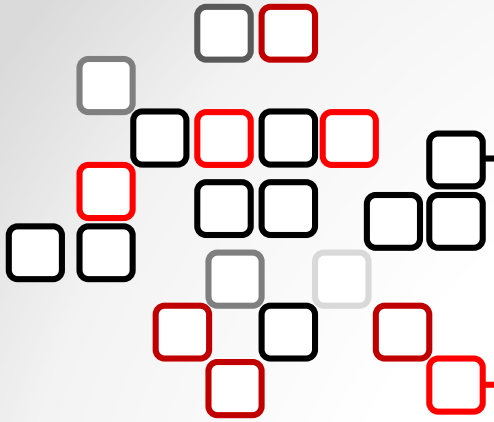
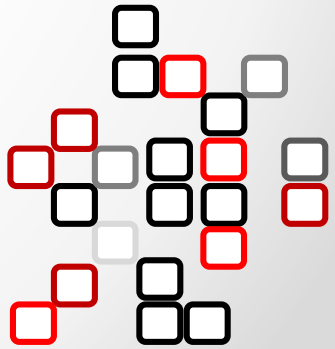


Autonomous Systems

Lecture 03

Knowledge representation
Selected approaches



Martina Husáková

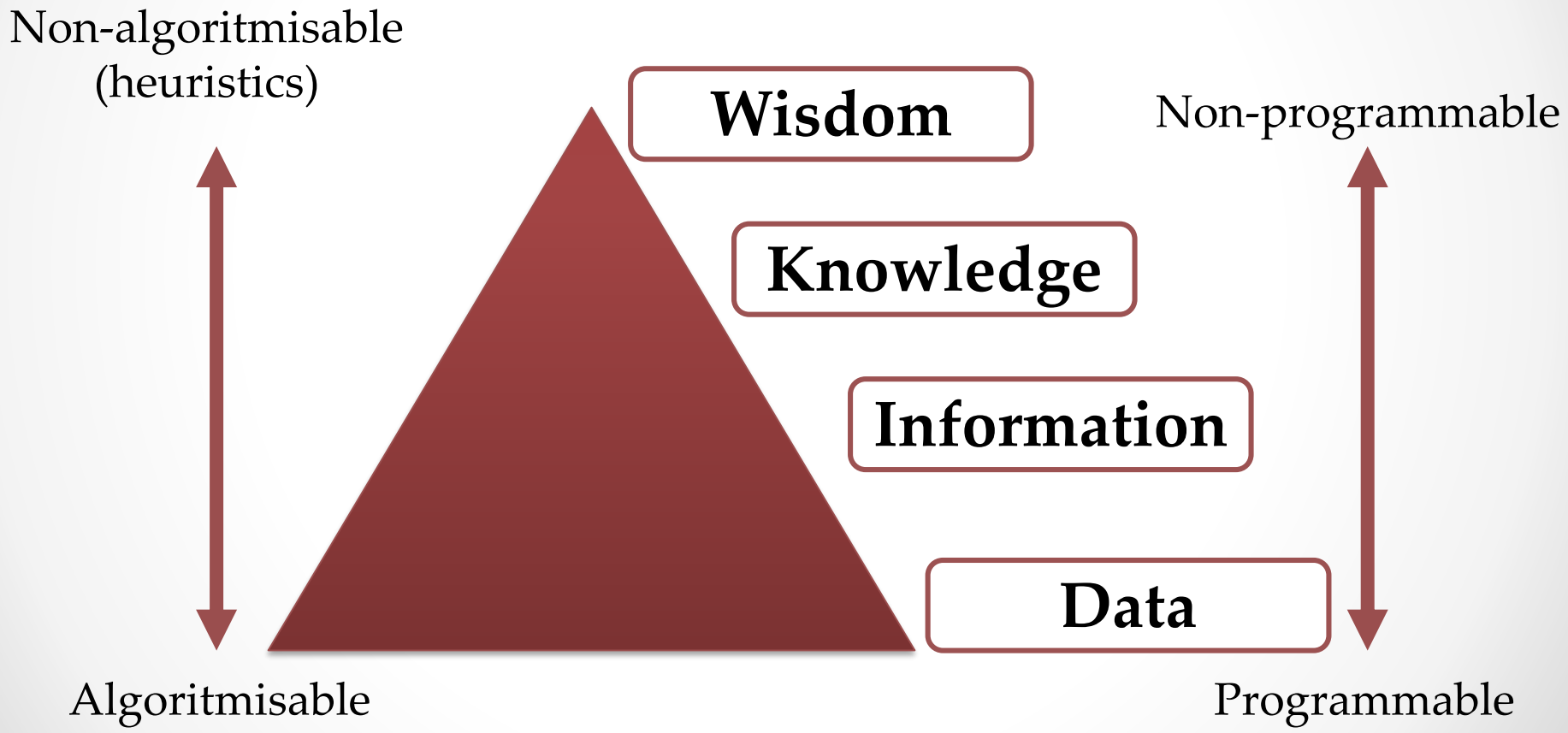
Outline

- Data, information and knowledge
- Knowledge representation
- Mind mapping
- Concept mapping
- Ontologies

Data, information and knowledge

- **Data:** something what is represented without meaning; we do not understand what it is; we only know that it is a text, symbol, etc.
  - form: text, code, picture, sound, symbol
  - data are used for information or knowledge specification
- **Information:** data with meaning
  - We are able to answer on the following questions with the information: Who?, What?, Where?, When?
  - Goal: to decrease the entrophy
- **Knowledge:** relations between information or data are represented with the aim to understand something or to solve a problem
  - We are able to answer on the following questions with knowledge: How?
  - Shape: collection of rules, manual, procedure, …
- **Wisdom:** knowledge leading to understanding

