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Introduction, Semantic Networks and the Others ...

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FEL ČVUT

laboratory Gerstner

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Topic Maps

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- web page [currently in czech]: http://cw.felk.cvut.cz/doku.php/courses/a4m33rzn/start
- three basic topics: description logics, probabilistic models, fuzzy logic
- **Please go through the course web page carefully !!!**

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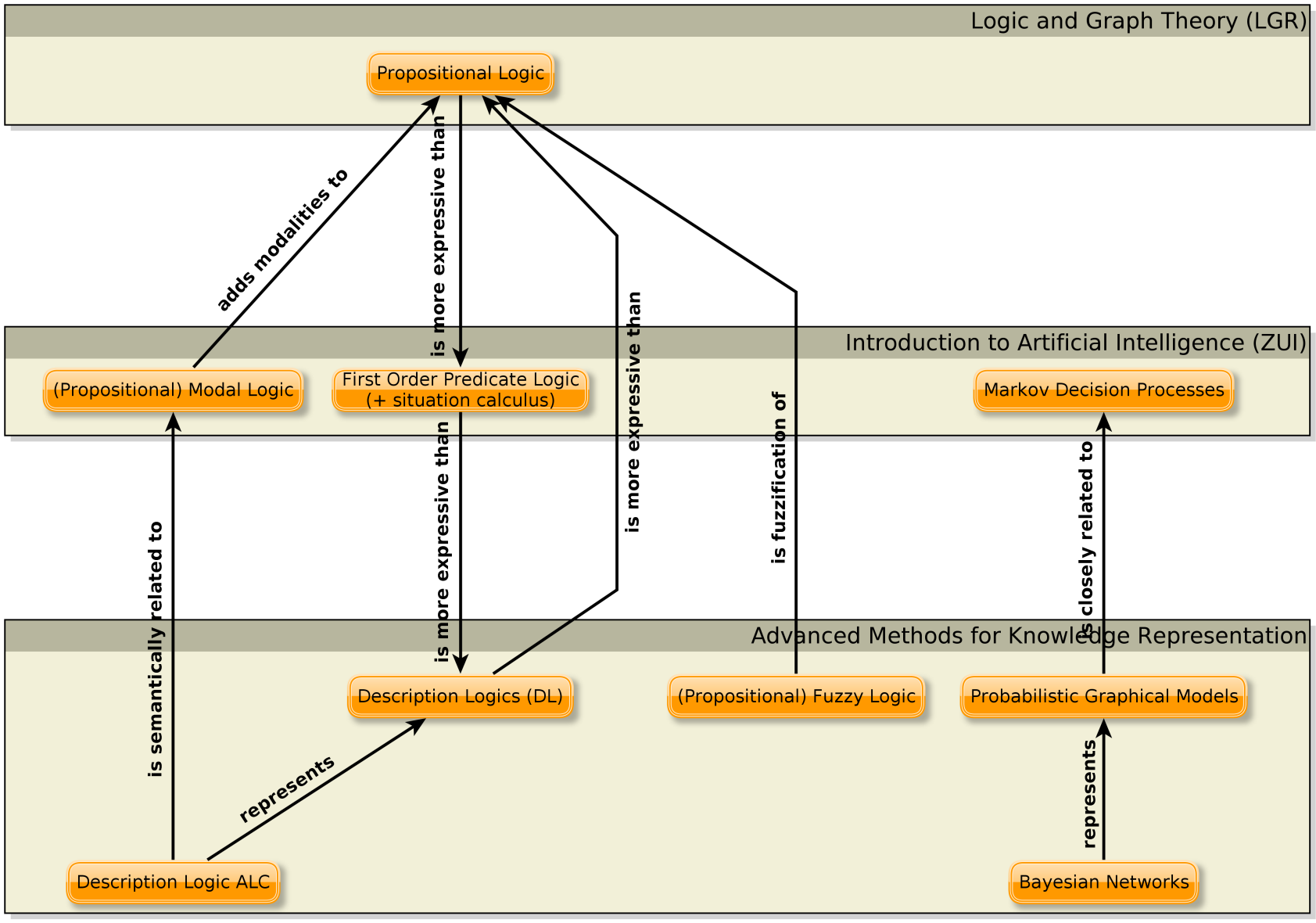

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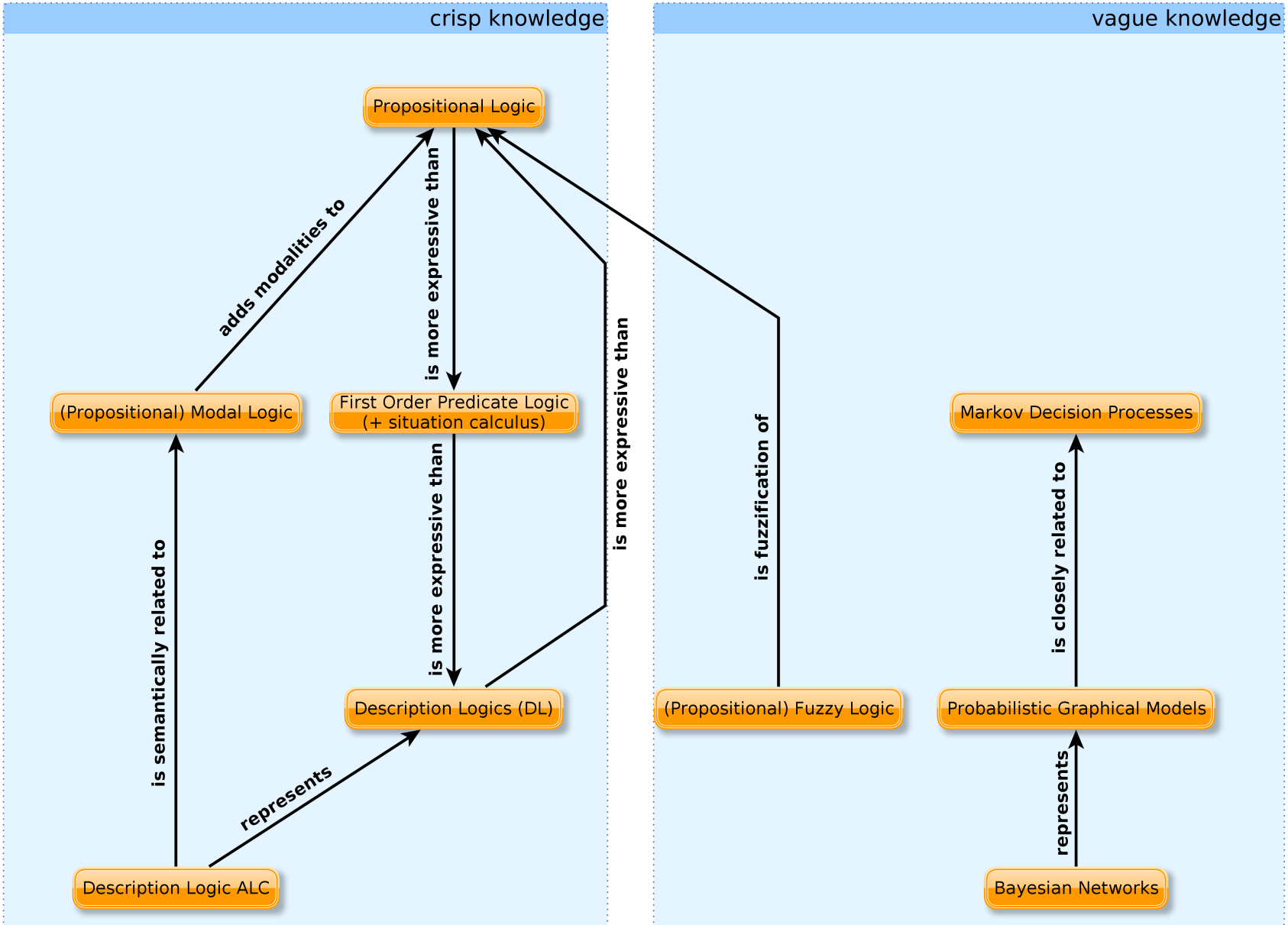

