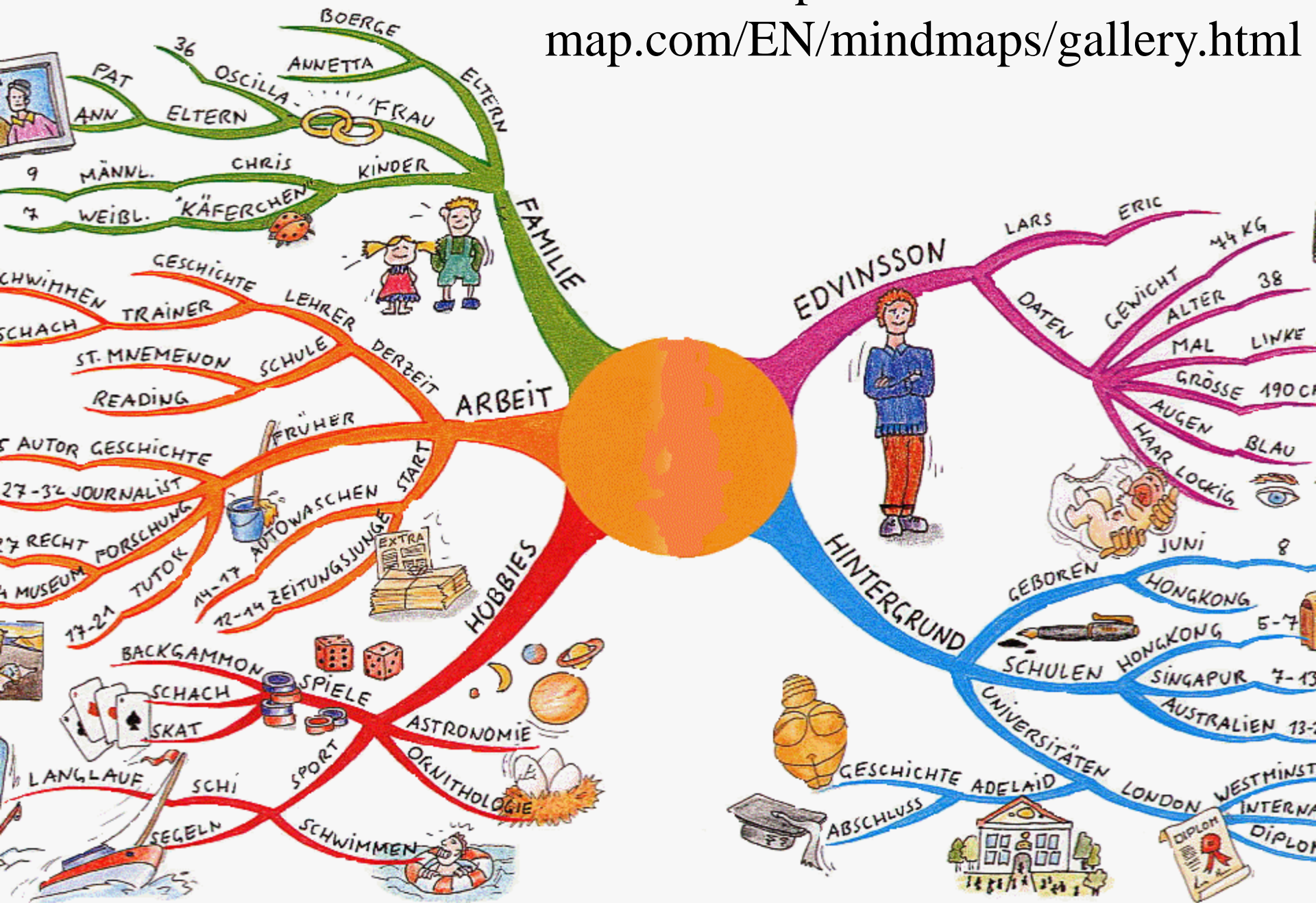


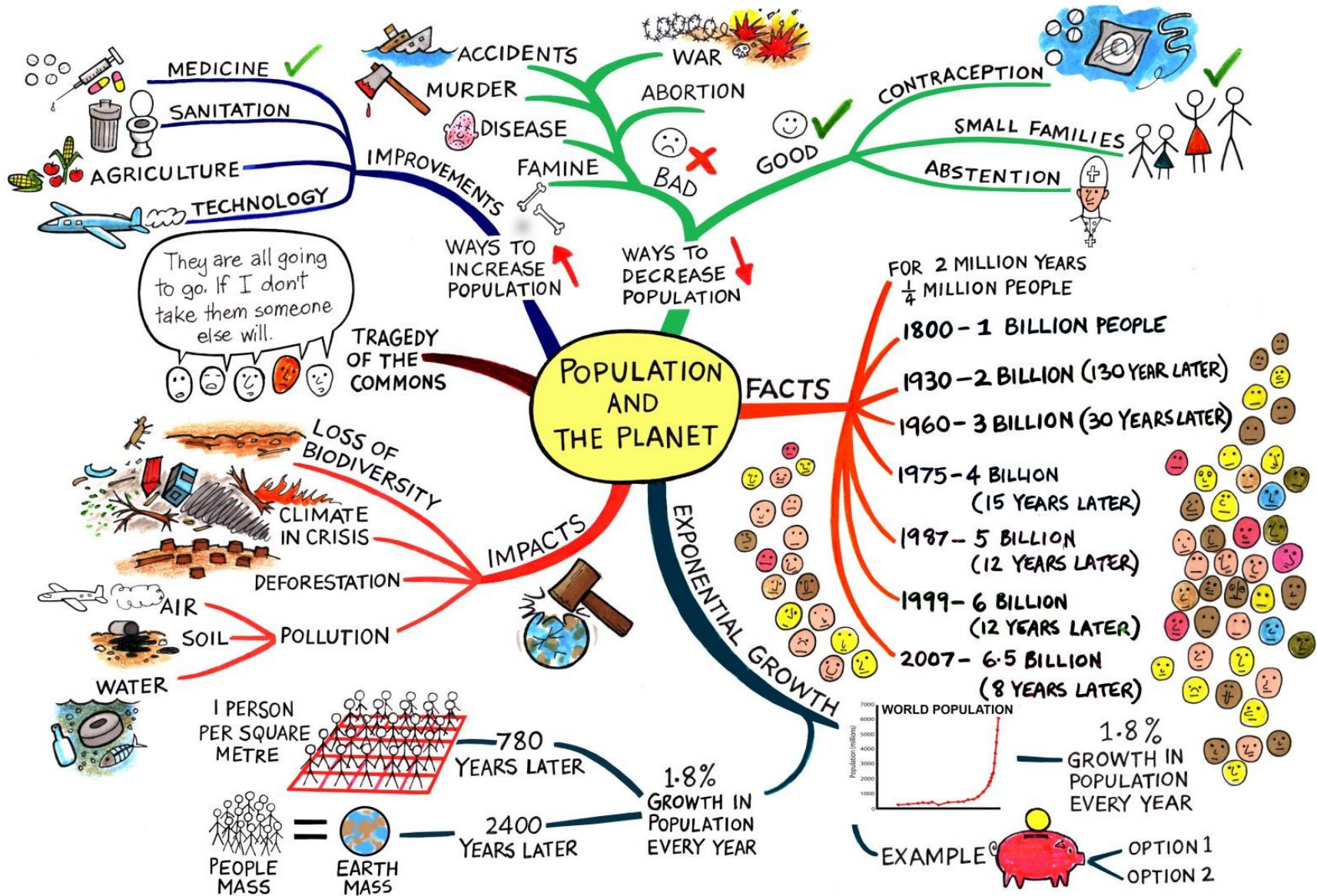
Funky business by
Kjell A. Nordström, Jonas Ridderstråle