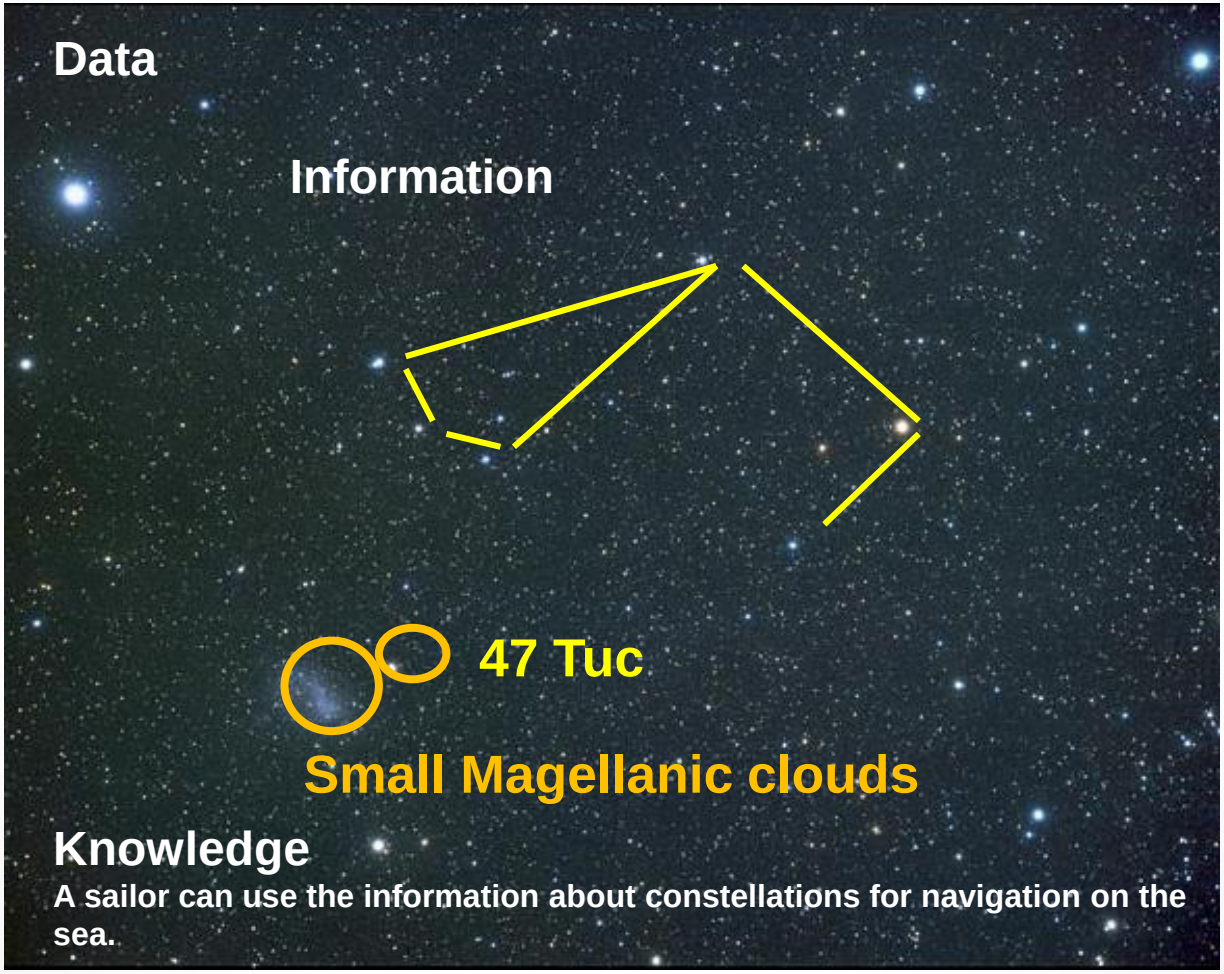
Data, information and knowledge



Data, information, knowledge Example 1

- **Data in binary code:** 01010000 11000101 10011001 01100101 01100100 01110000 01101111 01110110 11000100 10011011 11000100 10001111 00100000 01110000 01101111 11000100 10001101 01100001 01110011 11000011 10101101 00100000 01101110 01100001 00100000 01100100 01100101 01101110 00100000 00110010 00110001 00101110 00100000 00111001 00101110 00100000 00110010 00110000 00110001 00110000 00100000 01101000 01101100 11000011 10100001 01110011 11000011 10101101 00100000 01110000 01110010 01101111 00100000 01100100 01101111 01100010 01110101 00100000 00111000 00111010 00110001 00110101 00100000 01110100 01100101 01110000 01101100 01101111 01110100 01110101 00100000 00110001 00110010 00100000 01110011 01110100 01110101 01110000 11000101 10001000 11000101 10101111 00100000 01000011 01100101 01101100 01110011 01101001 01100001 00100000 01100001 00100000 01110100 01101100 01100001 01101011 00100000 00110001 00110000 00110010 00110000 00100000 01101000 01010000 01100001 00101110 00100000
- **Information: Weather forecast for 21. 9. 2010 and the time 8:15 is 12 degrees of Celsius and preassure 1020 hPa.**
- **Knowledge: High preassure is the indicator of the nice weather => It is not necessary to take the umbrella.**

Data, information, knowledge Example 2



Knowledge representation

- **Knowledge representation (KR):** a subfield of the artificial intelligence (AI) using various methods of knowledge acquisition, representation, storage; used by the machines for intelligent problem solving
- **KR** was mainly mentioned in the view of the expert systems providing solutions for specific problem

Knowledge representation

PRESENT

- Development of reusable and sharable knowledge-based structures with the aim to separate procedural mechanism processing knowledge and particular knowledge structures
- Possible techniques:
  - Mind mapping
  - Concept mapping
  - Ontologies
  - Semantic nets
  - Frames
  - Conceptual graphs
  - …

Mind mapping – What is it?

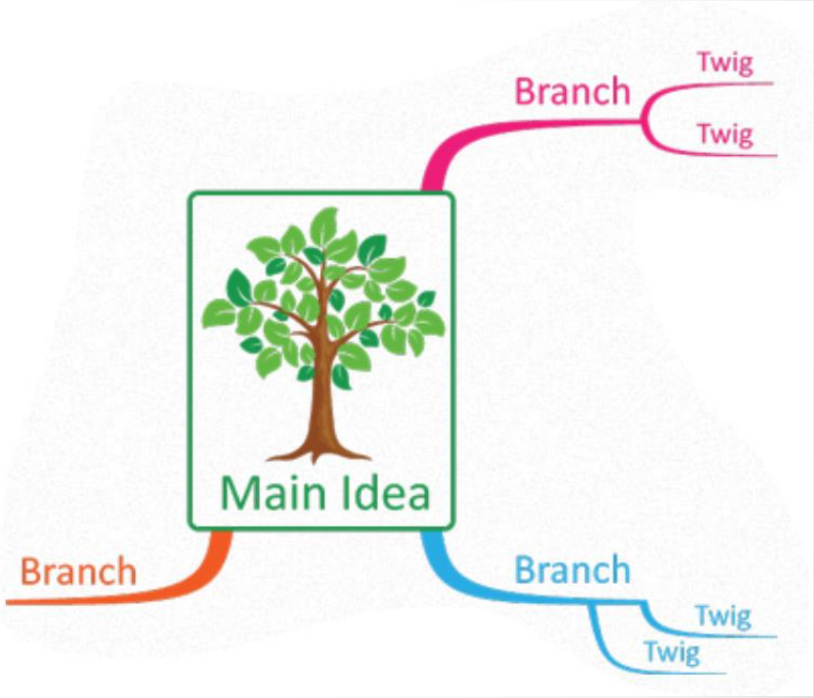
- **Mind mapping: a non-formal technique developed in 1960´s by T. Buzan**
- **This technique is used for sorting, organisation and presentation of own ideas about one particular topic**
- ***„Mind mapping is a creative and logical means of note-taking and note-making that literally "maps out" your ideas.“* (mindmapping.com)**
- **Mind map is a subjective structure => it should represent only your own ideas about particular topic which can be visualised by the text, colours, symbols, pictures, etc.**

Mind mapping - purpose

- **Purpose and advantages:**
  - Information and knowledge representation
  - One-page method => everything is only on the one page
  - Mind map can ease the orientation in the topic that can be complex
  - Mind map can help you in memorisation of the facts
  - Brainstorming support
- **Disadvantages:**
  - Mind maps hardly represent complex knowledge structures, mainly in the view of relations between concepts
  - Linear structures (no network-like structures)
  - Mainly not used for machine processing