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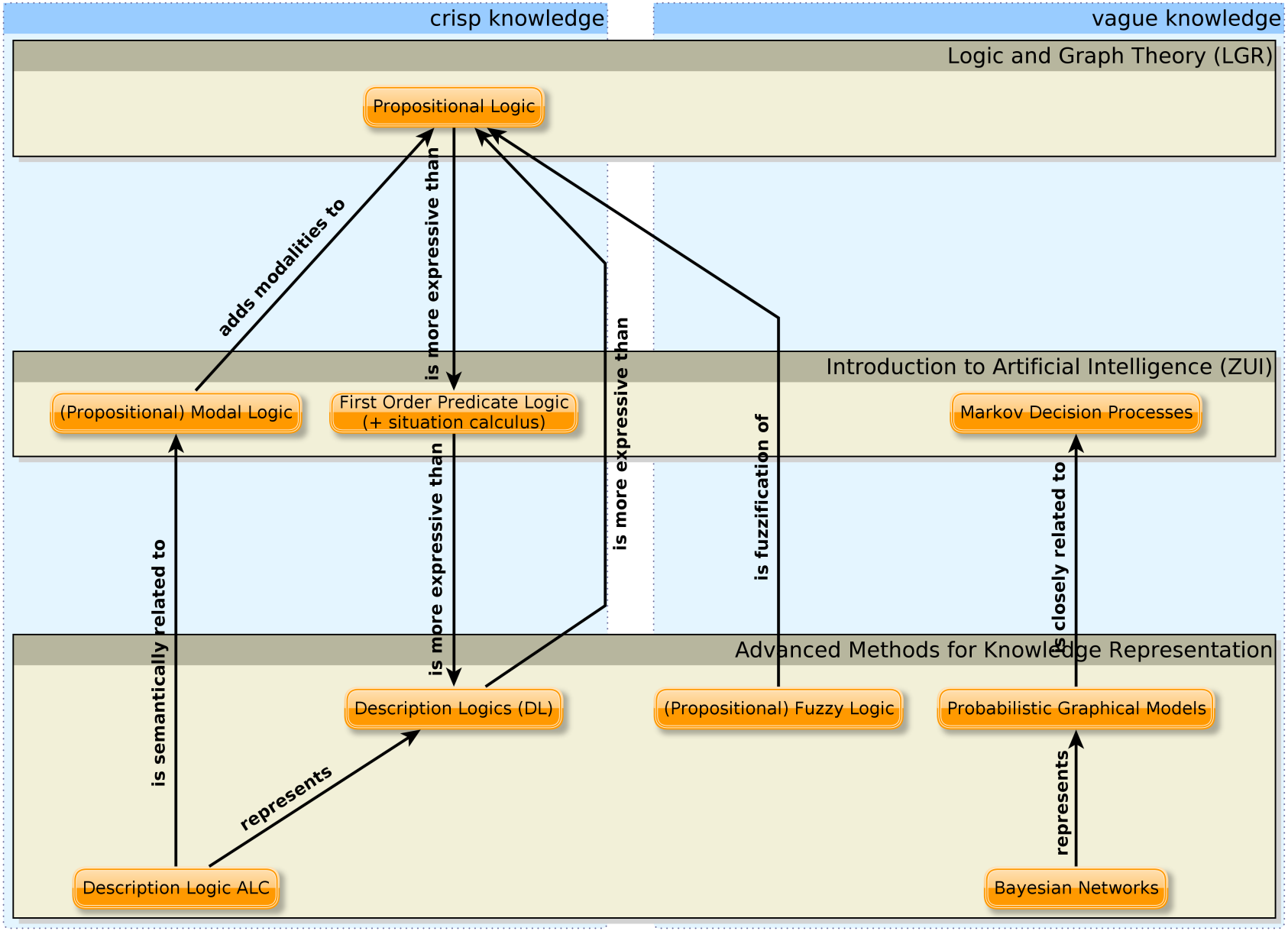

Crisp Knowledge Representation

Motivation

- Let's have the domain of a university. Each stakeholder needs different type of information:
  - Student: **"Which bachelor course should I enroll in order to get at least 6 credits ?"**
  - Teacher : **"How many hours per week am I going to teach this term ?"**
  - Dean : **"Which courses are popular among students ?"**
- **Knowledge** tries to capture relationships in the domain, so that they can be used for answering various types of queries.
  - "Bachelor courses are courses."
  - "In most cases a course can be opened only if 2 or more students are enrolled."
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- So, two questions remain ...
  - How to formally represent knowledge ?
    - declaratively × procedurally ? – this course will deal with **declarative knowledge**. např.
      $(\forall P)(BachelorCourse(P) \Rightarrow Course(P))$
    - without uncertainty (crisp) × with uncertainty – this course will cover both, starting without uncertainty. např.
      $(\forall K)(Course(K) \Rightarrow (CourseWithExcpetion(K) \vee (\exists X_1, X_2)(IsEnrolledTo(X_1, K) \wedge IsEnrolledTo(X_2, K) \wedge X_1 \neq X_2))$
  - How to make use of the knowledge representation ?
    - knowledge management – search engines (database, question answering servers, semantics web)
    - multiagent systems – content of messages, ontologies
    - machine learning – language bias
    - in all AI branches

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Declarative Knowledge Representation without Uncertainty

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- thesauri, topic maps
- relational databases (relational calculus)
- rule-based systems, Prolog (first-order predicate logics)
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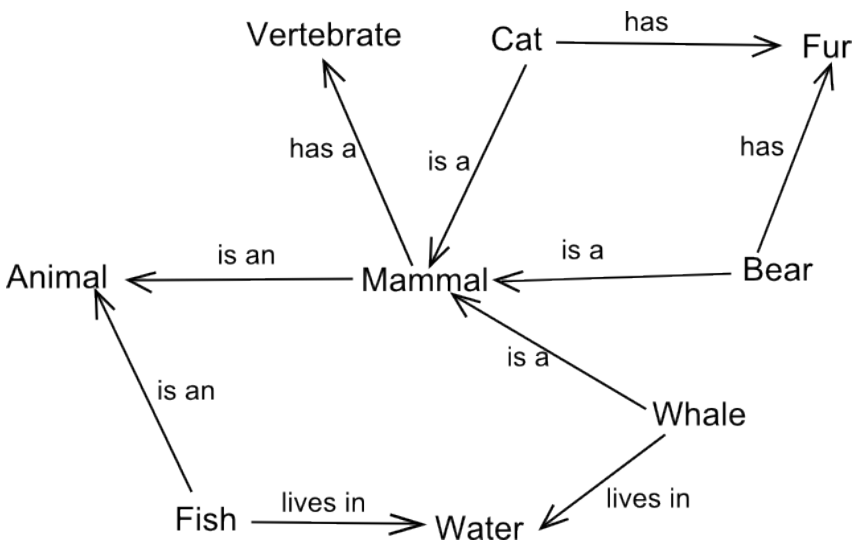

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Nodes = entities (individuals, classes),

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- The only possible inferrence is *inheritance* by means of **is a** relationship.

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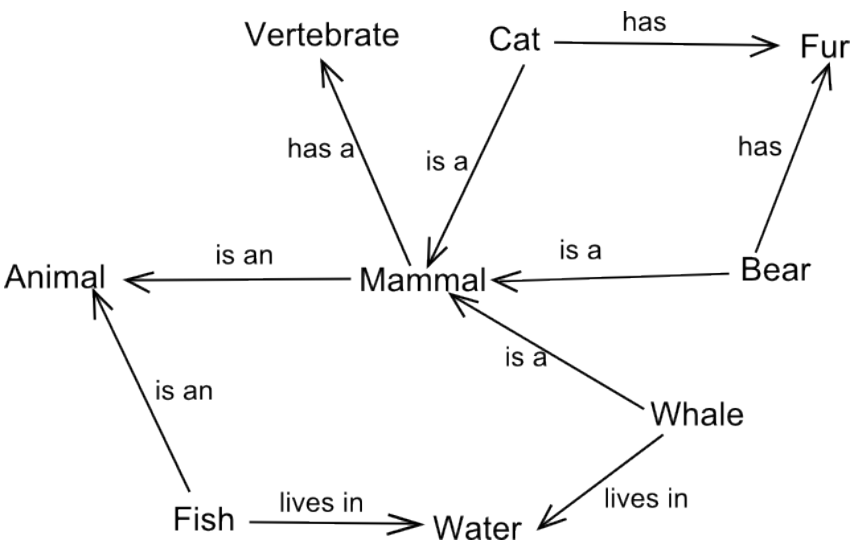

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Example

Each Cat has a Vertebrate, since each Cat is a Mammal.

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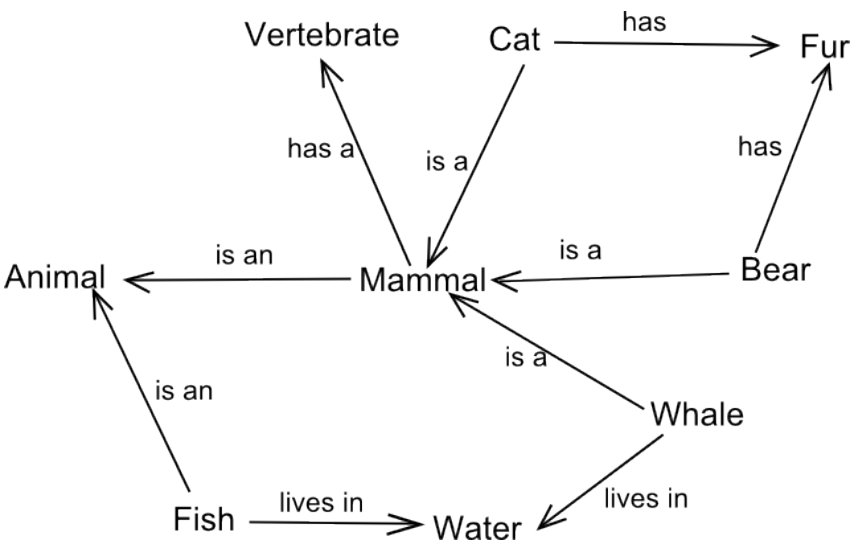