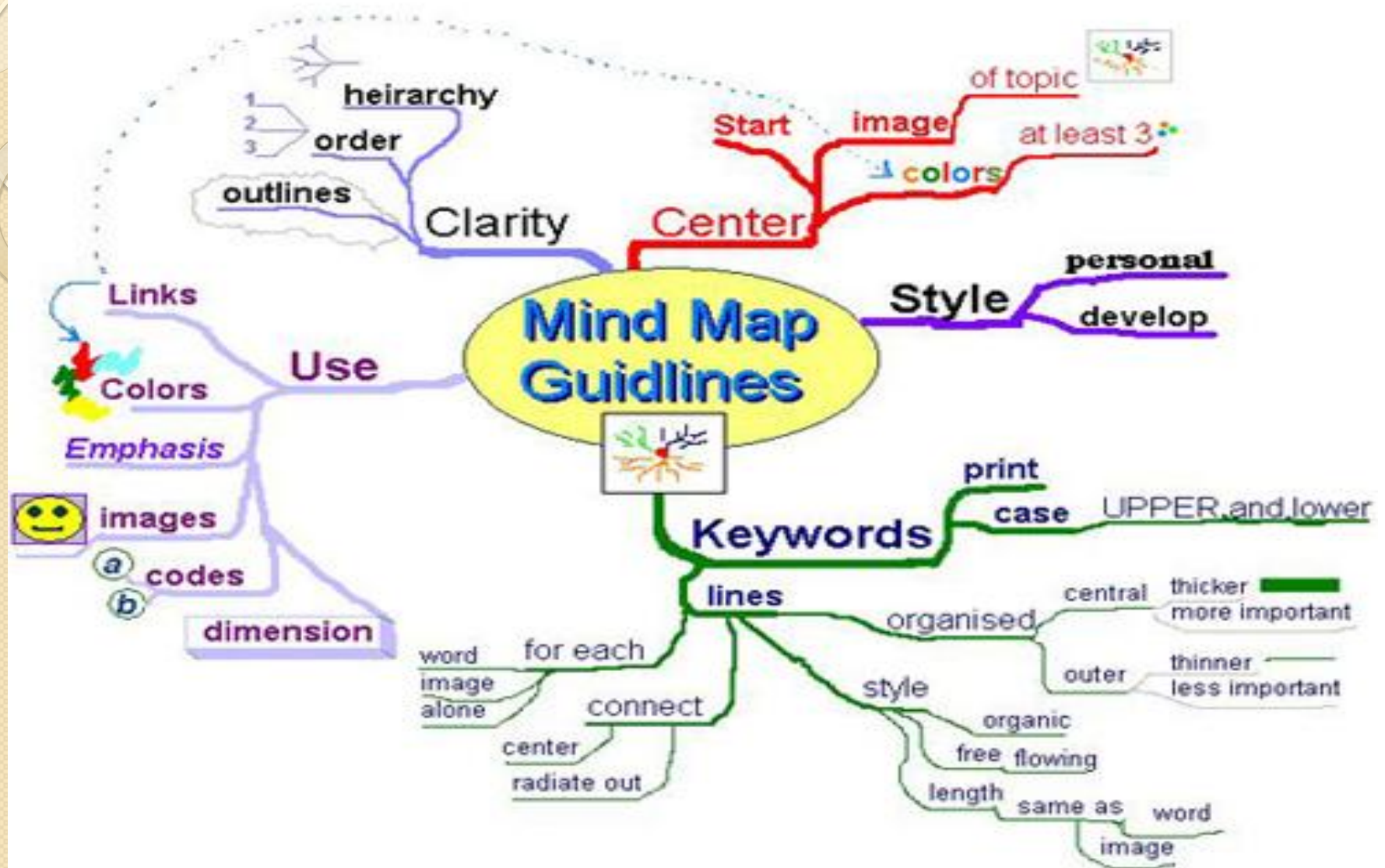
Mind Mapping

- Visual structures that help to understand relationships of concepts (Tony Buzen)







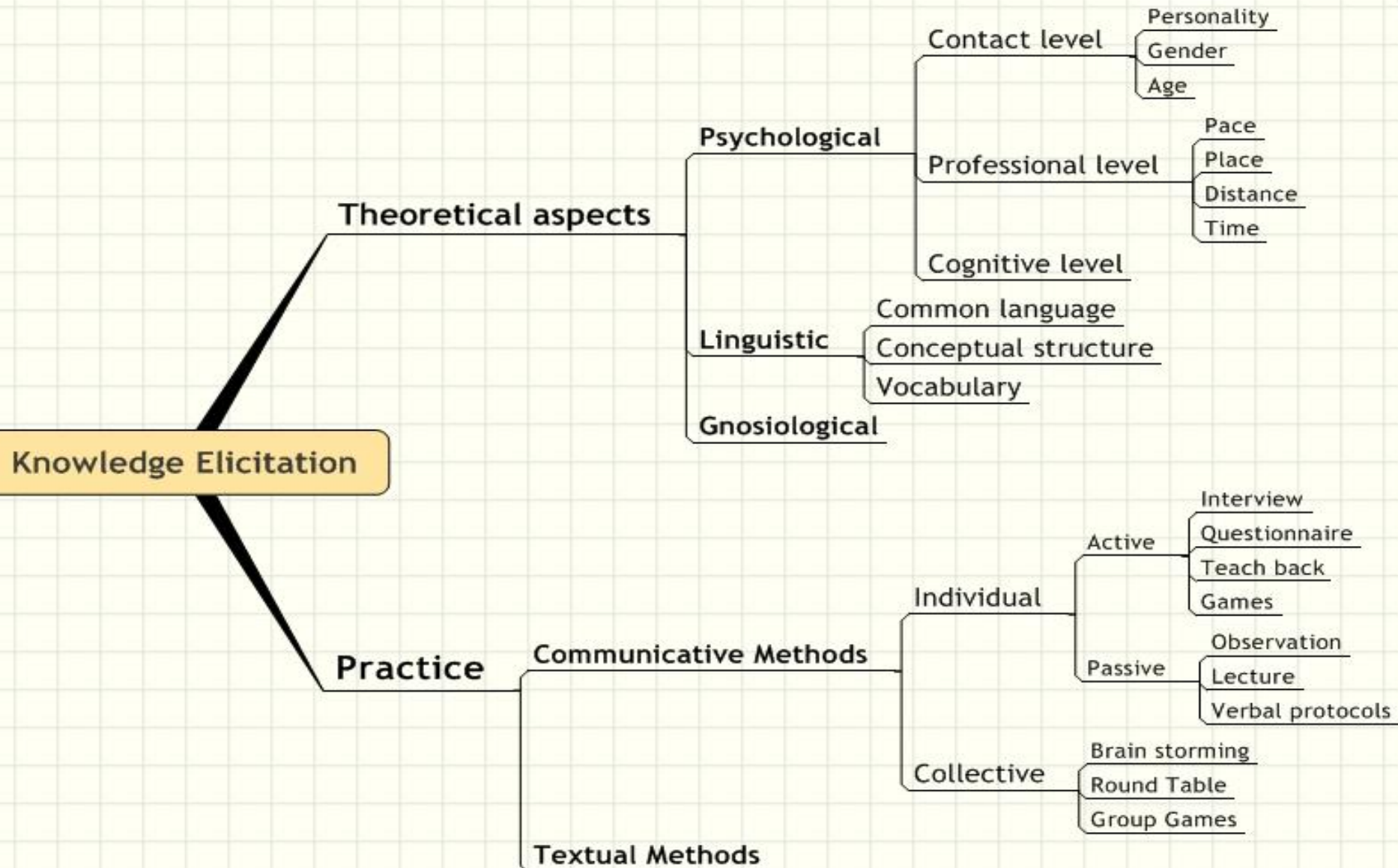


www.spicynodes.org/images/cookbook/reference/

Mind Map by Tony Buzan:

- Give you an overview of a large subject/area.
- Enable you to plan routes/make choices and let you know where you are going and where you have been.
- Gather and hold large amounts of data for you.
- Encourage problem solving by showing you new creative pathways.
- Enable you to be extremely efficient.
- Be enjoyable to look at, read, muse over and remember.
- Attract and hold your eye/brain.
- Let you see the whole picture *and* the details at the same time.
- Assist YOU!