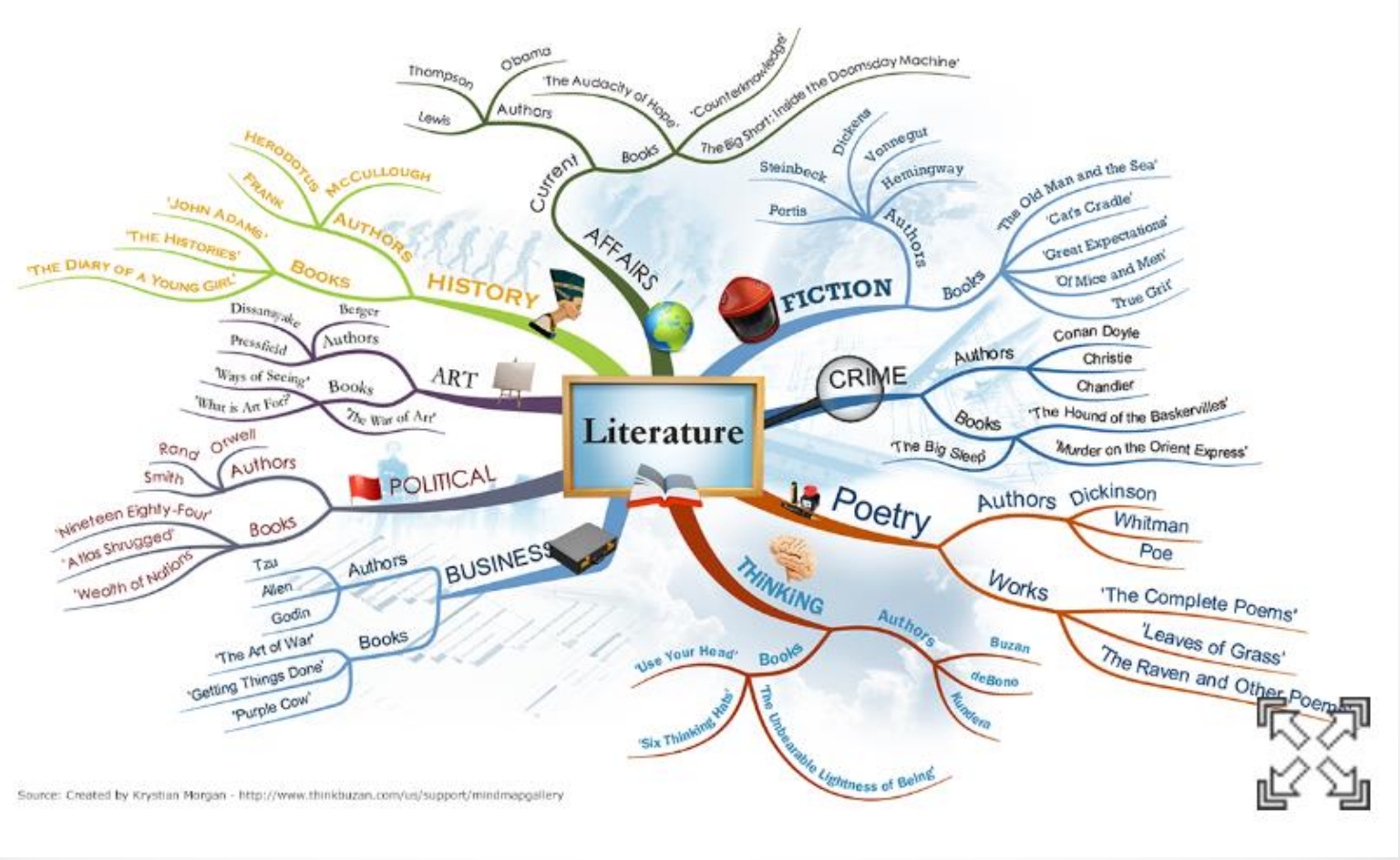
Mind mapping

- We start with the one concept that is in the centre of the mind map
- Gradually, we add the next concepts to this central concept
- Branches can comprise images, keywords drawn or printed on its associated line
- Topics of lesser importance are represented in smaller sizes and pictures



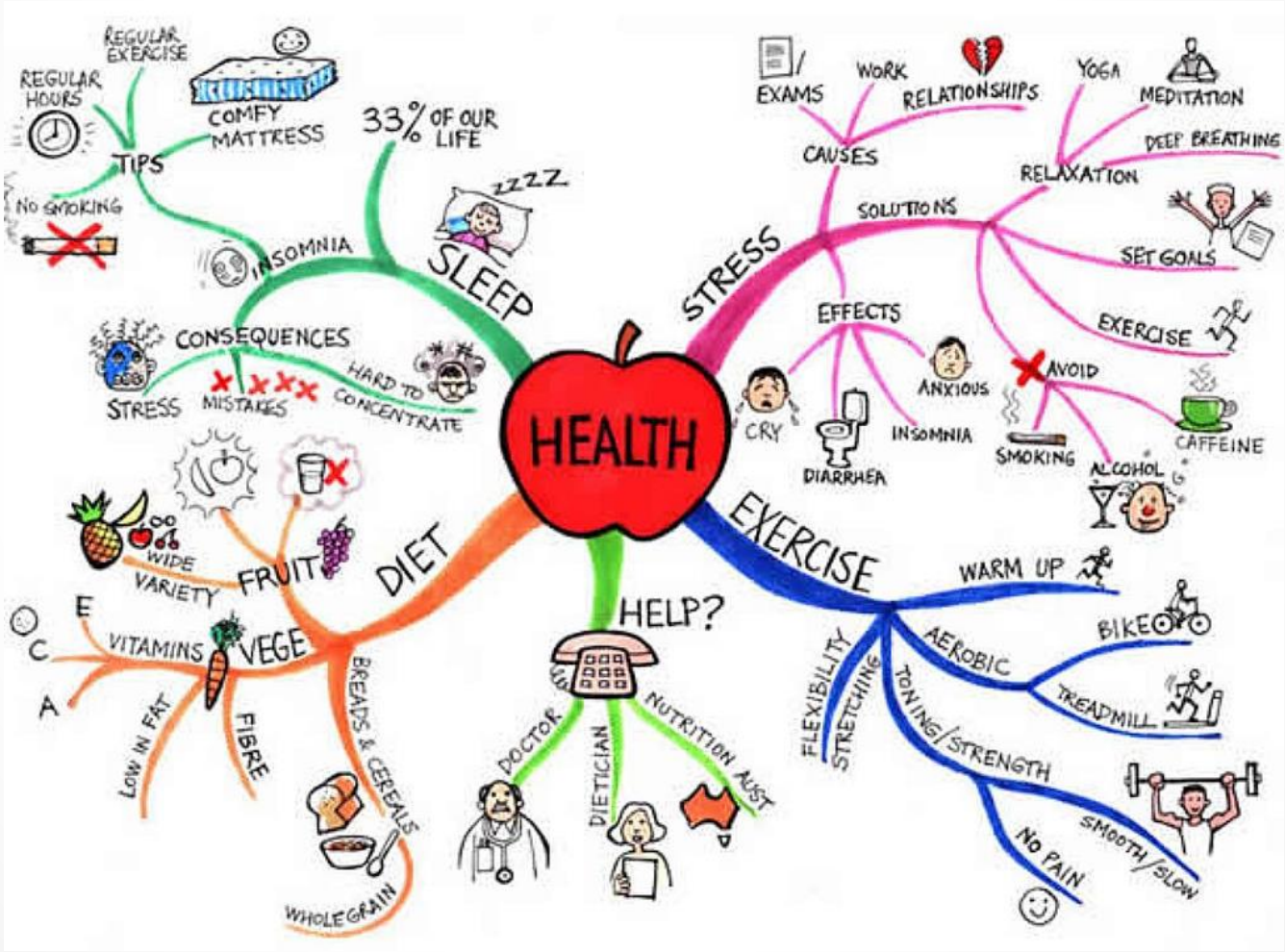
Source: http://oregonstate.edu/tac/how-to-use/mind-mapping

Mind map – Example 1



Developed by K. Morgan, zdroj: http://oregonstate.edu/tac/how-to-use/mind-mapping

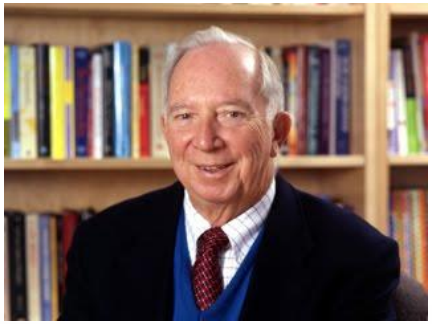
Mind map – Example 2



Source: http://www.tonybuzan.com/gallery/mind-maps/

Concept Mapping

- **Knowledge representation and organisation in a visual mannger**
- **Author of the technique: J. D. Novak**
  - **He proposed CM in the research program at the Cornell University in 1972**
  - **Research program was focused on understanding how the knowledge is changed during study of children**