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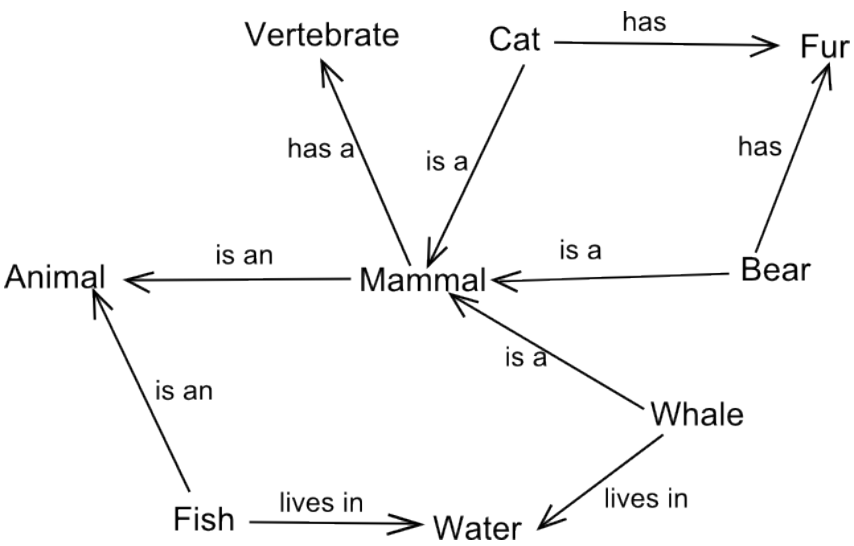

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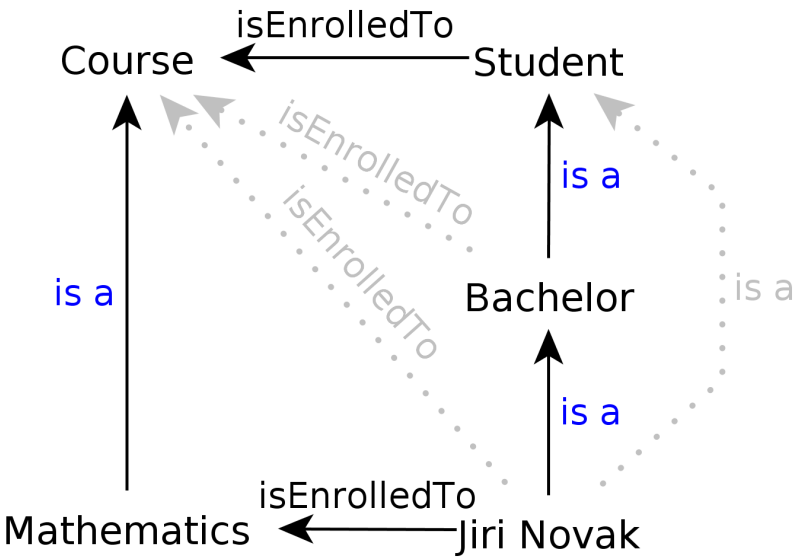
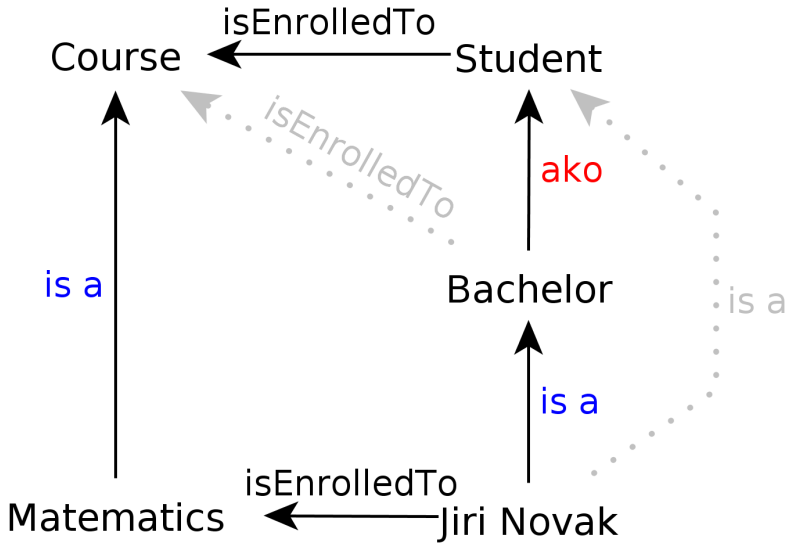


However, this does not allow distinguishing individuals (instances) and groups (classes).



To solve this, a new relationship type "is a kind of" **ako** can be introduced and used for inheritance, while **is a** relationships would be restricted to expressing individual-group relationships.

Semantic Networks (3)

☺ are simple – from the point of logics they are not much more than a binary structure + **ako** and **is a** relationships with the following semantics:

$$relation(X, Y) \wedge ako(Z, X) \Rightarrow relation(Z, Y).$$
$$isa(X, Y) \wedge ako(Y, Z) \Rightarrow isa(X, Z).$$
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☹ no way to express non-monotonous knowledge (like FOL).

☹ no easy way to express n-ary relationships (**reification** needed).

☹ no way to express binary relationships characteristics – transitivity, functionality, reflexivity, etc., or their hierarchies "to be a father means to be a parent", aj.,

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Semantic Networks – Wordnet, MultiWordnet

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hyponyms, hypernyms correspond to the **ako** relationship.

meronyms, holonyms denote "part-of" relationships between terms.

synonyms, antonyms synonyms are grouped into *synsets* – i.e. sets of terms that build up a single semantic context/meaning (e.g. $S_1 = \{\text{man}, \text{adult male}\}, S_2 = \{\text{man}, \text{human being}\}$)

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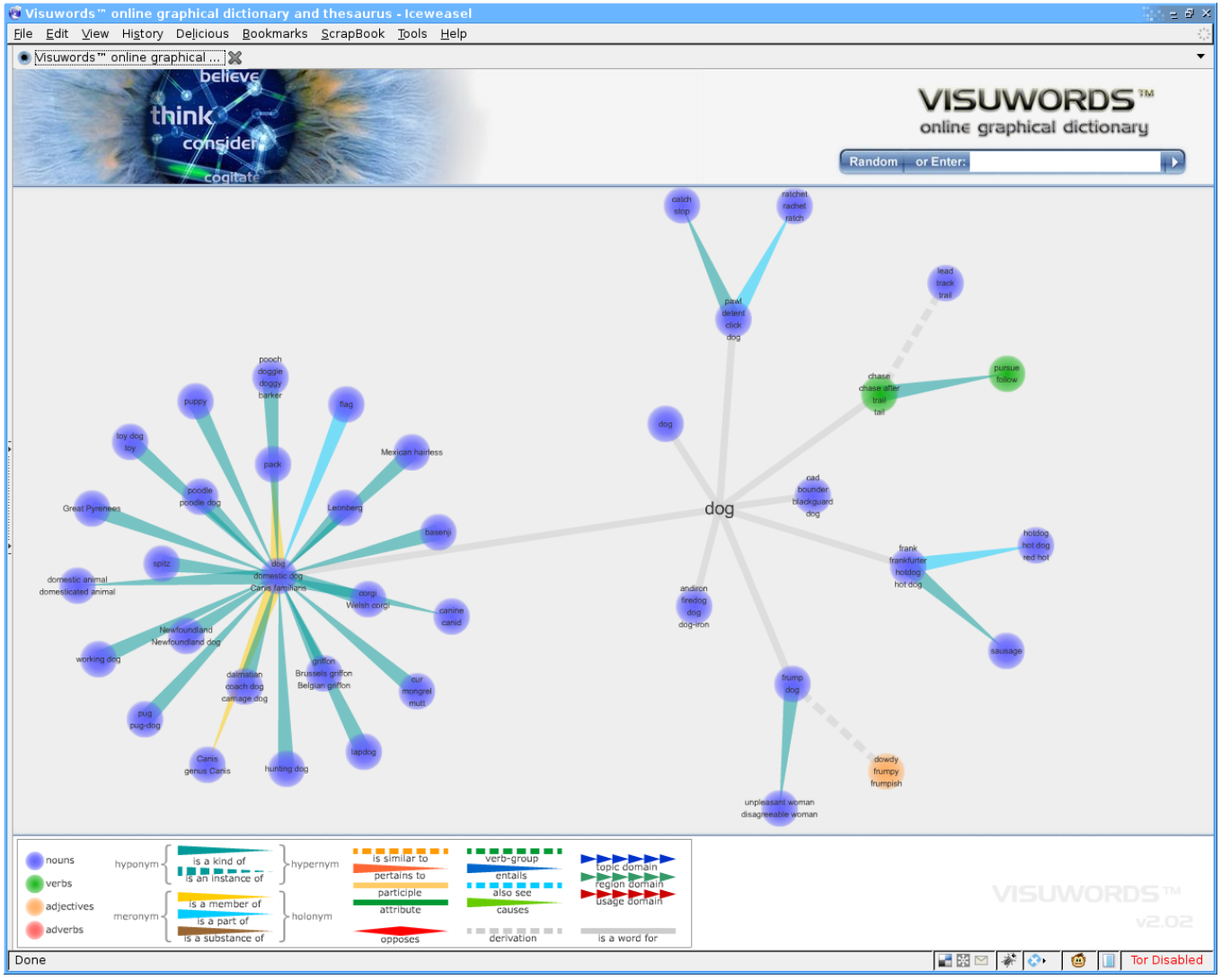

Frames

Frames

frame: Škoda Favorit
slots:
is a: car
has engine: four-stroke engine
has transmission system: manual
has carb: *value*: Jikov
default: Pierburg

- more structured than semantic networks
- forms that contain **slots** (binary relationships).