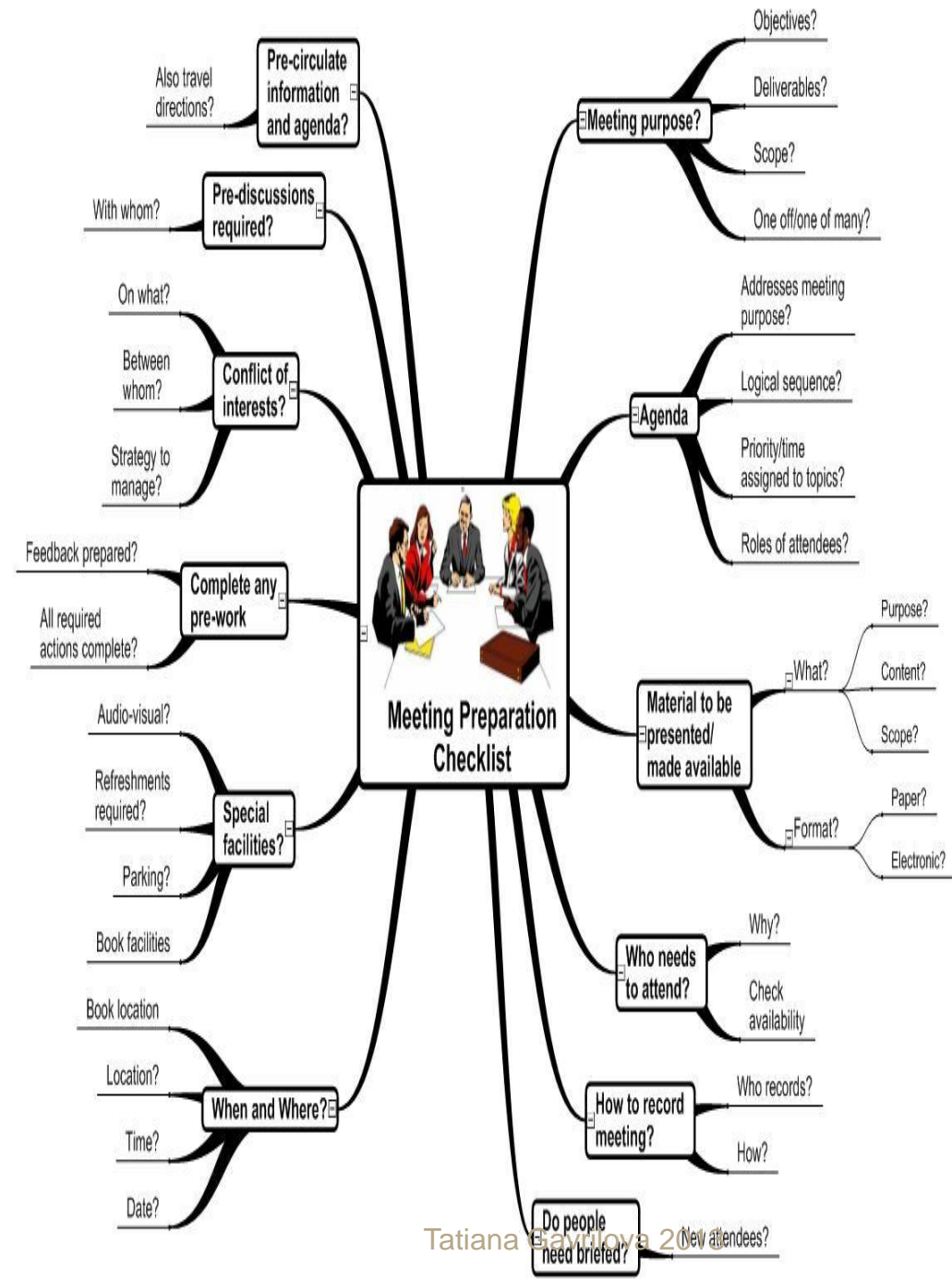
Example “Knowledge Elicitation”



Brain - mapping

- Inspiration 7.6
- Map it! 2003 (by Tony Buzan)
- MindMapper 4.2. Pro
- MindGenius Business 2005
- Visual Mind 7
- Mind Pad 1.1
- Mind manager
- The Brain

- <http://www.mindmeister.com/>
- <http://comapping.com/>



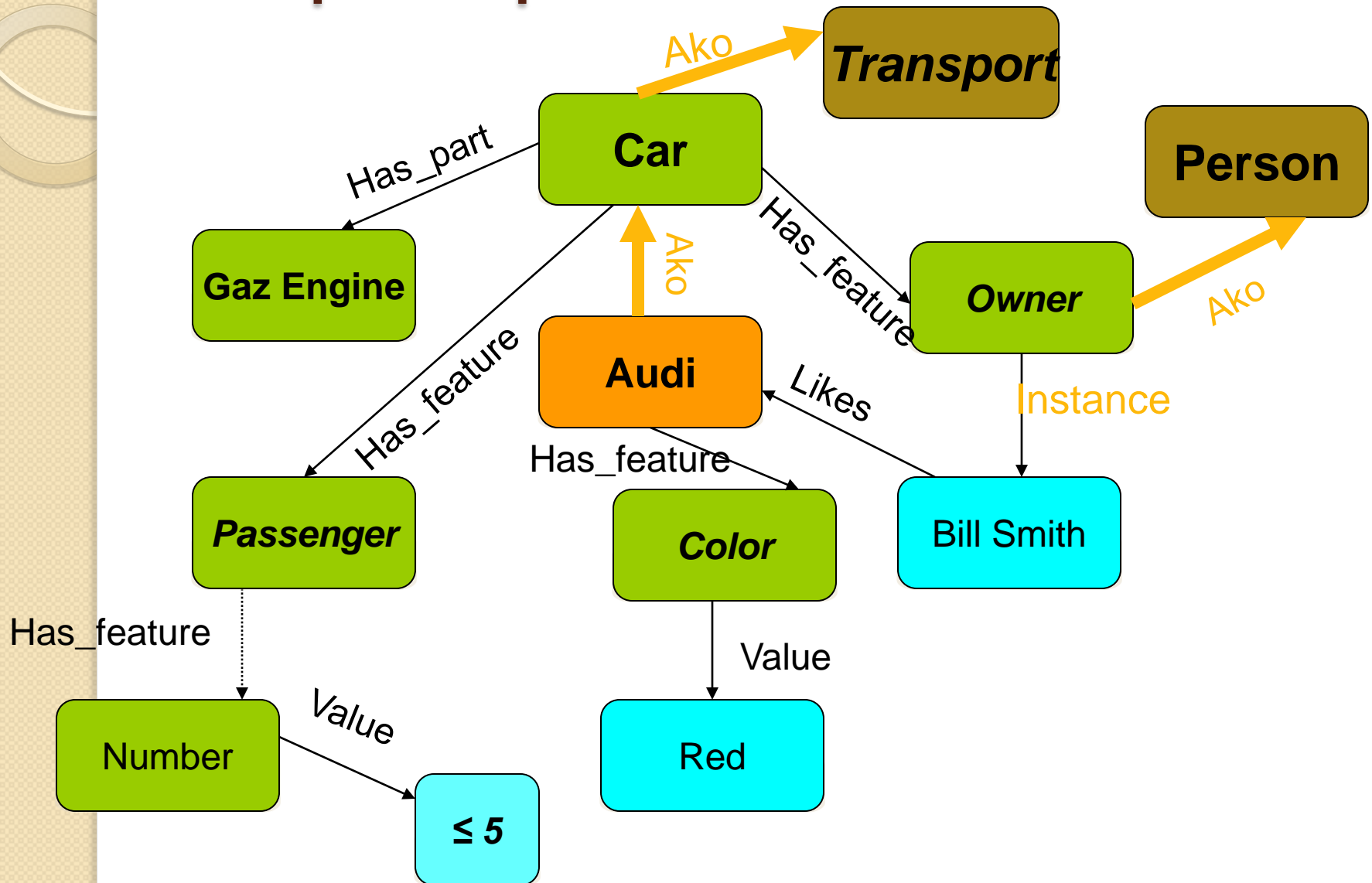
Concept map

Concept map is an oriented graph with nodes representing objects/concepts and arrows (links) representing relations between them.

Concept maps (or semantic networks)

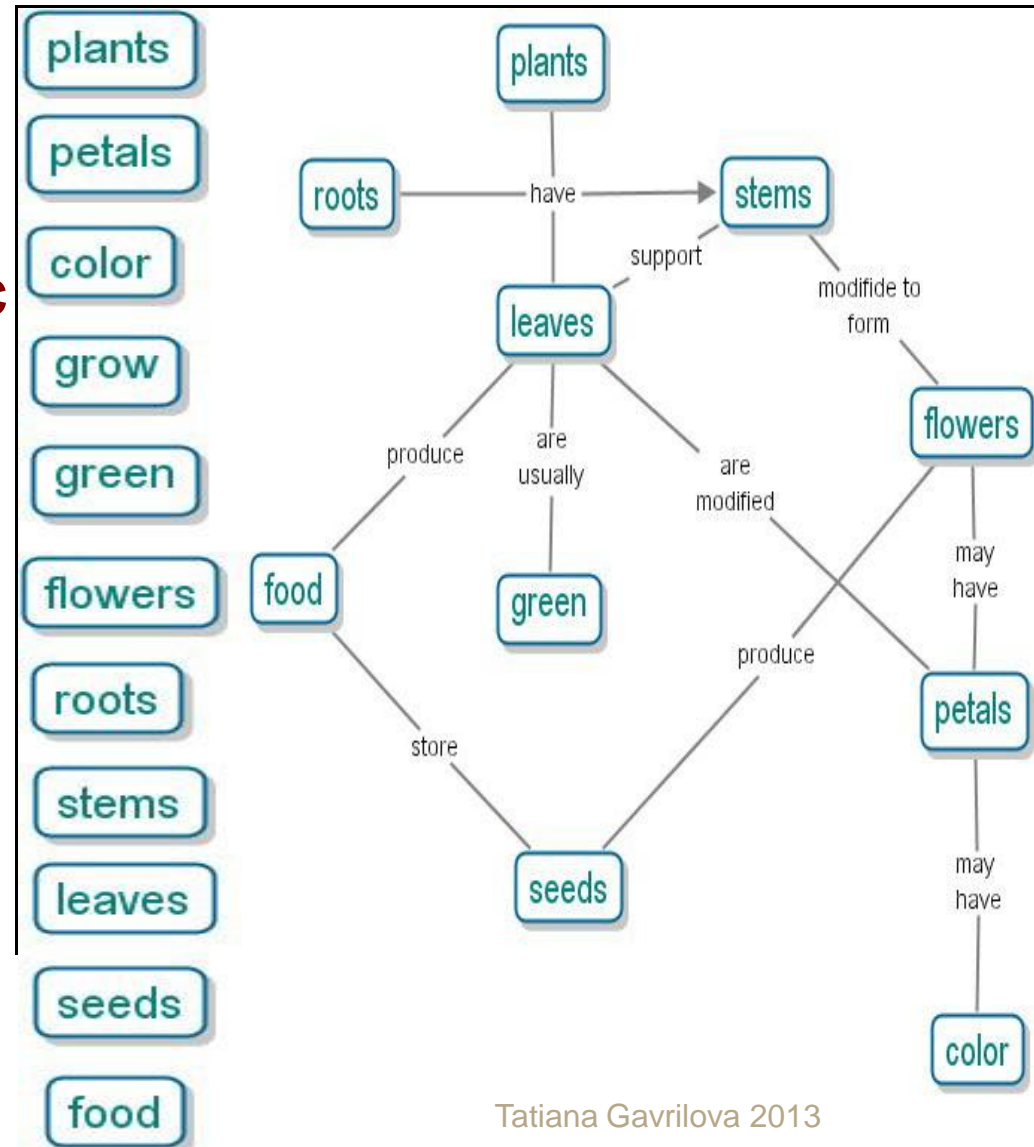
- **Another method for organizing information visually.**
- **Format for linking simple ideas to a complex scheme.**
- **Based on the idea that the brain interprets meaning from images more easily.**