Source: http://jnovakupn.blogspot.cz/2010/04/biografia-del-autor_17.html

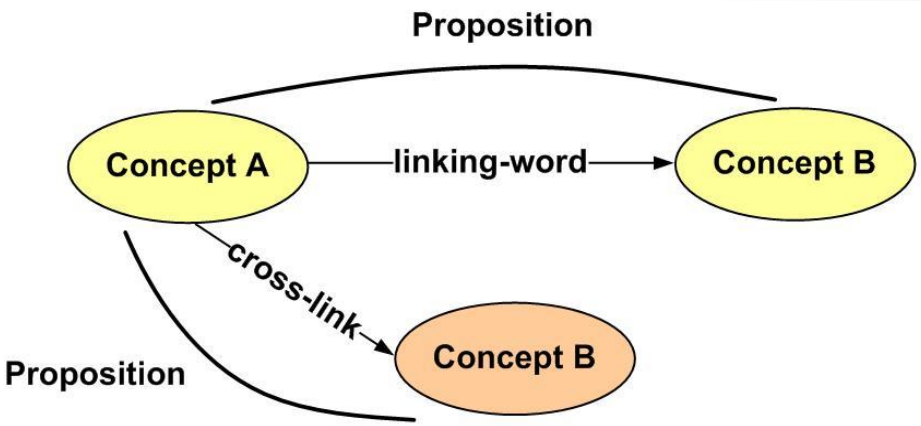
Concept Mapping

- **CM are based on the meaningful learning theory of D. Ausubel**
- **Learning process and understanding of a new knowledge is mainly based on the idea what person already knows about studied topic**
- *„If I had to reduce all of educational psychology to just one principle I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.“*

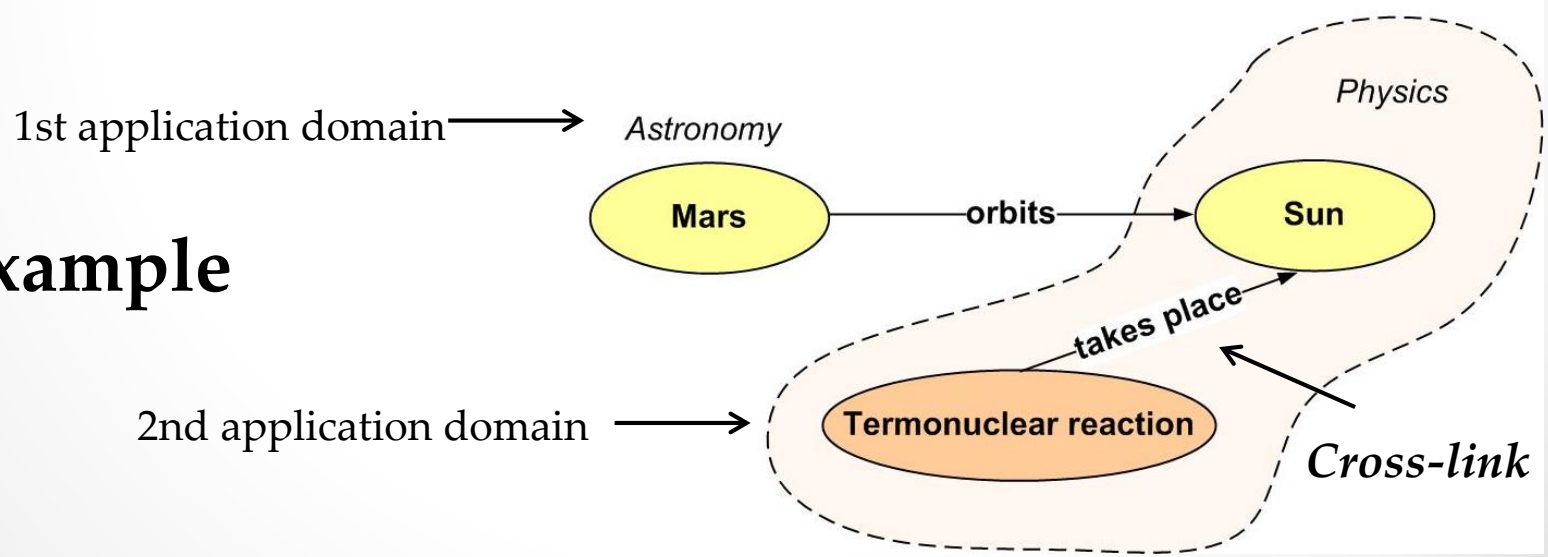
D. Ausubel, 1968

Structure of the concept map (1)

Structure



Example



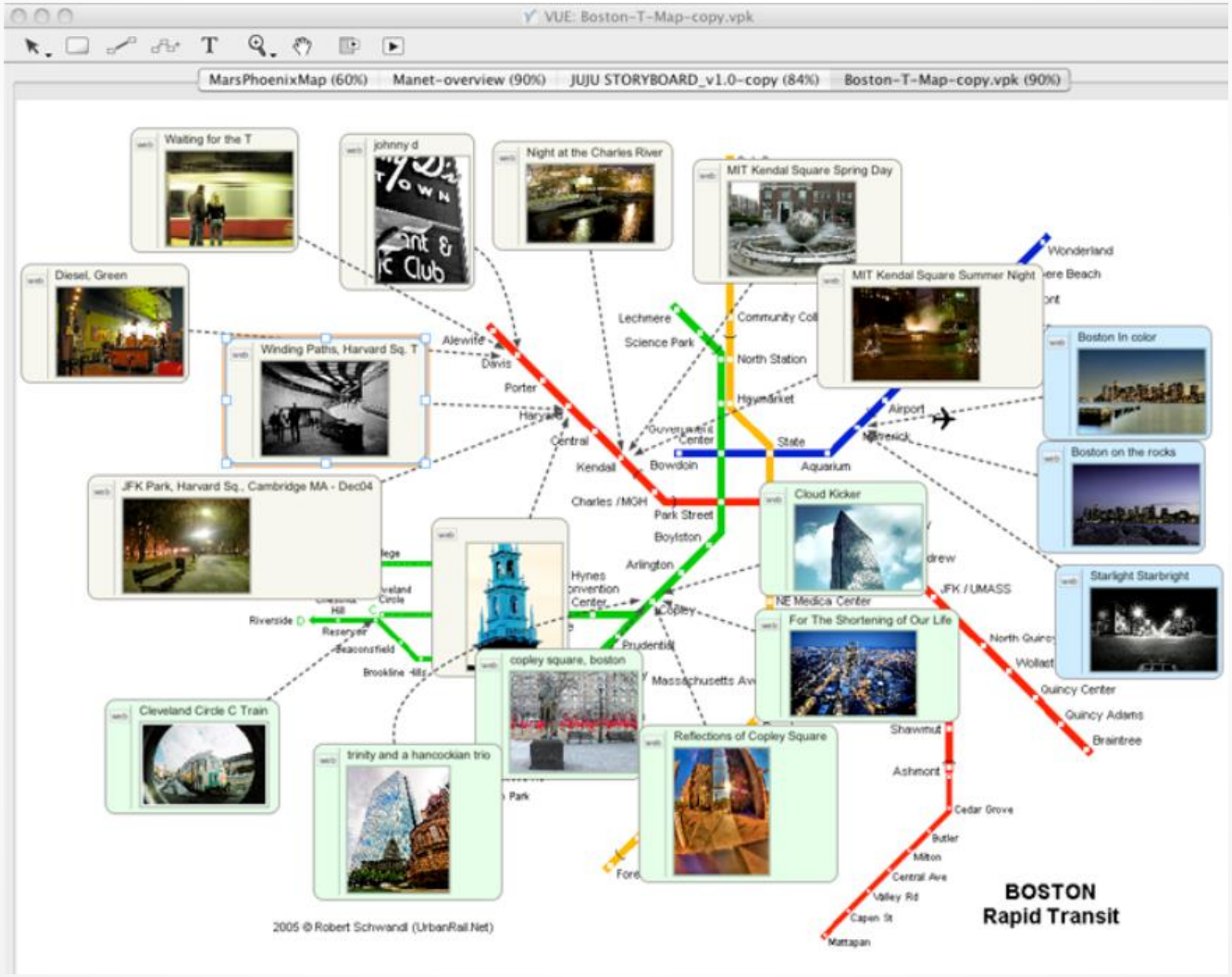
Structure of the concept map (2)