([MvL93])

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laboratory Gerstner

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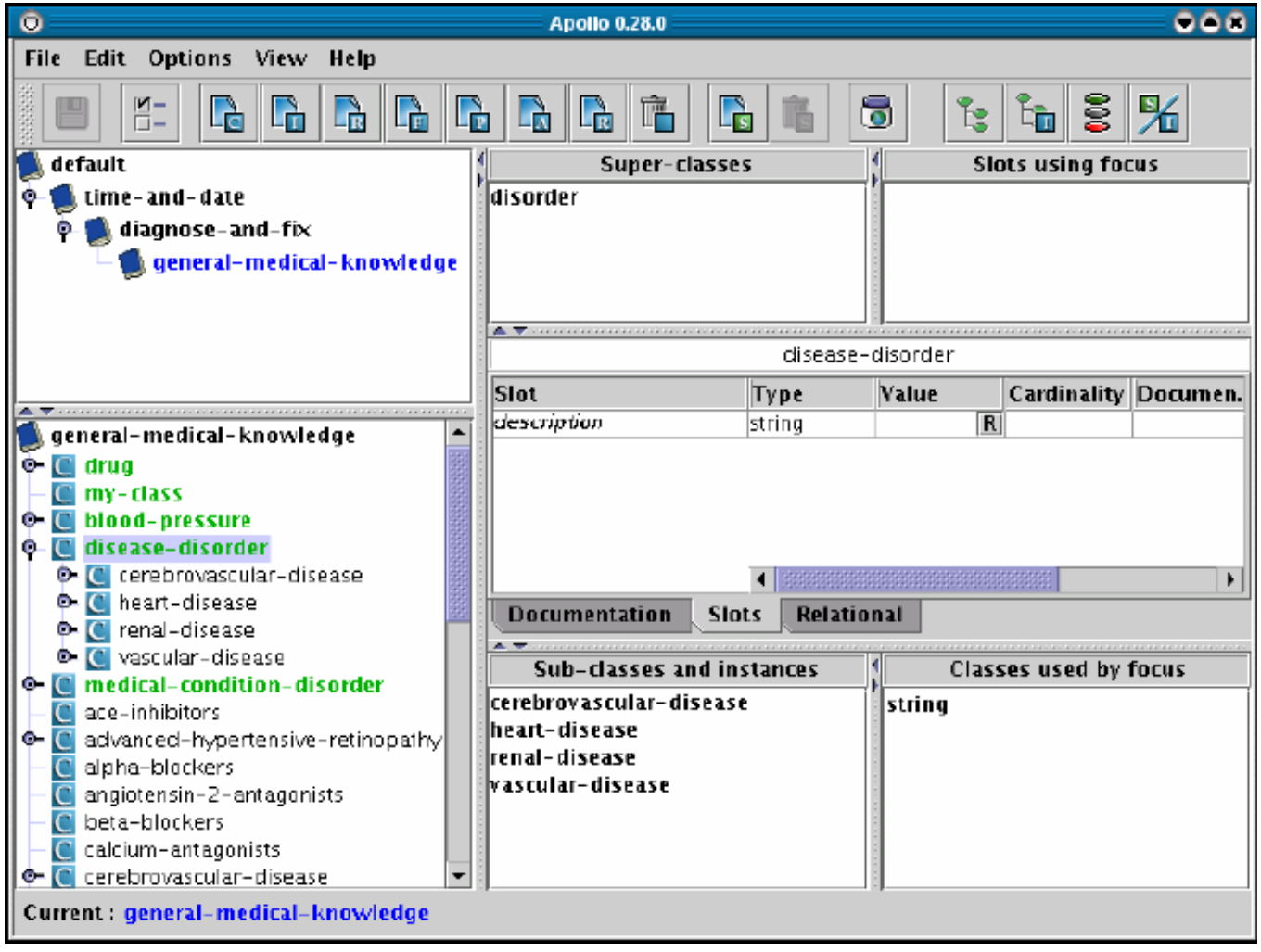
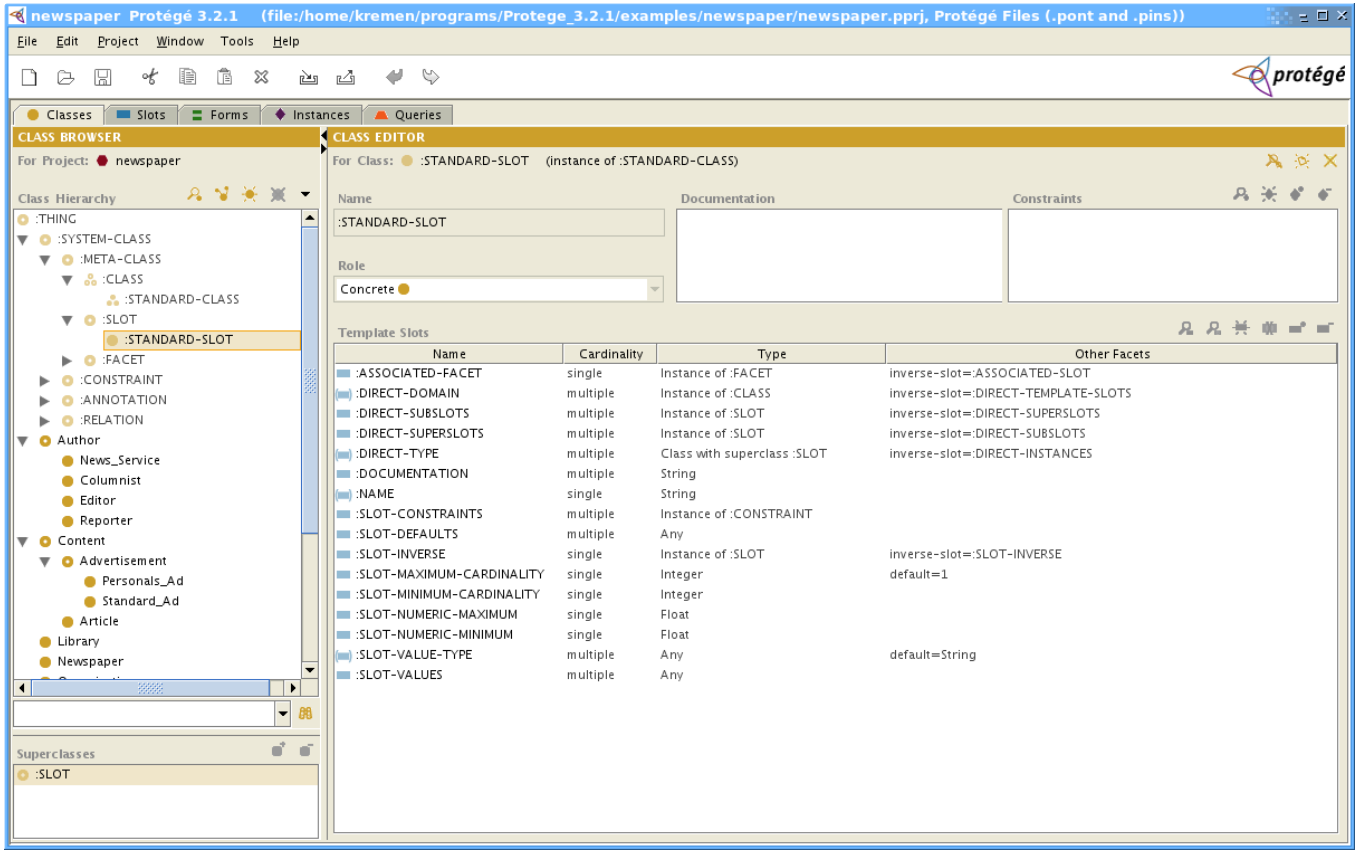


Frames (4) - Protégé



Frames and Semantics Networks – Summary

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Thesauri

Thesauri

thesaurus is a taxonomy (hierarchy of terms) enriched with new types of relationships, e.g.:

BT/NT (broader/narrower term) = term hierarchy.

Example

beef → NT → meat

SN (scope note) explains meaning of a given term.