Concept map “Bill’s red Audi”



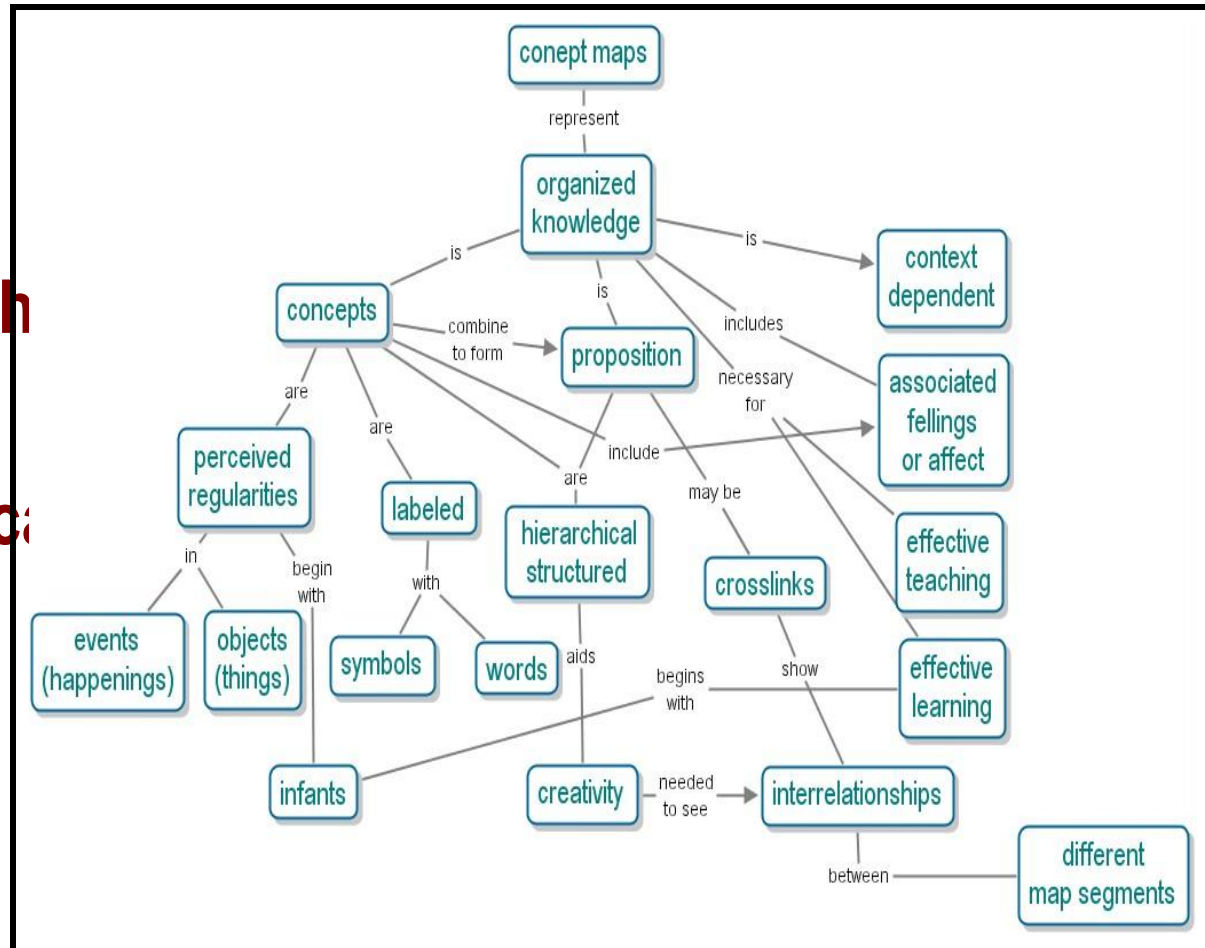
Concept mapping

- Concepts are written in boxes
- Major concepts appear at the top of the page, more specific concepts appear lower down
- Links have arrowheads to show the direction
- Links must have labels



Concept maps

- Concepts
- Relationships
- Hierarchical



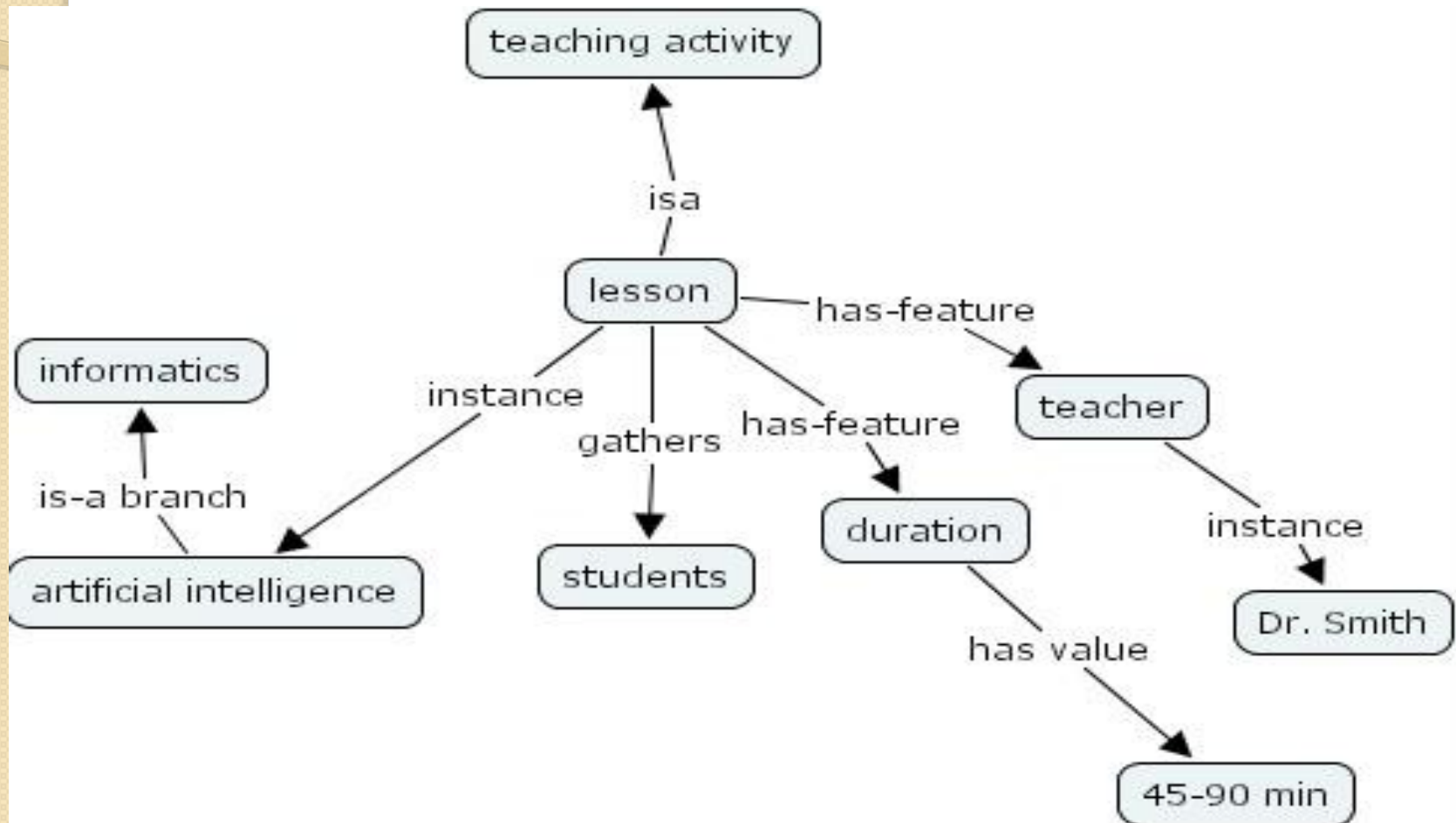
Concept maps development

- The method was first introduced by Novak and Gowin in the 1960s and was based on the learning psychology of David Ausubel.
- Bridges short term working memory to long term working memory.
- Can be a powerful organizational and evaluation tool.
- Software: CmapTools
<http://cmap.ihmc.us/>