- Concept: represents particular regularity in events or objects. This regularity has a name or is marked with a symbol, e. g. Life, Cell, Blue, Ship, Mathematics, Programm, … (nouns)
- Linking-words (relations): help to define context in which we should understand the concepts
  - relations between concepts
  - cross-links: relations connecting concepts of various application domains -> multi-disciplinarity
- Concept map is a collection of statements which relate with (min.) one application domain

Usefulness of concept maps

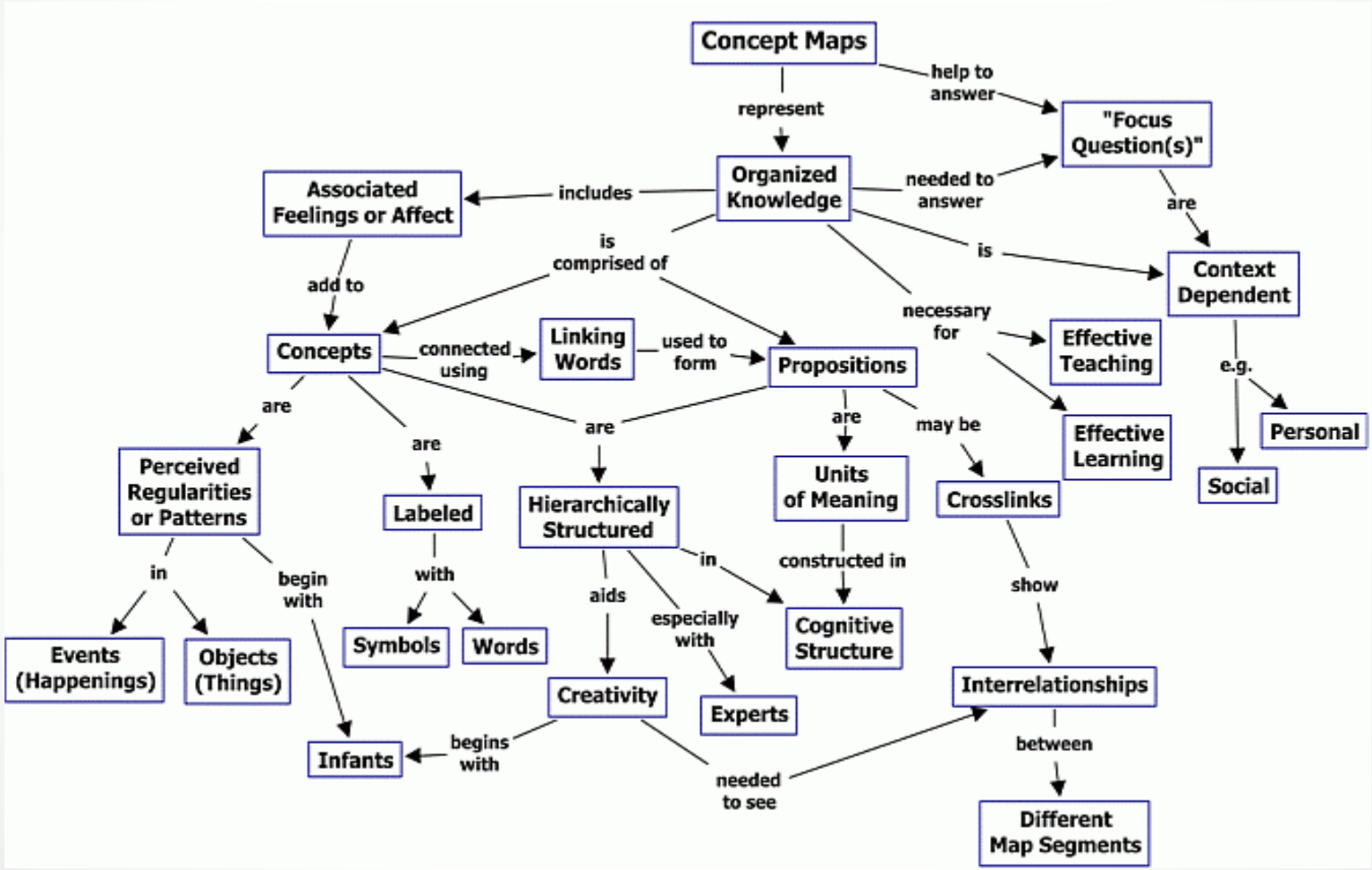
- Visualisation of information and knowledge
- Help with understanding of complex topics (multi-disciplinary topics)
- Summarisation of knowledge in the graph-based format (*possibility to use CM in preparation of tests*)
- Structuring of a content of educational courses
- Evaluation of student´s understanding of topics by a teacher (comparison of concept maps)
- An attempt in decreasing the tendency to memorise facts by students
- Brainstorming (generation of new ideas)
- Acquisition of tacit knowledge of experts

Concept Map - Example



Source: http://vue.tufts.edu/gallery/index.cfm

Concept Map - Example



Source: http://www.sicotests.com/psyarticle.asp?id=151

Mind Maps vs. Concept Maps
Brief comparison

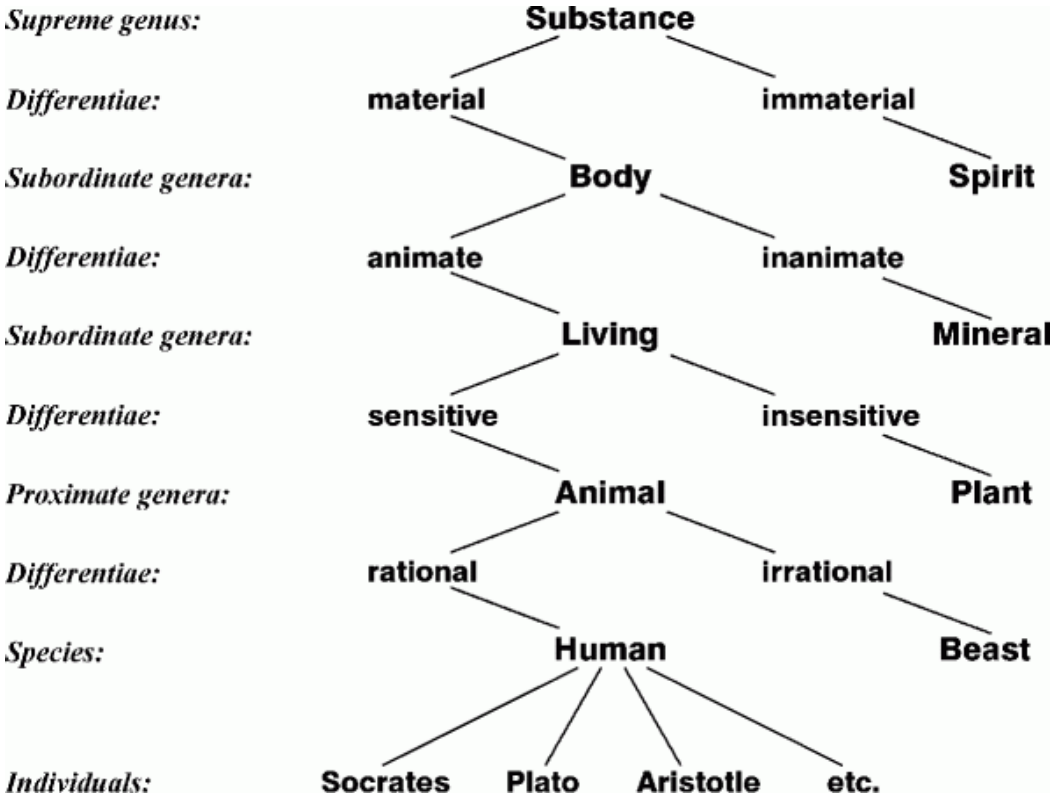
Mind Maps	Concept Maps
Main topic is in the centre of the map.	We are not able to find the centre of the map.
Subjective structure	Non-subjective structure
Non-formal structure	Non-formal structure
Visualisation ideas about one topic.	Multi-disciplinarity is acceptable.
Star-like structure	Tree or graph-based structure
Support for brainstorming, learning and teaching	Support for brainstorming, learning, teaching and knowledge sharing

… more information in the seminar nr. 3.