Example

school → SN → institution for education

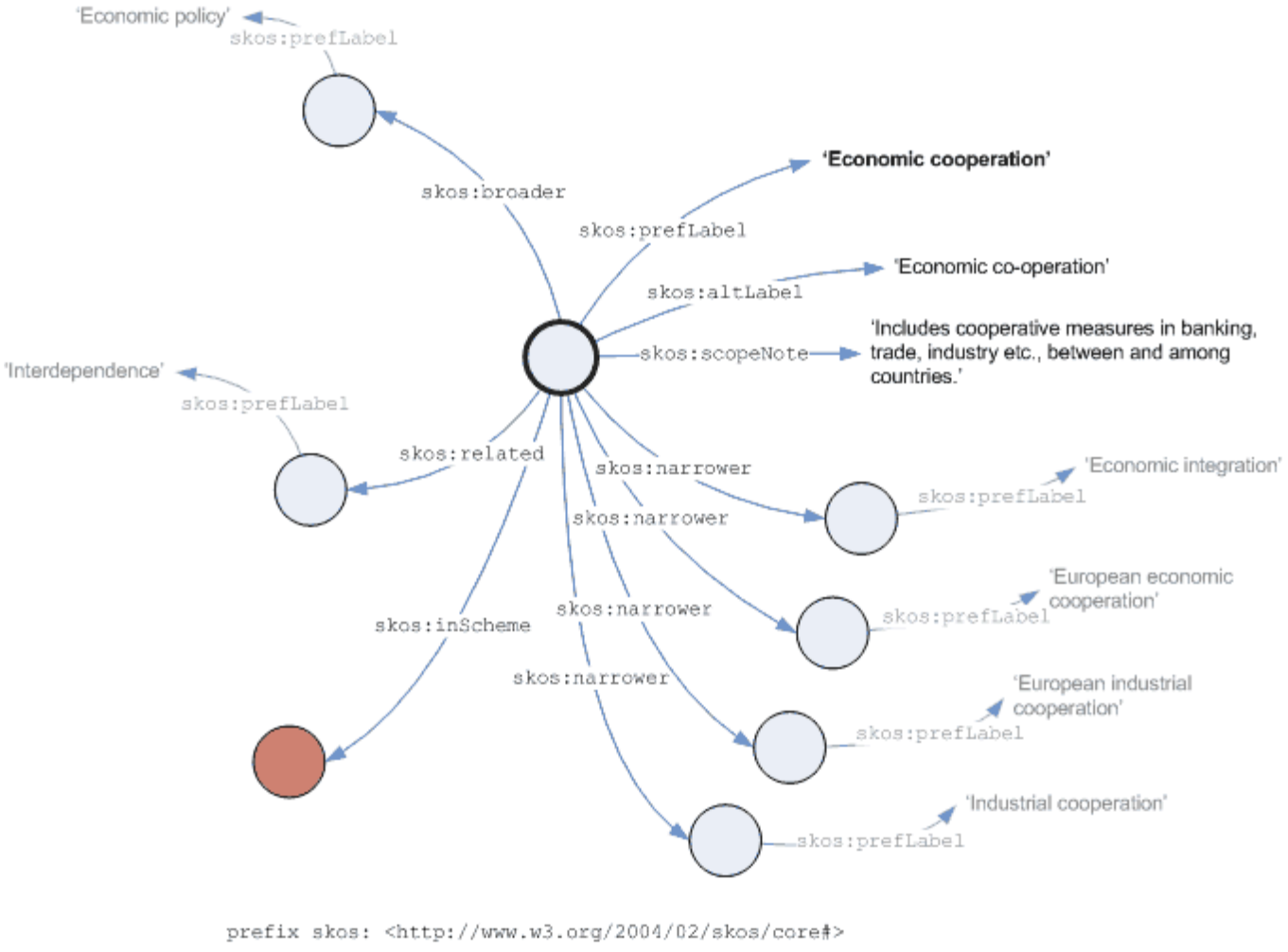
RT (related term) describes general term relationships (excluding BT/NT, USE, ...).

Příklad

topic maps → RT → knowledge management.

SKOS `http://www.w3.org/2004/02/skos`

Thesauri – Example



http://metadaten-twr.org/2011/01/19/skos-simple-knowledge-organisation-system, cit. 16.9.2012

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☺ simple, easy-to-use by non-experts in knowledge engineering

☹ problems in formal semantics:

- example:
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BT relationships can be used in several meanings:

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Topic Maps

Topic Maps – Topics

- ISO standard – ISO/IEC 13250:2003
- three types of objects : **topics**, their **occurences** and mutual **associations**.
- topics
  - represent concepts – classes, instances, properties, etc.
  - topics can have several topic types. The relationship "has type" build up a hierarchy of topics (analogy to UML relationships in semantics networks, or property roles/types in ROF(S))
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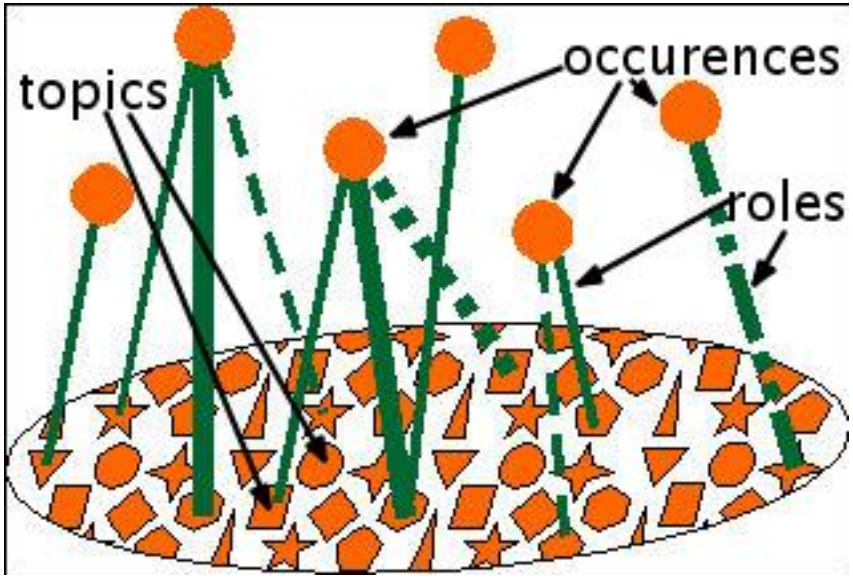

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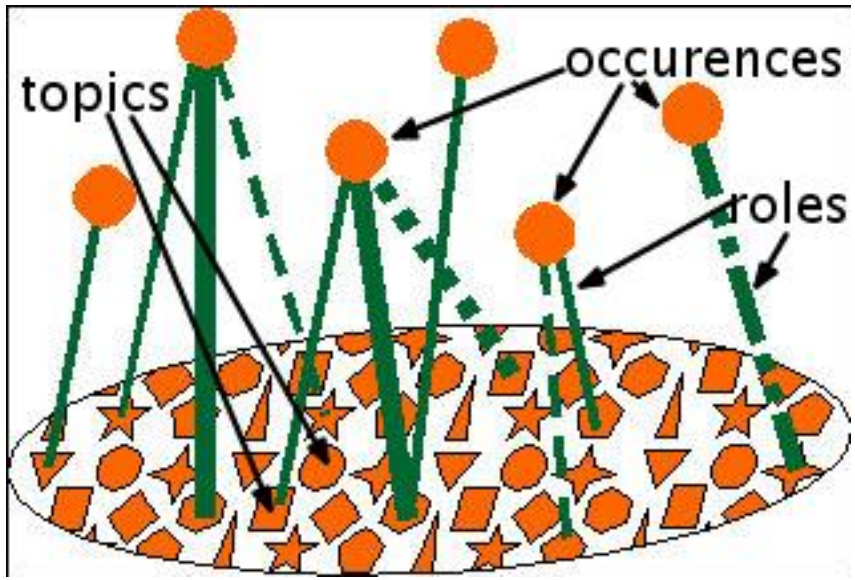

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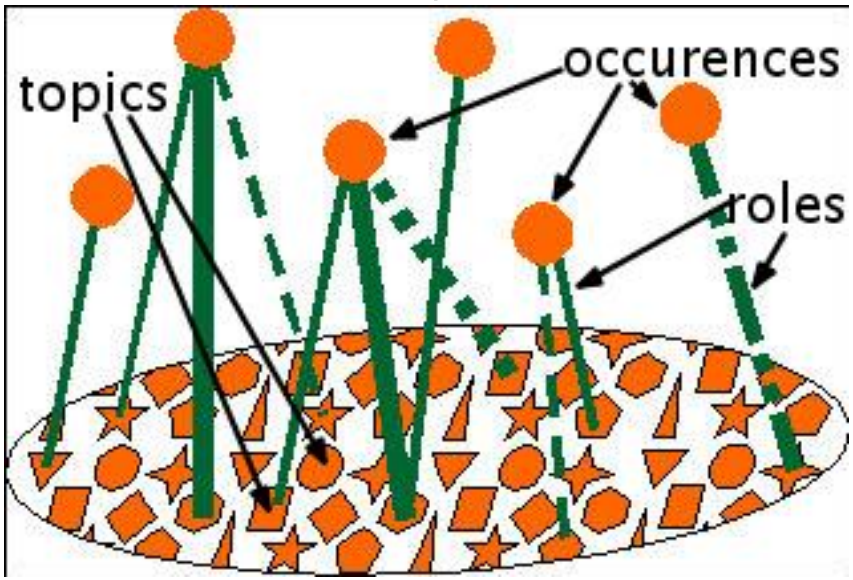

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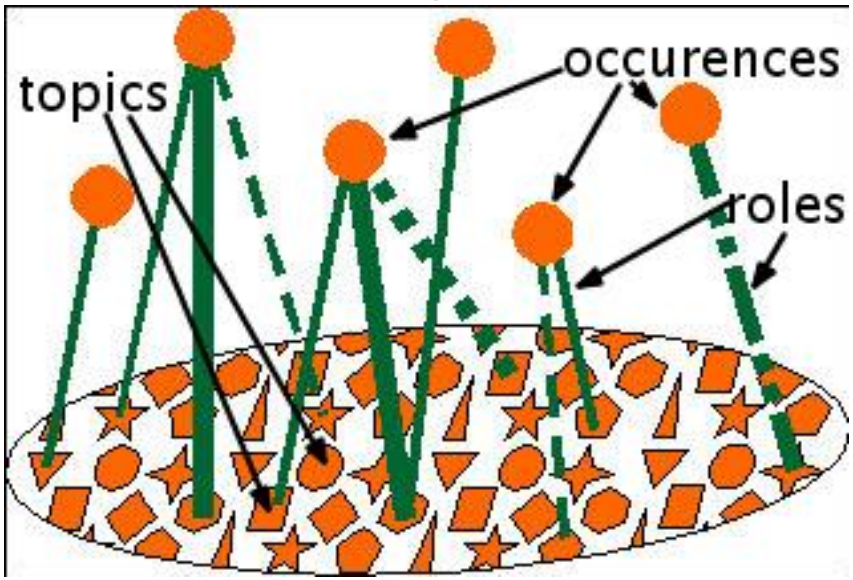