Types of relationships

- **Hierarchical** (A-Kind-Of, Is-A)
- **Causal** (if- then)
- **Quantitative** (more than, equal...)
- **Functional** (runs, eats, is...)
- **Spatial** (on, behind, inside...)
- **Temporal** (after, before, until...)
- **Attribute** (colour, weight...)
- **Value** (red, heavy...)
- **Structural** (has-part)

C-map “Lesson”



Similar approaches

- **Definitional networks**
 - **Assertional networks**
 - **Implicational networks**
 - **Executable networks**
 - **Learning networks**
 - **Hybrid networks**
- **Quillian**
 - **Winston**

Main Relations (partly from work of Asuncion Gomez- Perez asun@fi.upm.es)

- **Between classes:**

Subclass (superclass)- of

Subclass- partition

- **between objects (concepts) and classes**

Instance- of (AKO -A-kind-of)

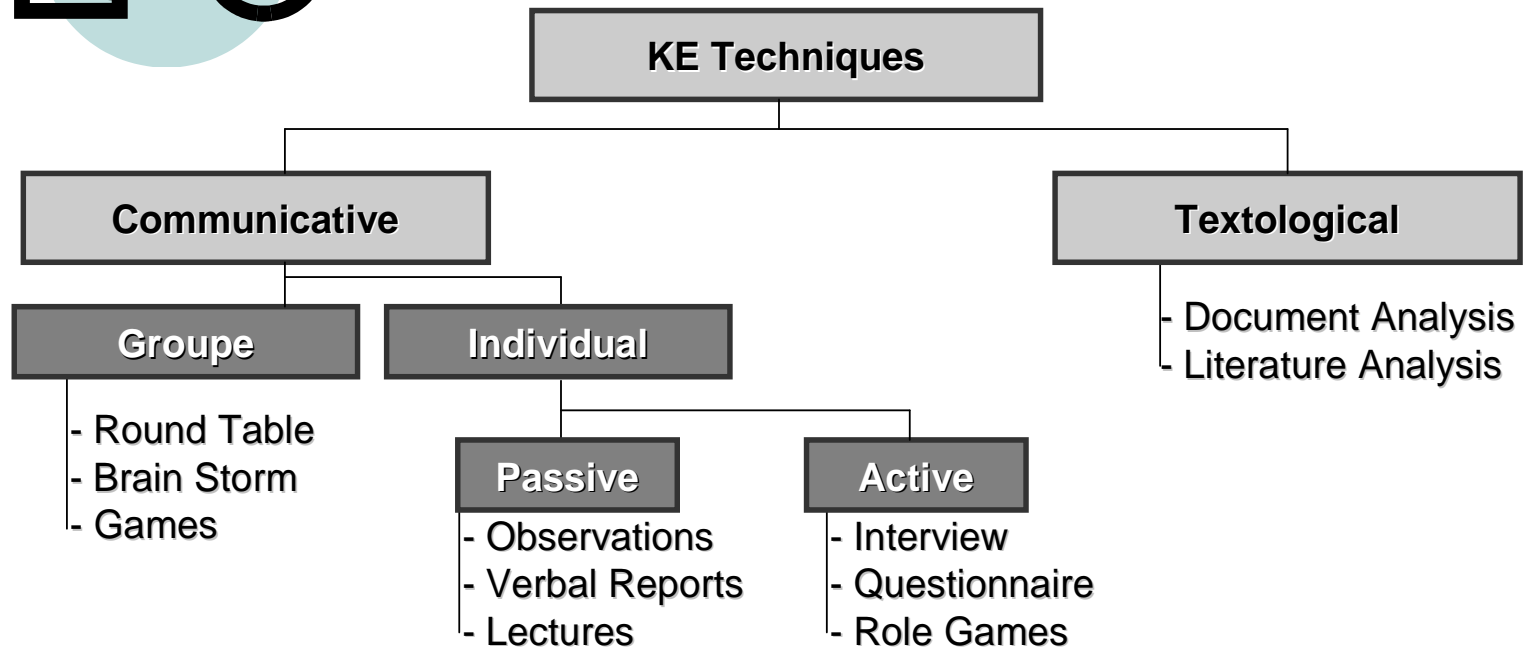
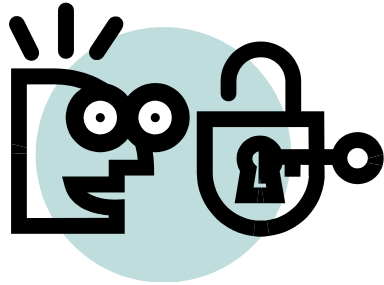
Has- Instance

- **between objects**

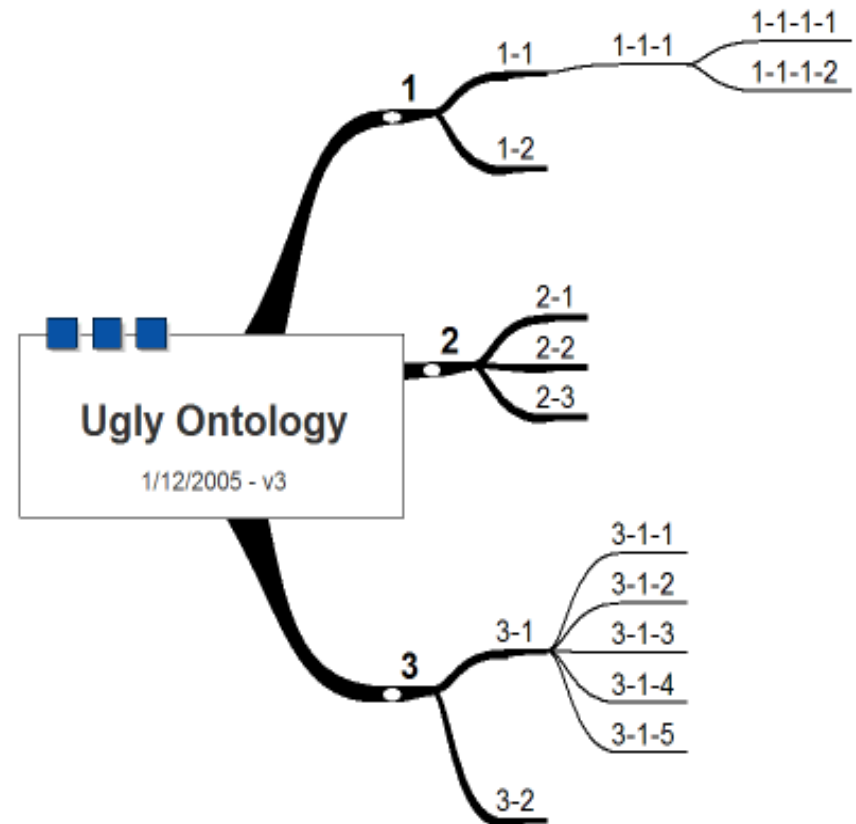
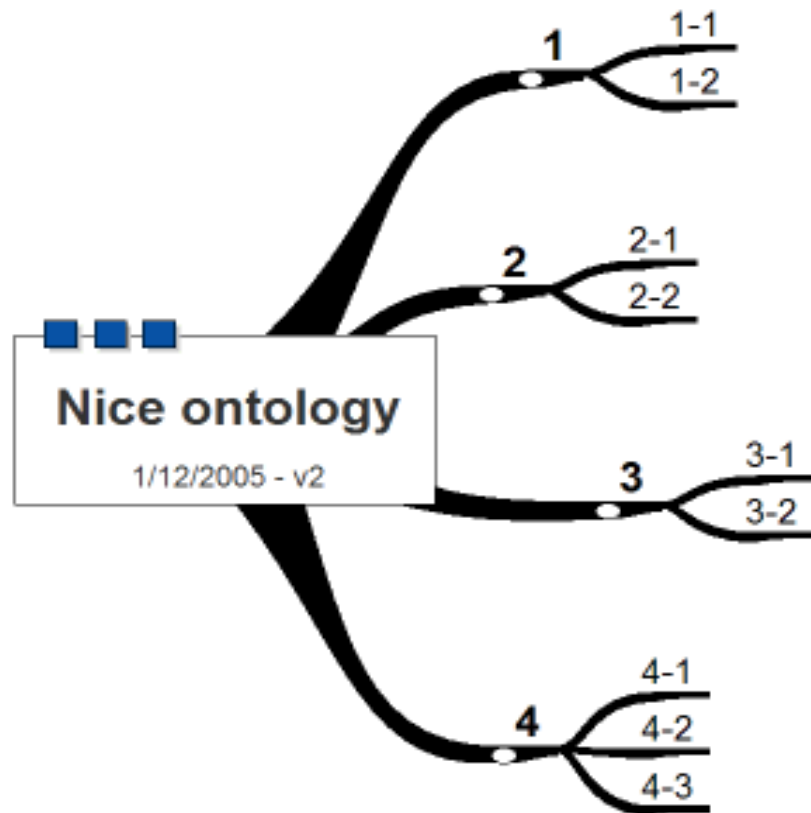
Has part