Ontology

- Ontology as a subarea of philosophy – metaphysics
- Ontology: greek Ontos (being), logos (word, meaning, speech)
- It investigates the human being and the essence of our world
- It tries to answer the following questions:
  - „What is a part of being?“
  - „What is the nature of things which are part of the reality?“
  - „Why does anything exist?“
  - „What is the meaning of things?“
- Metaphysics = Ontology (philosophical point of view)

Three of Porphyry (Arbor Porphyriana)
The first classical ontology

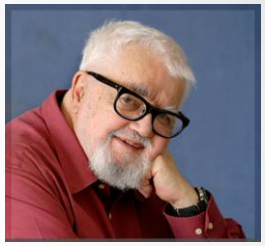


- The oldest adaptation of the hierarchical structure which appeared in the work Isagoge (introduction into the Cathegories of the Aristotle)
- The author: greek philosopher Porphyry of the Tyre

Tree of Porphyry. URL: http://faculty.washington.edu/smcohen/433/PorphyryTree.html

Ontologies in the Computer Science point of view (1)

- **The word *ontology* was firstly used by J. McCarthy in the context of the common sense knowledge (1980)**



McCarthy J., 1980. Circumscription – A Form of Nonmonotonic Reasoning. In: Artificial Intelligence, vol. 13, pp. 27 – 39.

- **Knowledge (expert) system should not fail for unfamiliarity of „obvious things“. It should have common sense knowledge.**

Mařík V., a kol., 1997. Umělá inteligence 2. Praha: Academia, str. 130 – 131. ISBN 8020005048.

Picture of J. McCarthy: http://www.saildart.org/jmc2012.html

Ontologies in the Computer Science point of view (2)

- **T. Gruber (1993, [4]): „Ontology is explicit specification of the conceptualisation.“**
  - ***explicit*: knowledge is easy accessible**
  - ***conceptualization*: the system of terms that model particular part of the world**
- **W. N. Borst (1997, [5]): „Ontology is formal specification of shared conceptualisation.“**
  - ***formal*: computable knowledge, e. g. we use languages with defined syntax/semantics**
  - ***shared*: ontology as a result of concensus**

Ontologies in the Computer Science point of view (2)

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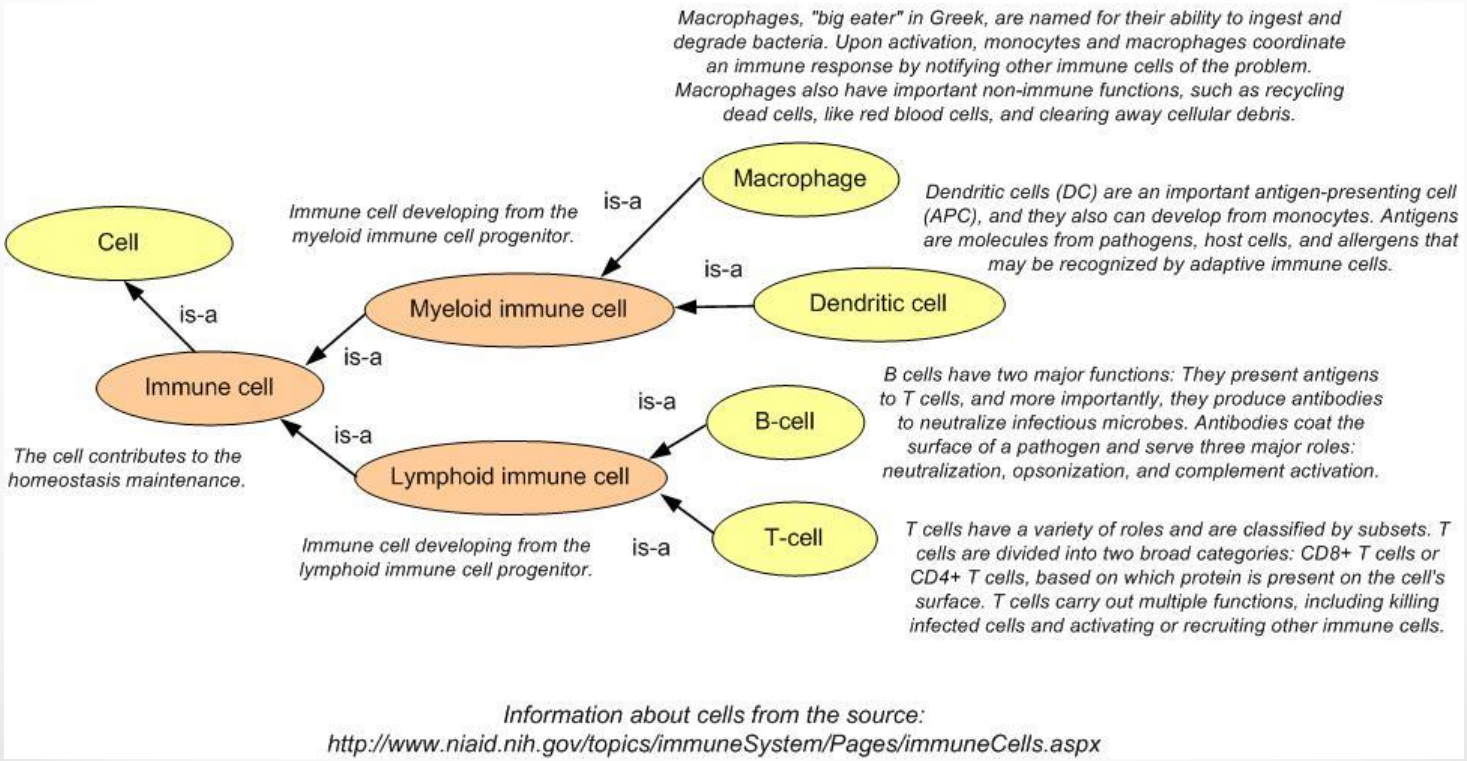
  - ***shared*: ontology as a result of concensus**