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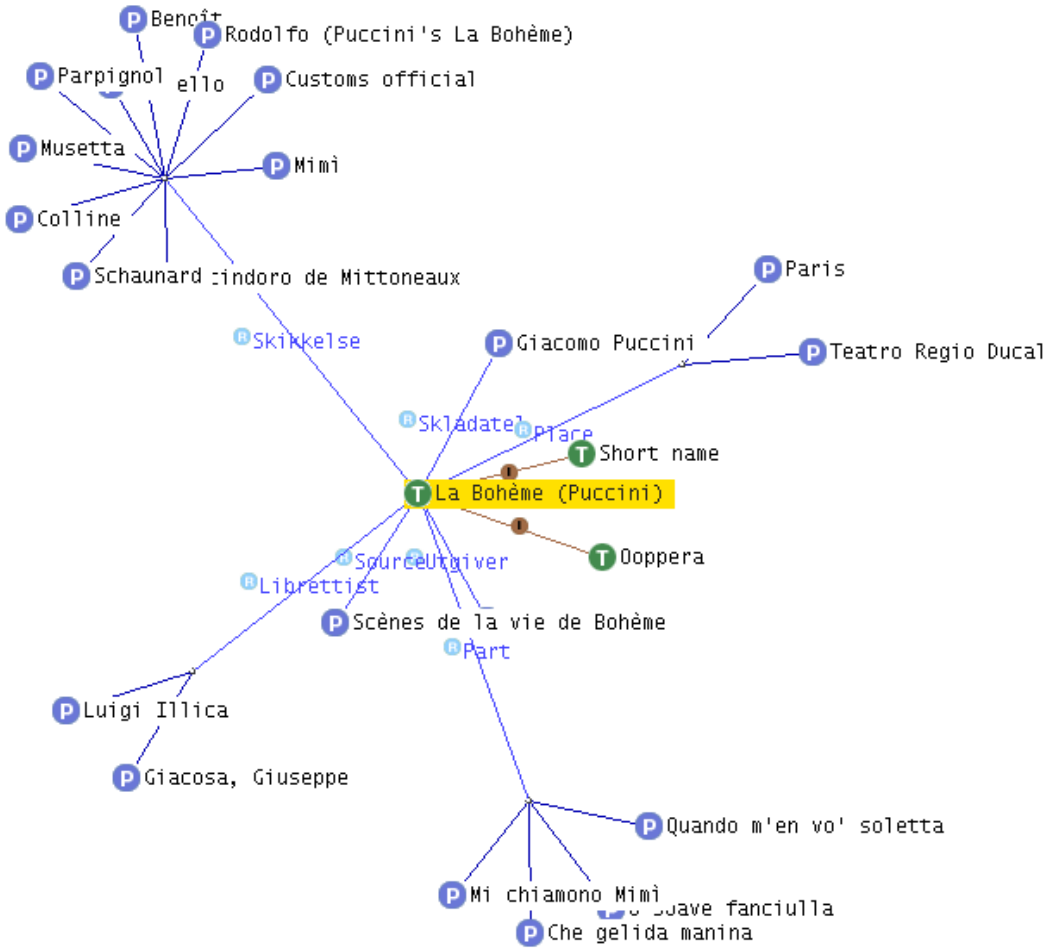
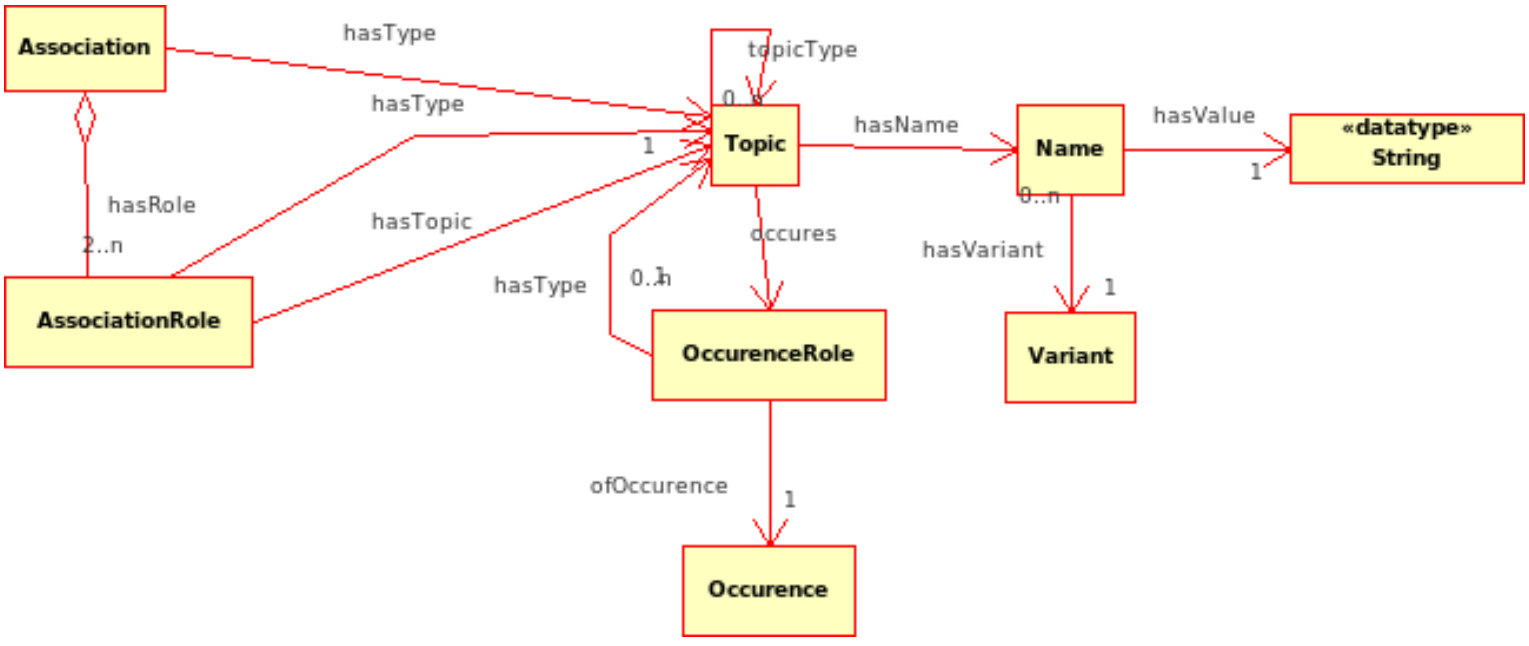


T … topics

P … partially expanded topics (except topic types)