Has attribute

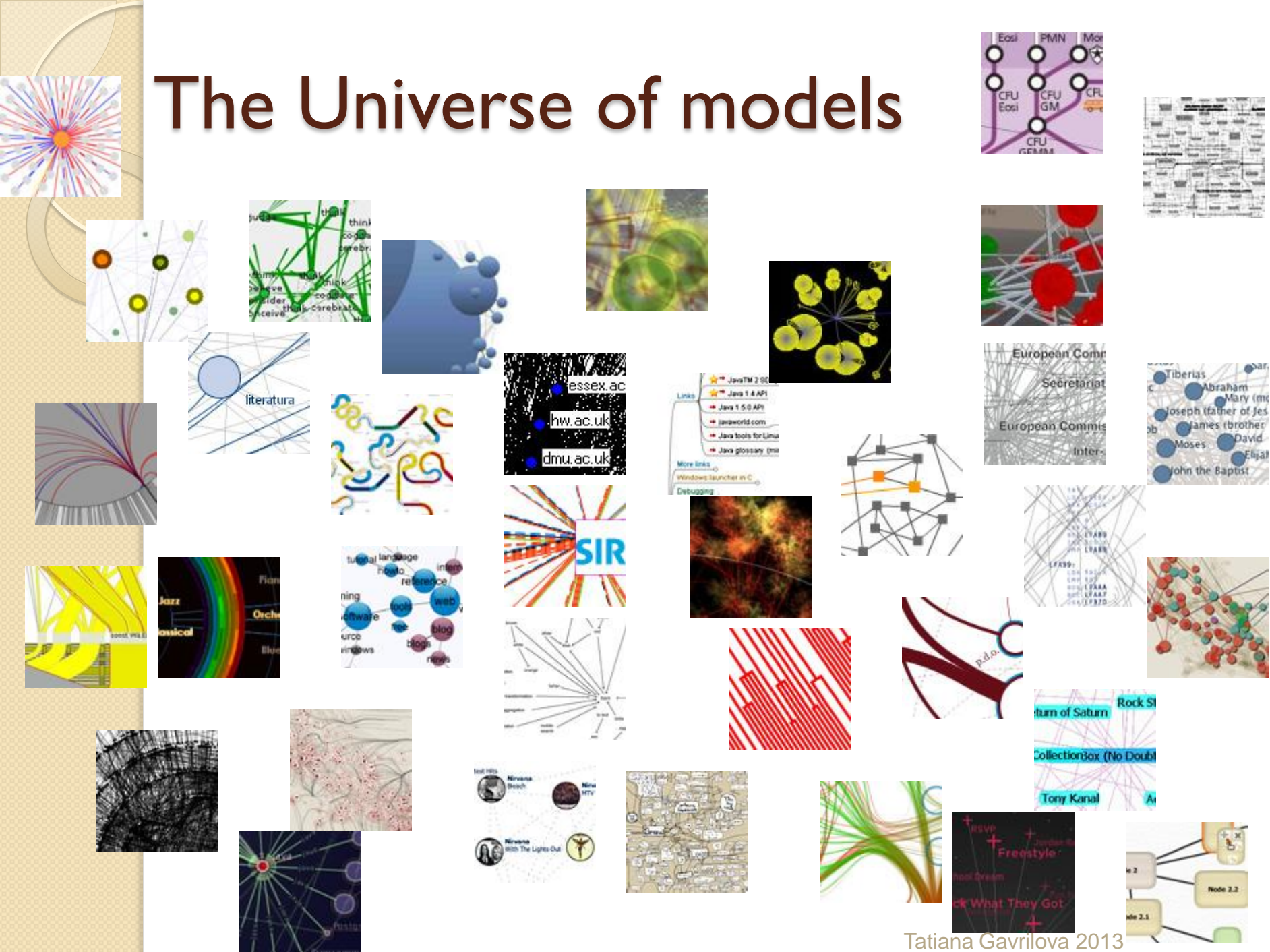
Taxonomy of practical knowledge elicitation methods



Good shape principle



The Universe of models



Visualization Methods (by Lengler and Eppler)

<div><div><div></div><div></div><div></div></div><div>C</div><div>continuum</div></div>	<div><div><div></div><div>Data Visualization</div><div>Visual representations of quantitative data in schematic form (either with or without axes)</div></div><div><div></div><div>Strategy Visualization</div><div>The systematic use of complementary visual representations in the analysis, development, formulation, communication, and implementation of strategies in organizations.</div></div></div>										<div><div><div></div><div>G</div><div>graphic facilitation</div></div></div>						
<div><div><div></div><div></div><div></div></div><div>Tb</div><div>table</div></div>	<div><div><div></div><div></div><div></div></div><div>Ca</div><div>cartesian coordinates</div></div>	<div><div><div></div><div>Information Visualization</div><div>The use of interactive visual representations of data to amplify cognition. This means that the data is transformed into an image, it is mapped to screen space. The image can be changed by users as they proceed working with it</div></div><div><div></div><div>Metaphor Visualization</div><div>Visual Metaphors position information graphically to organize and structure information. They also convey an insight about the represented information through the key characteristics of the metaphor that is employed</div></div></div>										<div><div><div></div><div></div><div></div></div><div>Me</div><div>meeting trace</div></div>	<div><div><div></div><div></div><div></div></div><div>Mm</div><div>metro map</div></div>	<div><div><div></div><div></div><div></div></div><div>Tm</div><div>temple</div></div>	<div><div><div></div><div></div><div></div></div><div>St</div><div>story template</div></div>	<div><div><div></div><div></div><div></div></div><div>Tr</div><div>tree</div></div>	<div><div><div></div><div></div><div></div></div><div>Ct</div><div>cartoon</div></div>
<div><div><div></div><div></div><div></div></div><div>Pi</div><div>pie chart</div></div>	<div><div><div></div><div></div><div></div></div><div>L</div><div>line chart</div></div>	<div><div><div></div><div>Concept Visualization</div><div>Methods to elaborate (mostly) qualitative concepts, ideas, plans, and analyses.</div></div><div><div></div><div>Compound Visualization</div><div>The complementary use of different graphic representation formats in one single schema or frame</div></div></div>										<div><div><div></div><div></div><div></div></div><div>Co</div><div>communication diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Fp</div><div>flight plan</div></div>	<div><div><div></div><div></div><div></div></div><div>Cs</div><div>concept sceleton</div></div>	<div><div><div></div><div></div><div></div></div><div>Br</div><div>bridge</div></div>	<div><div><div></div><div></div><div></div></div><div>Fu</div><div>funnel</div></div>	<div><div><div></div><div></div><div></div></div><div>Ri</div><div>rich picture</div></div>
<div><div><div></div><div></div><div></div></div><div>B</div><div>bar chart</div></div>	<div><div><div></div><div></div><div></div></div><div>Ar</div><div>area chart</div></div>	<div><div><div></div><div></div><div></div></div><div>R</div><div>radar chart cobweb</div></div>	<div><div><div></div><div></div><div></div></div><div>Pa</div><div>parallel coordinates</div></div>	<div><div><div></div><div></div><div></div></div><div>Hy</div><div>hyperbolic tree</div></div>	<div><div><div></div><div></div><div></div></div><div>Cy</div><div>cycle diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>T</div><div>timeline</div></div>	<div><div><div></div><div></div><div></div></div><div>Ve</div><div>venn. diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Mi</div><div>mindmap</div></div>	<div><div><div></div><div></div><div></div></div><div>Sq</div><div>square of oppositions</div></div>	<div><div><div></div><div></div><div></div></div><div>Cc</div><div>concentric circles</div></div>	<div><div><div></div><div></div><div></div></div><div>Ar</div><div>argument slide</div></div>	<div><div><div></div><div></div><div></div></div><div>Sw</div><div>swim lane diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Gc</div><div>gantt chart</div></div>	<div><div><div></div><div></div><div></div></div><div>Pe</div><div>perspectives diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>D</div><div>dilemma diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Pr</div><div>parameter ruler</div></div>	<div><div><div></div><div></div><div></div></div><div>Kn</div><div>knowledge map</div></div>
<div><div><div></div><div></div><div></div></div><div>Hi</div><div>histogram</div></div>	<div><div><div></div><div></div><div></div></div><div>Sc</div><div>scatterplot</div></div>	<div><div><div></div><div></div><div></div></div><div>Sa</div><div>sankey diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>In</div><div>information lense</div></div>	<div><div><div></div><div></div><div></div></div><div>E</div><div>entity relationship diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Pt</div><div>petri net</div></div>	<div><div><div></div><div></div><div></div></div><div>Fi</div><div>flow chart</div></div>	<div><div><div></div><div></div><div></div></div><div>Cl</div><div>clustering</div></div>	<div><div><div></div><div></div><div></div></div><div>L</div><div>layer chart</div></div>	<div><div><div></div><div></div><div></div></div><div>Py</div><div>minto pyramid technique</div></div>	<div><div><div></div><div></div><div></div></div><div>Ce</div><div>cause-effect chains</div></div>	<div><div><div></div><div></div><div></div></div><div>Tl</div><div>toulmin map</div></div>	<div><div><div></div><div></div><div></div></div><div>Dt</div><div>decision tree</div></div>	<div><div><div></div><div></div><div></div></div><div>Cp</div><div>cpm critical path method</div></div>	<div><div><div></div><div></div><div></div></div><div>Cf</div><div>concept fan</div></div>	<div><div><div></div><div></div><div></div></div><div>Co</div><div>concept map</div></div>	<div><div><div></div><div></div><div></div></div><div>Ic</div><div>iceberg</div></div>	<div><div><div></div><div></div><div></div></div><div>Cm</div><div>cognitive mapping</div></div>
<div><div><div></div><div></div><div></div></div><div>Tk</div><div>tukey box plot</div></div>	<div><div><div></div><div></div><div></div></div><div>Sp</div><div>spectrogram</div></div>	<div><div><div></div><div></div><div></div></div><div>Da</div><div>data map</div></div>	<div><div><div></div><div></div><div></div></div><div>Tr</div><div>treemap</div></div>	<div><div><div></div><div></div><div></div></div><div>Cn</div><div>cone tree</div></div>	<div><div><div></div><div></div><div></div></div><div>Sy</div><div>system dyn./ simulation</div></div>	<div><div><div></div><div></div><div></div></div><div>Df</div><div>data flow diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Se</div><div>semantic network</div></div>	<div><div><div></div><div></div><div></div></div><div>So</div><div>soft system modeling</div></div>	<div><div><div></div><div></div><div></div></div><div>Sn</div><div>synergy map</div></div>	<div><div><div></div><div></div><div></div></div><div>Fo</div><div>force field diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Ib</div><div>ibis argumentation map</div></div>	<div><div><div></div><div></div><div></div></div><div>Pr</div><div>process event chains</div></div>	<div><div><div></div><div></div><div></div></div><div>Pe</div><div>pert chart</div></div>	<div><div><div></div><div></div><div></div></div><div>Ev</div><div>evocative knowledge map</div></div>	<div><div><div></div><div></div><div></div></div><div>V</div><div>Yee diagram</div></div>	<div><div><div></div><div></div><div></div></div><div>Hh</div><div>heaven 'n' hell chart</div></div>	<div><div><div></div><div></div><div></div></div><div>I</div><div>informul</div></div>