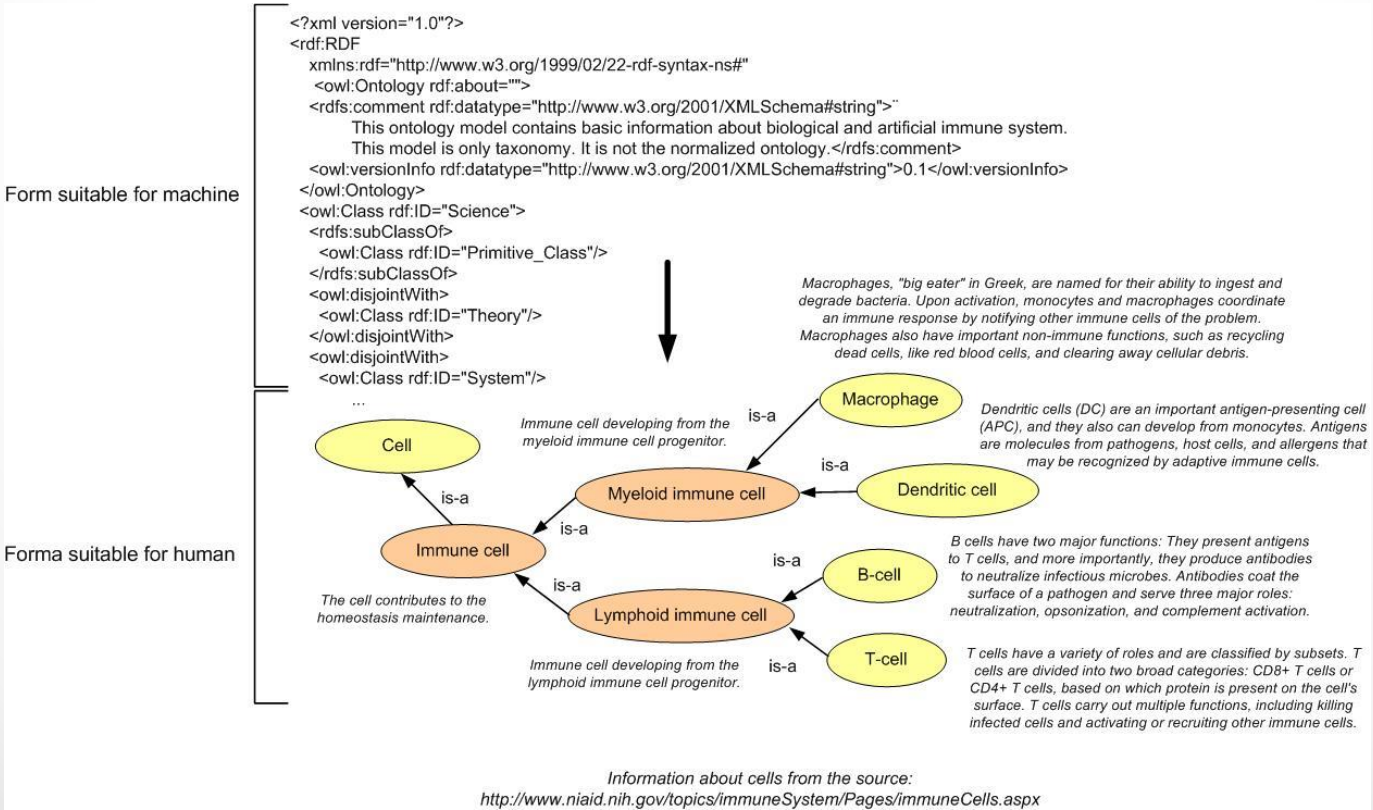
The usage of ontologies (1)

- **Ontologies ease the communication between:**
  - **Human versus human**



The usage of ontologies (2)

- **Ontologies ease the communication between:**
  - **Human versus computer**
  - **Between computers**



Information about cells from the source:
http://www.niaid.nih.gov/topics/immuneSystem/Pages/immuneCells.aspx

The usage of ontologies: recap

- **For whom?**
  - **communication: human-human**
    - **pictures, diagrams, non-formal structures**
    - **non-formal ontology is sufficient**
    - **support for communication between knowledge engineer and expert or during design/analysis of the software**
  - **communication: human-machine**
    - **support for communication between various computer systems with the usage of the unique "vocabulary"**
    - **ontology as a format for data exchange**
  - **communication between machines**
    - **formal language for the semantic-web applications development is necessary**

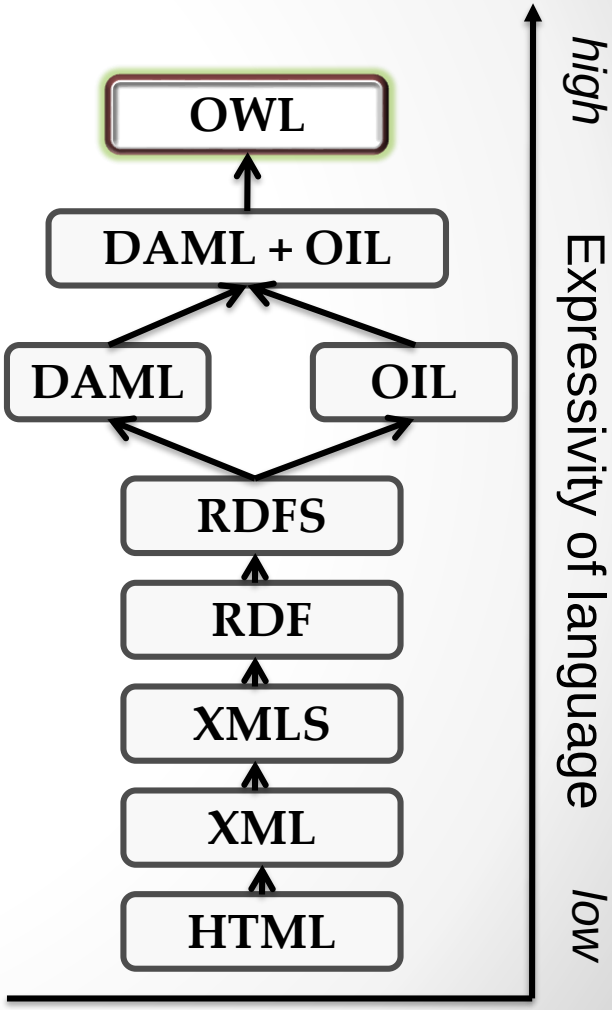
Application areas

- Multi-agent systems
- Semantic web
- Biomedicine, bioinformatics
- Knowledge-based (expert) systems
- E-learning systems
- Semantic web portals
- Applications for tourism

OWL ontologies

- Formal language used for development of ontologies used in the semantic web spaces (Ontology Web Language)
- Official W3C standard (2004)
- It is based on RDF(S) and description logics

(formal logics for representation of relations between concepts)

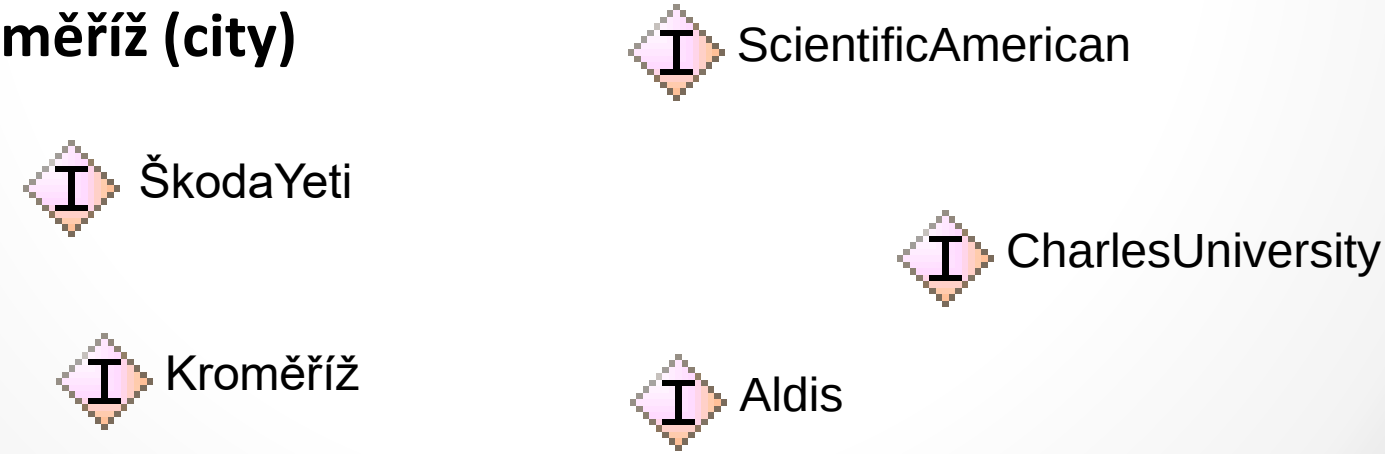


Building blocks of OWL ontologies

- Classes and hierarchy of classes
- Properties (object, annotation, datatype)
  - Relations between classes - inheritance, disjointness, equivalency
  - Restrictions for properties (domain, range, cardinality)
  - Attributes of properties (transitivity, reflexivity, …)
- Individuals are not often a part of the OWL ontology