R … associations

Topic Maps – Model



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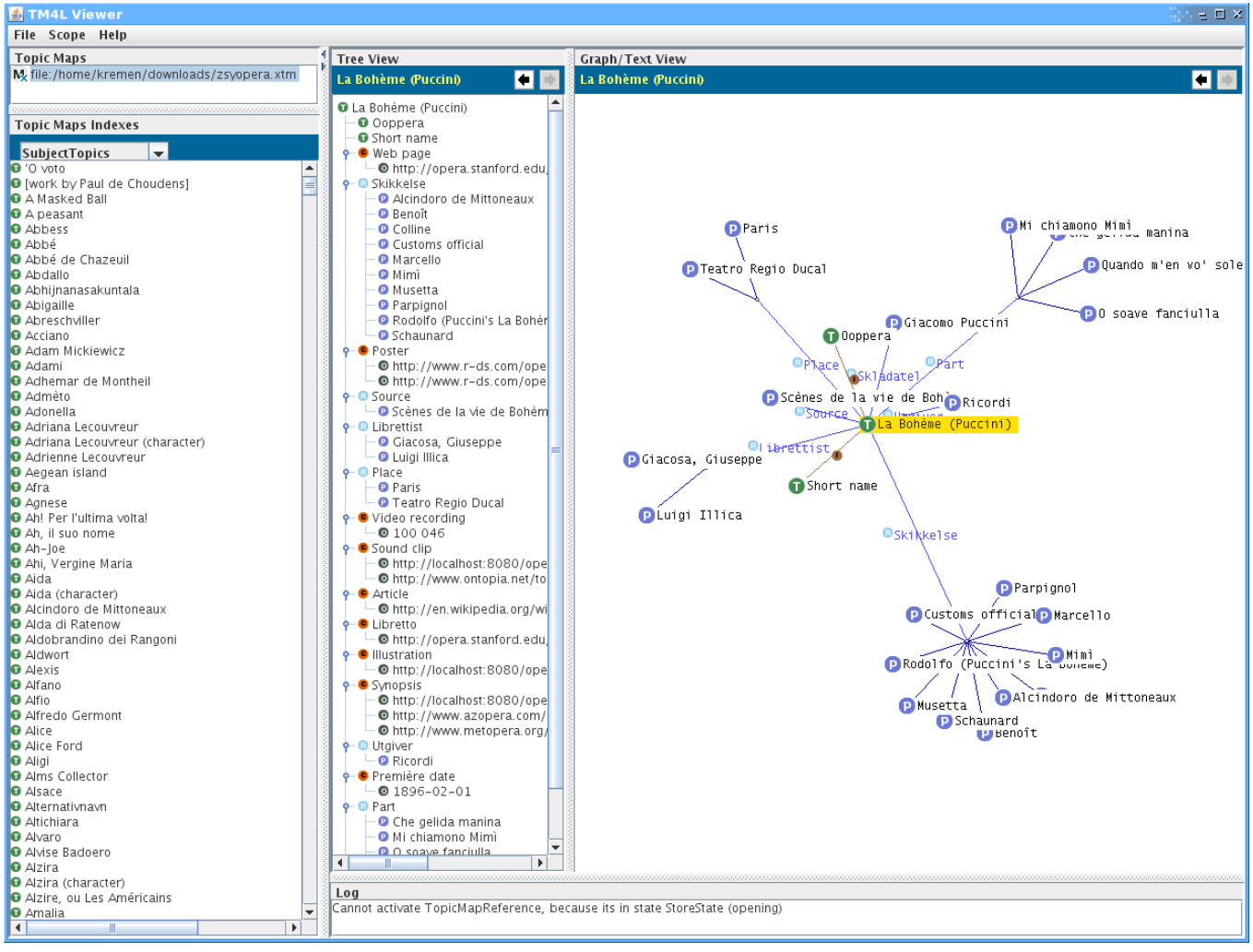
TM4L Viewer
File Scope Help
Topic Maps
file:/home/kremen/downloads/zsyopera.xtm
Topic Maps Indexes
SubjectTopics
'O voto
[work by Paul de Choudens]
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Afra
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Ahi, Vergine Maria
Aida
Aida (character)
Alcindoro de Mittoneaux
Alda di Ratenow
Aldobrandino dei Rangoni
Aldwort
Alexis
Alfano
Alfio
Alfredo Germont
Alice
Alice Ford
Aligi
Alms Collector
Alsace
Alternativnavn
Altichiara
Alvaro
Alvise Badoero
Alzira
Alzira (character)
Alzire, ou Les Américains
Amalia
Tree View
La Bohème (Puccini)
La Bohème (Puccini)
Ooppera
Short name
Web page
http://opera.stanford.edu
Skikkelse
Alcindoro de Mittoneaux
Benoît
Colline
Customs official
Marcello
Mimì
Musetta
Parpignol
Rodolfo (Puccini's La Bohèr
Schaunard
Poster
http://www.r-ds.com/ope
http://www.r-ds.com/ope
Source
Scènes de la vie de Bohèm
Librettist
Giacosa, Giuseppe
Luigi Illica
Place
Paris
Teatro Regio Ducal
Video recording
100 046
Sound clip
http://localhost:8080/ope
http://www.ontopia.net/to
Article
http://en.wikipedia.org/wi
Libretto
http://opera.stanford.edu
Illustration
http://localhost:8080/ope
Synopsis
http://localhost:8080/ope
http://www.azopera.com/
http://www.metopera.org/
Utgiver
Ricordi
Première date
1896-02-01
Part
Che gelida manina
Mi chiamono Mimì
O soave fanciulla
Graph/Text View
La Bohème (Puccini)
Paris
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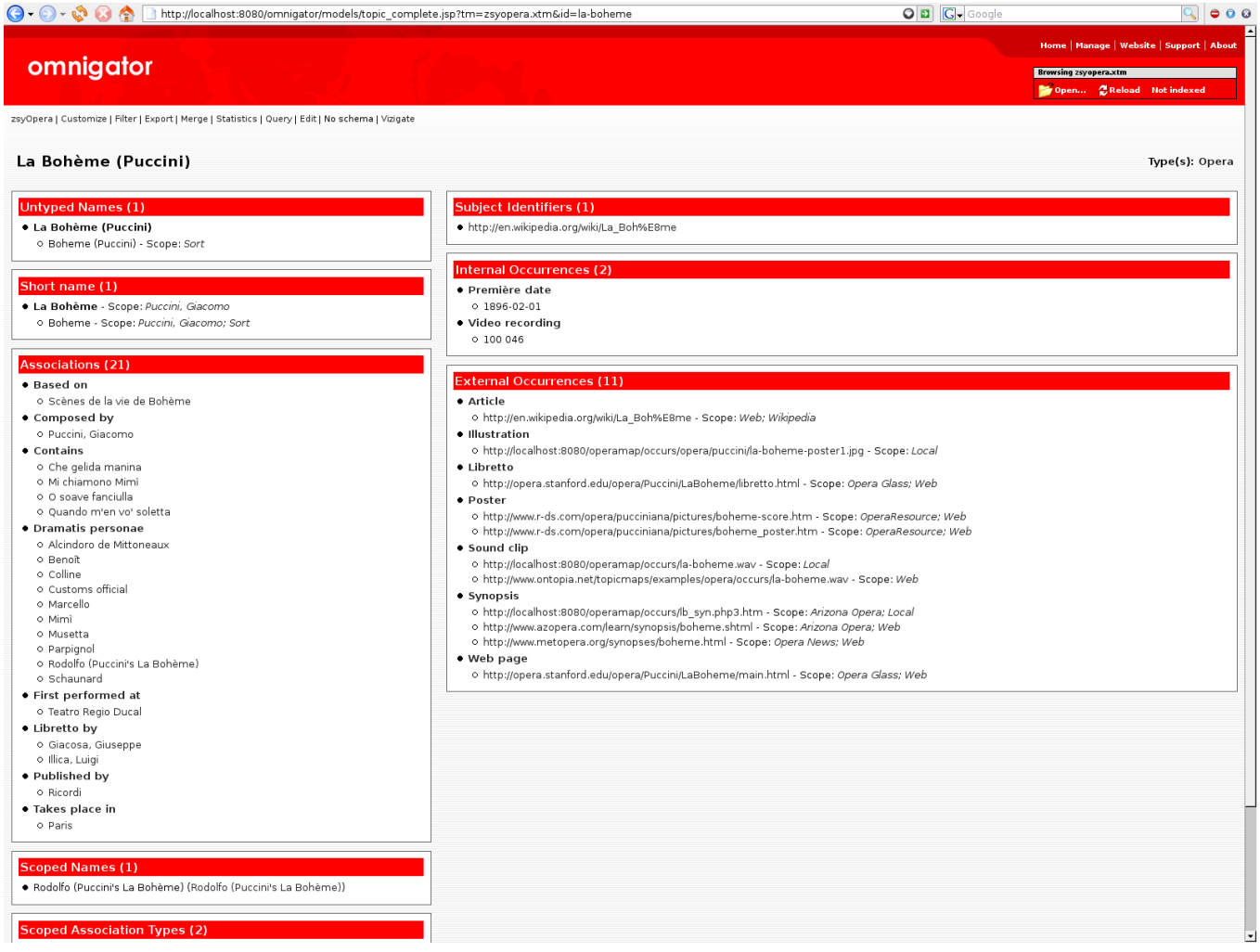
Musetta
Schaunard
Benoît
Log
Cannot activate TopicMapReference, because its in state StoreState (opening)