Cy

Process Visualization

Hy

Structure Visualization



Overview



Detail



Detail AND Overview

< >

Divergent thinking





























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Convergent thinking

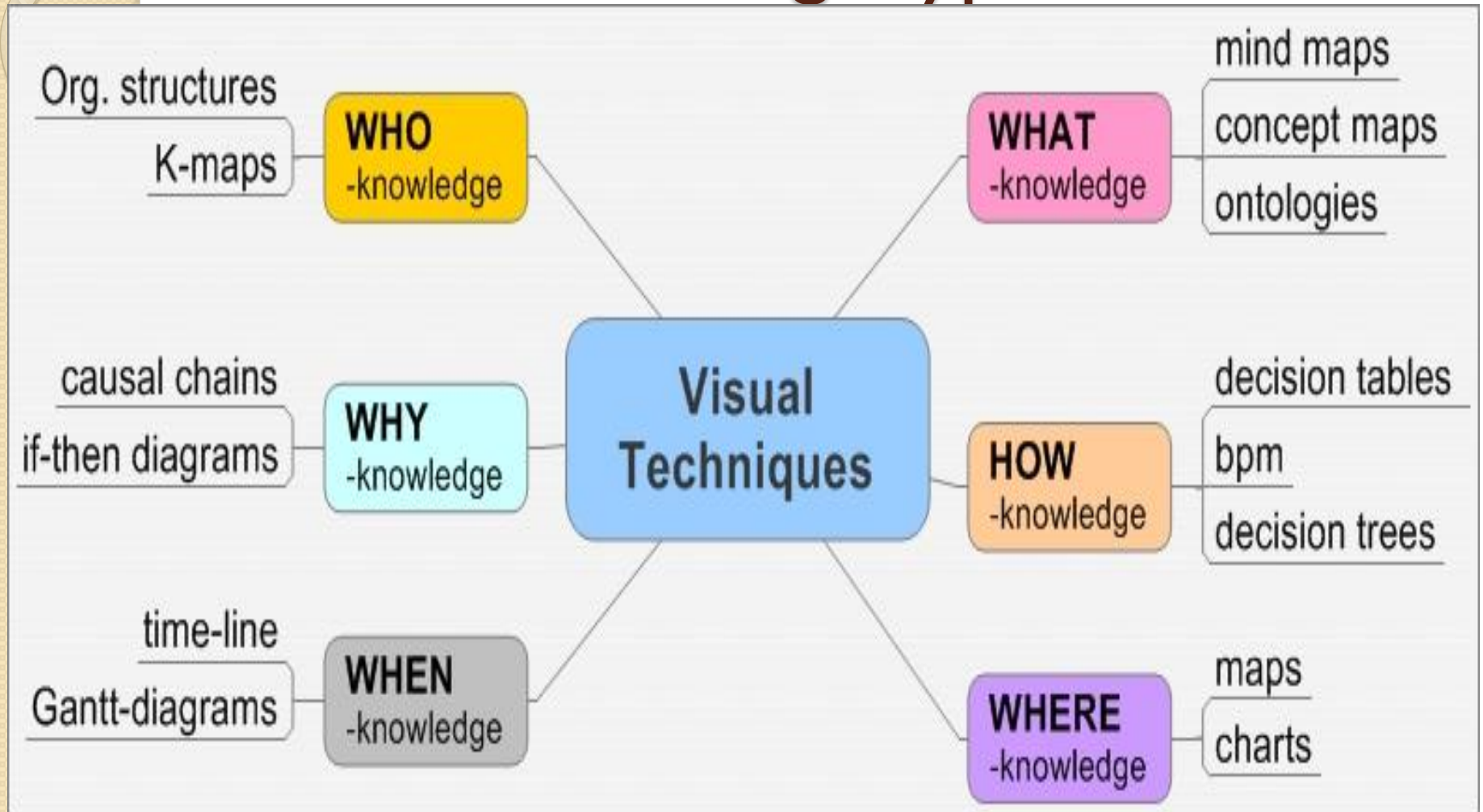
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version 1.5

 Su supply demand curve	 Pc performance charting	 St strategy map	 Oc organisation chart	 Ho house of quality	 Fd feedback diagram	 Ft failure tree	 Mq magic quadrant	 Ld life-cycle diagram	 Po porter's five forces	 S s-cycle	 Sm stakeholder map	 Is ishikawa diagram	 Tc technology roadmap
 Ed edgeworth box	 Pf portfolio diagram	 Sg strategic game board	 Mz mintzberg's organigraph	 Z zwicki's morphological box	 Ad affinity diagram	 De decision discovery diagram	 Bm bcg matrix	 Stc strategy canvas	 Vc value chain	 Hy hype-cycle	 Sr stakeholder rating map	 Ta taps	 Sd spray diagram

Classification based on knowledge type



Practical Cognitive Problems

- How to select and **define objects** (concepts, terms)?
- Where to find and how to **name relations**?
- How to **create categories** (meta-concepts)?

Free information mapping software

Concept maps

- [3D Topicscape Student Edition](#)
- [Bubbl.us](#)
- [Cayra](#)
- **IHMC CmapTool**
- [CoFFEE](#)
- [Compendium](#)
- [Conzilla](#)
- [Glinkr](#)
- [Hypergraph](#)
- [Labyrinth](#)
- [LifeMap](#)
- [Visuwords](#)
- [VUE \(Visual Understanding Environment\)](#)
- [yEd](#)

Concept maps or mind maps?