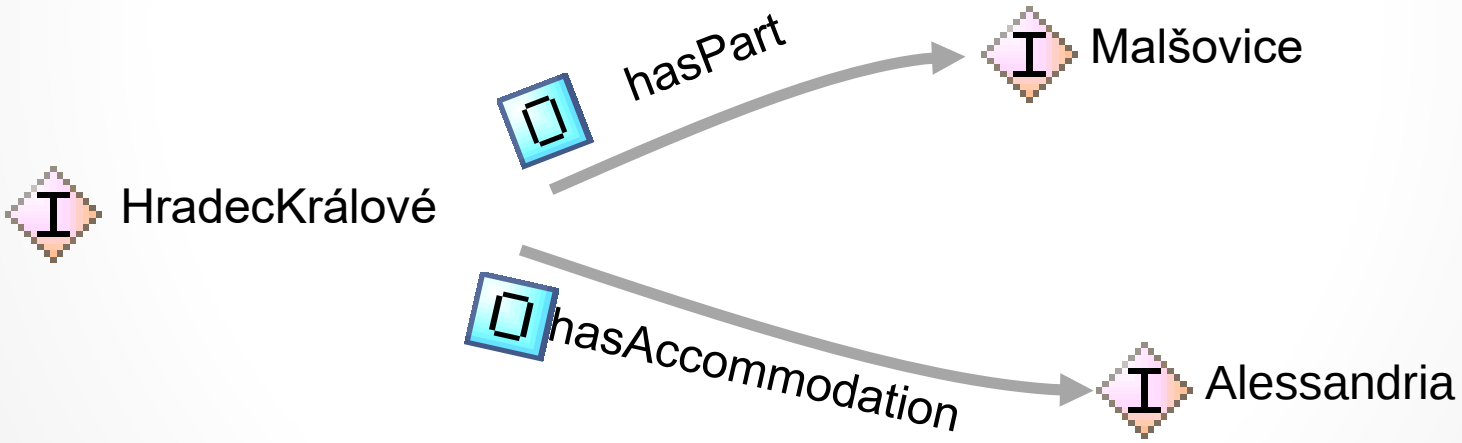
Individual

- **Instance of a class**
  - **A car ŠkodaYeti**
  - **A magazine Scientific American**
  - **Charles university**
  - **Aldis (cultural centre in Hradec Králové)**
  - **Kroměříž (city)**



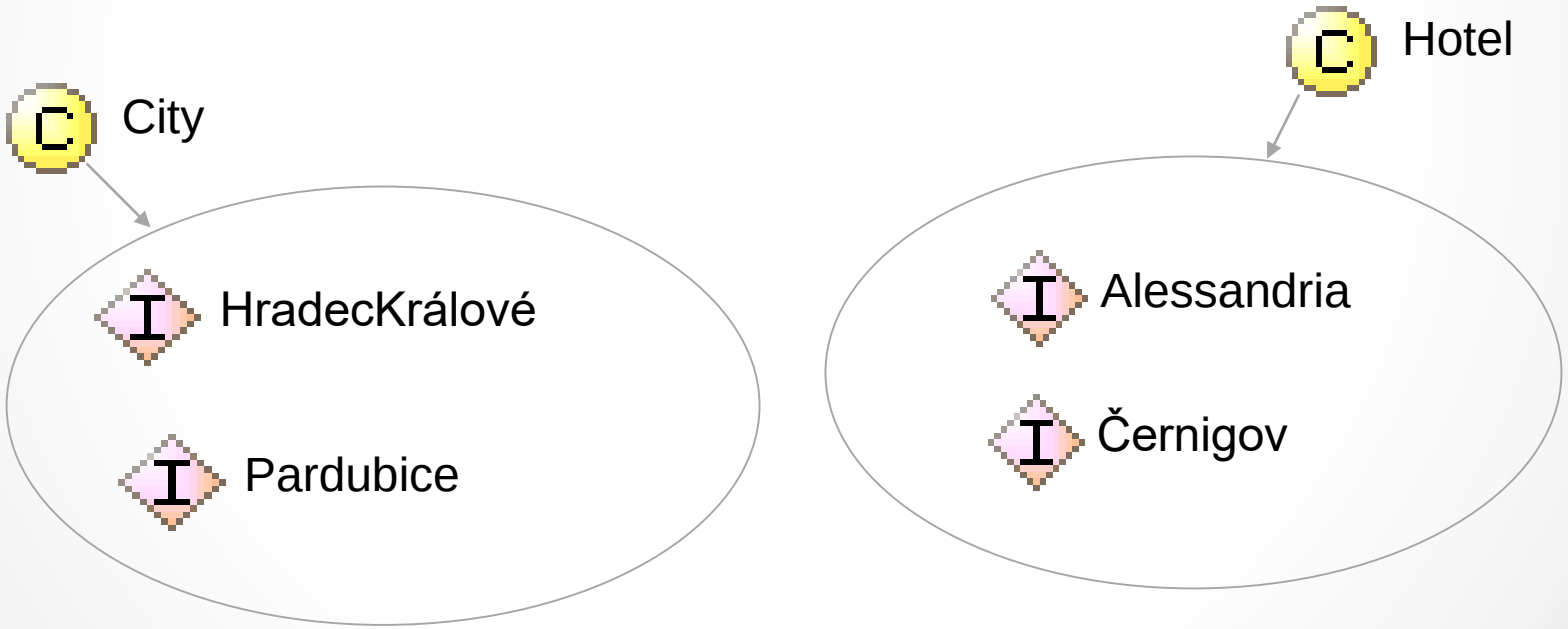
Object property

- **It connects two individuals**
- **Relation (0..n, n..m)**



Class

- **A group of individuals with common characteristics**
- **Individual is an instance of the one or more classes**



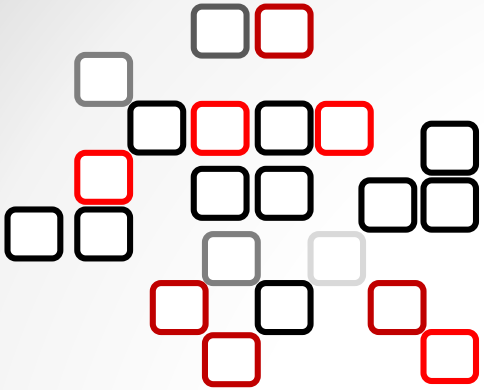
Mind Maps, Concept Maps and Formal ontologies

Brief comparison

Mind Maps	Concept Maps	Formal ontologies
Main topic is in the centre of the map.	We are not able to find the centre of the map.	We are not able to find the centre of the map.
Subjective structure	Non-subjective structure	Non-subjective structure
Non-formal structure	Non-formal structure	Formal structure
Visualisation ideas about one topic.	Multi-disciplinarity is acceptable.	Multi-disciplinarity is common.
Star-like structure	Tree or graph-based structure	Tree or graph-based structure
Support for brainstorming, learning and teaching	Support for brainstorming, learning, teaching and knowledge sharing	Mainly used for inference and reasoning

Literature

- [1] Gruber T. R., 1993. A Translation Approach to Portable Ontologies. In: Knowledge Acquisition 5 (2), pp. 199 – 220.
- [2] Borst W. N., 1997. Construction of Engineering Ontologies. Centre for Telematica and Information Technology, University of Tweenty. Enschede, The Netherlands.



THANK YOU FOR YOUR ATTENTION!