- [Bookvar](#)
- [CharTr](#)
- [Creately](#)
- [Ekpenso](#)
- [Freeplane](#)
- [Kdissert](#)
- [Semantik](#)
- [Text2Mindmap](#)
- [ThinkGraph](#)
- [Thoughtex](#)
- [Tomboy mindmap](#)
- [VYM \(View Your Mind\)](#)
- [WoW \(Web of Web\)](#)

Mindmaps

- [EDraw Mind Map](#)
- [FreeMind](#)
- [Mind42](#)
- **MIndjet**
- [Mind Map Viewer \(Eric Blue\)](#)
- [MindNode](#)
- [MindRaider](#)
- [Xmind](#)

Maps of Arguments

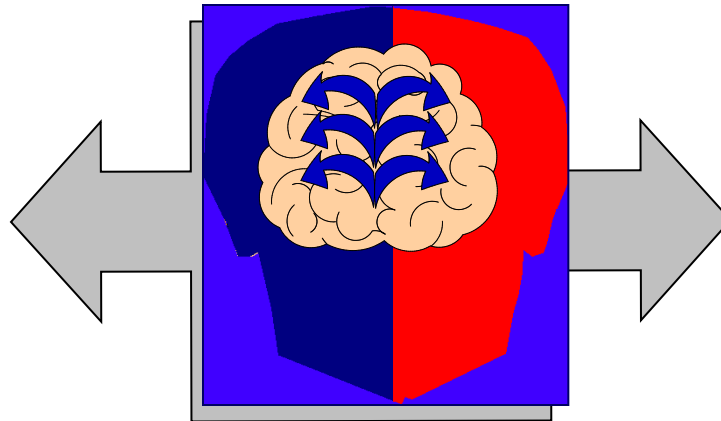
- [Argunet](#)
- [Cohere](#)
- [Debategraph](#)
- [Prefuse](#)

Dualism of Knowledge Analyst

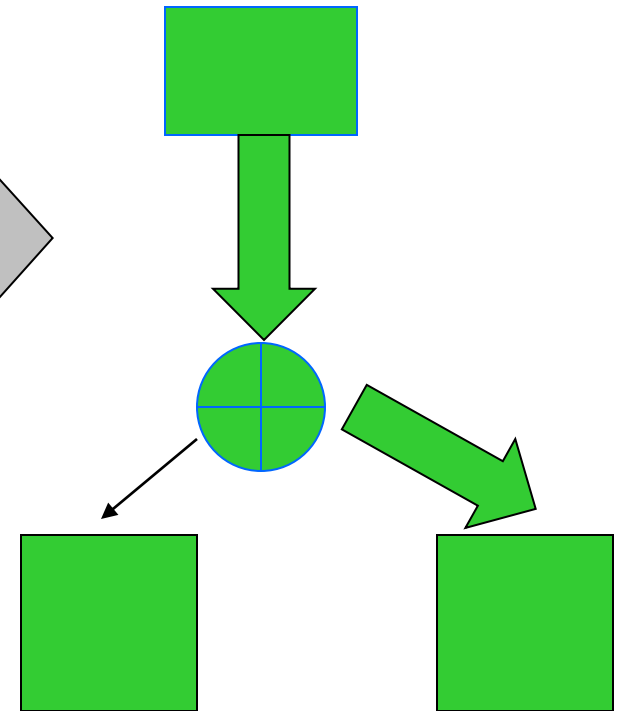
**Communicative
skills**



ANALYST



**Analytical
skills**



Analysts' Psychological Portrait

Generalist

Sociable pedant



Sincerity

Empathy

Interest to other people

Openness

Accuracy

Major cognitive gender differences



- Do their thinking in more focused regions of the brain
- Higher analyticity and field-independence
- Interest to the new decisions search (hunting)
- Better spatial orientation
- Better concentration
- Worse speech perception
- Have more connections and stronger cross-hemisphere links
- Better communicative skills
- Better detailing
- Hazard minimization, fear of novelty
- Better scope of cognitive likelihood and distinctions
- Mix up «right-left» (50%)

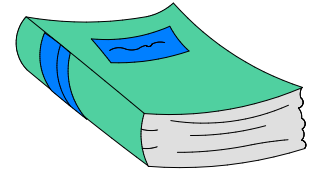
Summary

- Top-managers and IT-analysts are continually challenged by the need to analyze BIG DATA - massive volumes, velocities, and varieties of multilingual and multimedia data.
- Visual representation of the general corporate business concepts facilitate company personnel understanding of both substantive and syntactic knowledge.
- A cognitive visual approach to knowledge mapping helps to manage and innovate corporate knowledge on visionary level of understanding.

"If only HP knew what it knows it would make three times more profit tomorrow"

Lew Platt, ex CEO Hewlett Packard

Main references



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ГАВРИЛОВА Татьяна Альбертовна



Доктор технических наук, профессор, заведующий кафедрой информационных технологий в менеджменте Высшей школы менеджмента Санкт-Петербургского государственного университета, председатель петербургского отделения Российской ассоциации искусственного интеллекта

Один из ведущих российских специалистов в области инженерии знаний. Занимается разработкой баз знаний и информационным менеджментом более 15 лет.

Читает курсы по системно-аналитическому мышлению и инженерии знаний. Ведет корпоративные тренинги (компании BAT «British American Tobacco», Siemens Business Services, «Бизнес Инжиниринг Групп», ЦНТИ «Прогресс» и др.). С 2003 г. преподает как приглашенный профессор в Первом Варшавском независимом университете (бизнес-школе) (Польша), университете Милана (Италия), университете прикладных наук EVTEK (Эспоо, Финляндия), Тартуском университете. В 2004-2005 гг. прочла авторский курс по инженерии знаний и разработке интеллектуальных систем в Питтсбургском университете (США). Дважды выигрывала стипендию программы Фулбрайт.

Имеет более 100 научных публикаций, из них 55 на английском языке. Постоянный автор профессиональных журналов «Корпоративные системы», «Персонал-МИКС», «Сетевой журнал», «&Стратегии» и др. Автор книг «Извлечение и структурирование знаний для экспертных систем» (1991) и «Базы знаний интеллектуальных систем» (2001), соавтор учебника «Информатика» для экономических вузов.

Сфера научных интересов – интеллектуальные технологии и инженерия знаний.

МУРОМЦЕВ Дмитрий Ильич



Кандидат технических наук, доцент кафедры проектирования компьютерных систем Санкт-Петербургского государственного университета информационных технологий, механики и оптики. Окончил факультет технической кибернетики Санкт-Петербургского государственного политехнического университета (1999) и аспирантуру СПбГУ ИТМО (2003).

Имеет многолетний опыт руководства разработкой и внедрения систем искусственного интеллекта. В течение последних 10 лет – ведущий разработчик ряда ИТ компаний СПб. Активно занимается консалтинговой деятельностью.

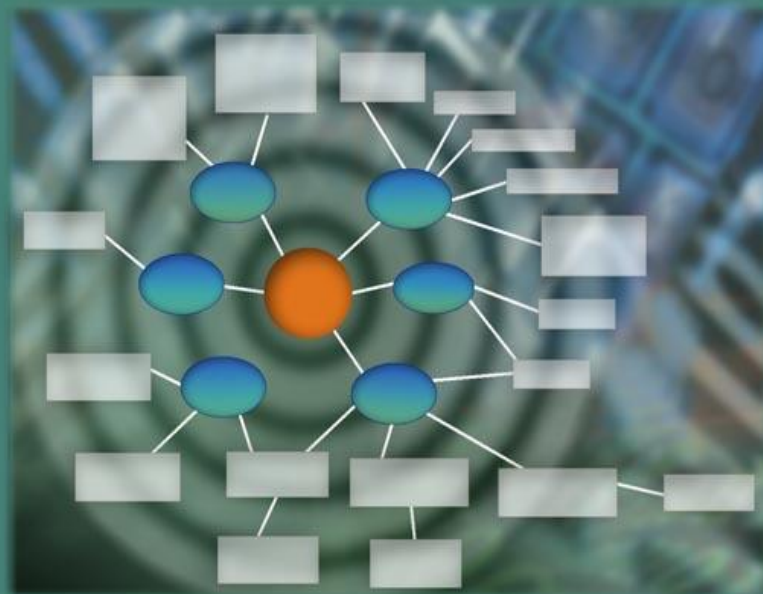
Автор более 30 печатных работ, в том числе четырех учебных пособий по интеллектуальным системам. Читает курсы по дисциплине «Интеллектуальные системы».

Сфера научных интересов: интеллектуальные системы, управление знаниями, модели представления знаний, проектирование.

Т.А. ГАВРИЛОВА
Д.И. МУРОМЦЕВ
ИНТЕЛЛЕКТУАЛЬНЫЕ
ТЕХНОЛОГИИ В МЕНЕДЖМЕНТЕ

Т.А. ГАВРИЛОВА, Д.И. МУРОМЦЕВ

ИНТЕЛЛЕКТУАЛЬНЫЕ ТЕХНОЛОГИИ В МЕНЕДЖМЕНТЕ



ИЗДАТЕЛЬСКИЙ ДОМ
С.-ПЕТЕРБУРГСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА

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- разработчикам интеллектуальных систем
- всем интересующимся вопросами инженерии знаний

That's IT!
Thank you!



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