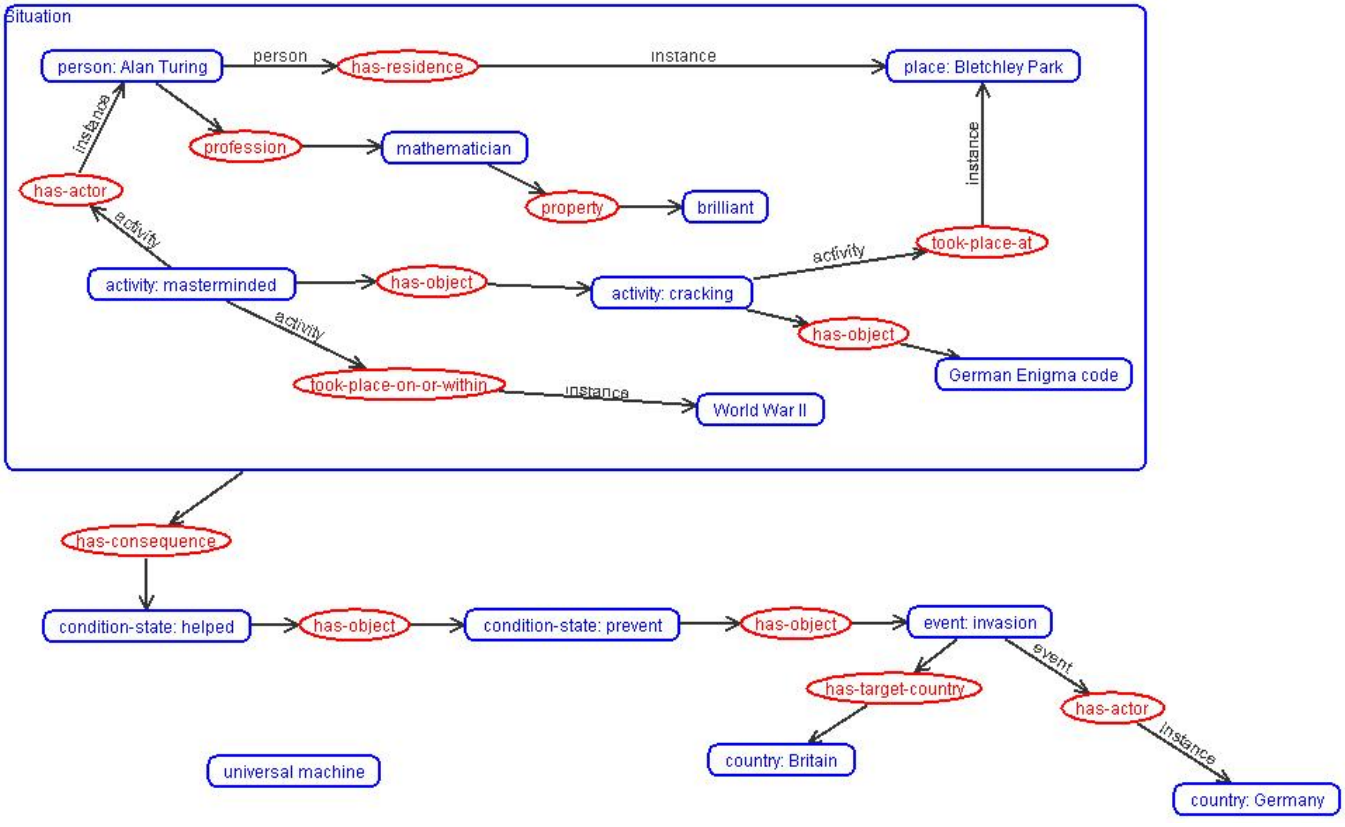
Omnigator



laboratory Gerstner

Conceptual Graphs

Example


Situation
person: Alan Turing
person
has-residence
instance
place: Bletchley Park
instance
profession
mathematician
instance
has-actor
property
brilliant
activity
took-place-at
activity
activity: masterminded
has-object
activity: cracking
activity
has-object
German Enigma code
took-place-on-or-within
instance
World War II
has-consequence
condition-state: helped
has-object
condition-state: prevent
has-object
event: invasion
event
has-target-country
has-actor
instance
universal machine
country: Britain
country: Germany

Conceptual Graphs

conceptual graph is a bipartite graph with two types of nodes (1) **concepts** a (2) **relations**.

concept has the form **concept type : referent**.

Example (Quantifier type)

dog : Lucky

Dog Lucky

$\exists x Dog(x) \wedge Name(x, Lucky)$

dog

Some dog

$\exists x Dog(x)$

dog : $\forall$

All dogs

$\forall x Dog(x) \rightarrow \ldots$

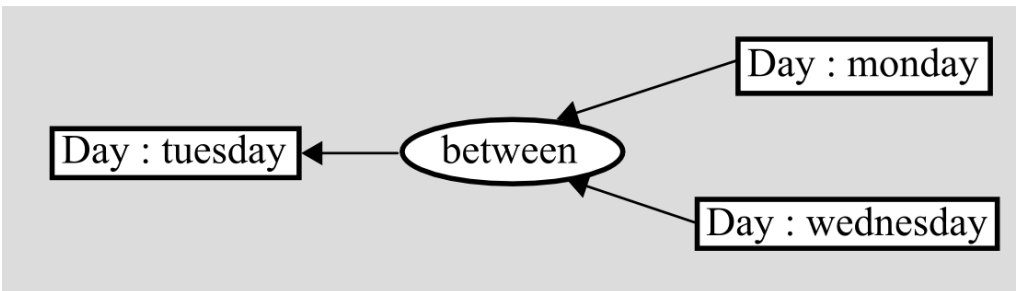
dog : {*}

Set of dogs

@ no FOPL

relation = predicate of arbitrary arity > 0.

Example (Ternary relation)



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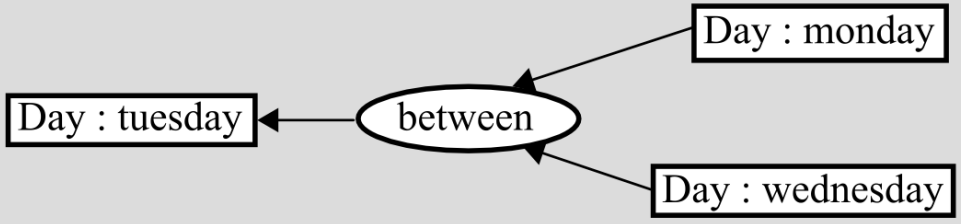

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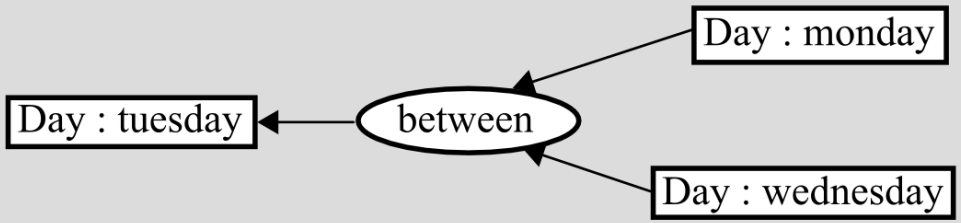

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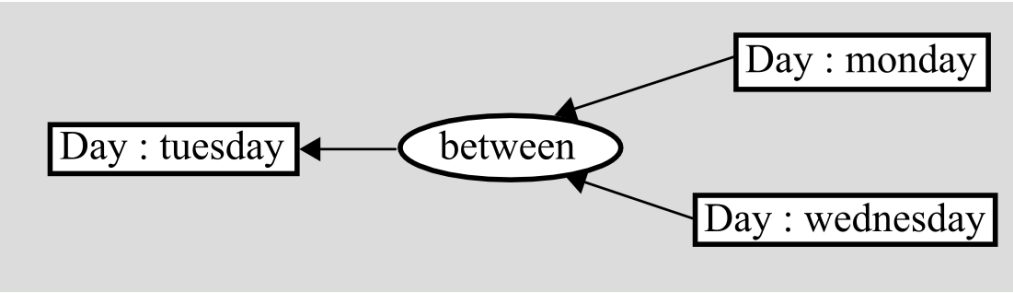

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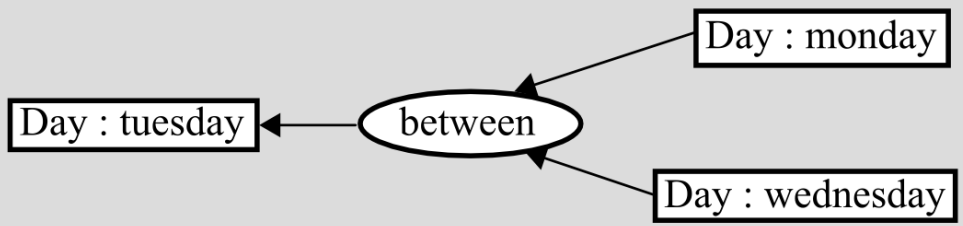

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referent consists of **quantifier** (existential, or defined (universal, collective, etc.)), **designator** (instance identifier, e.g. name) and possibly **descriptor** (conceptual graph describing the concept).

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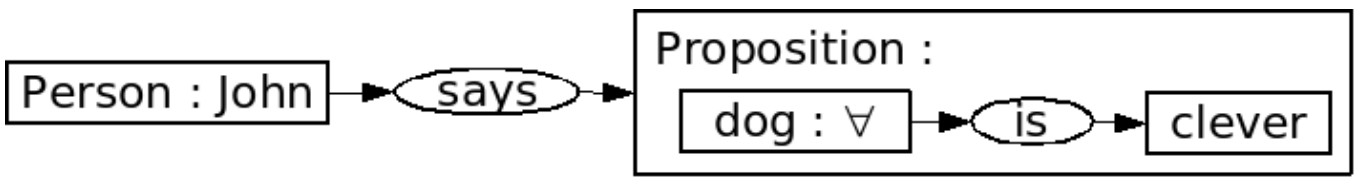

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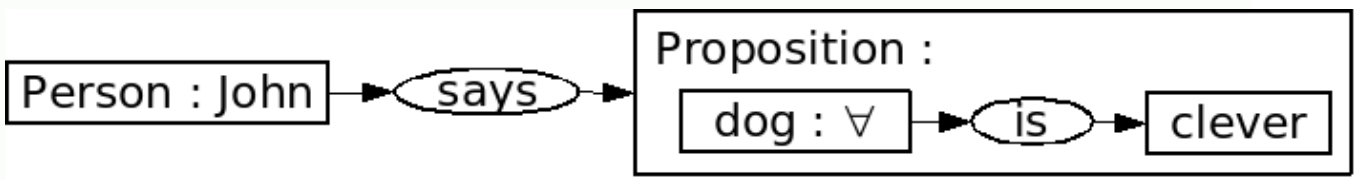

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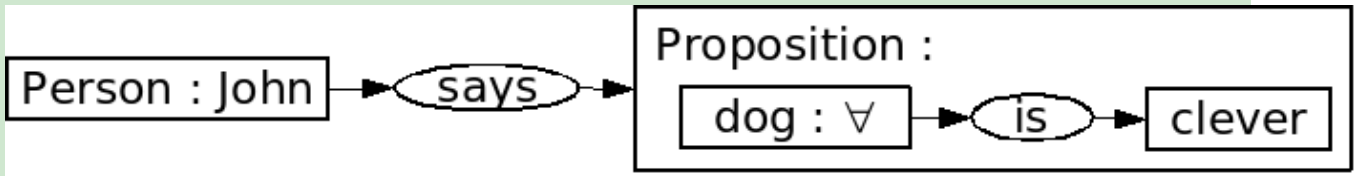

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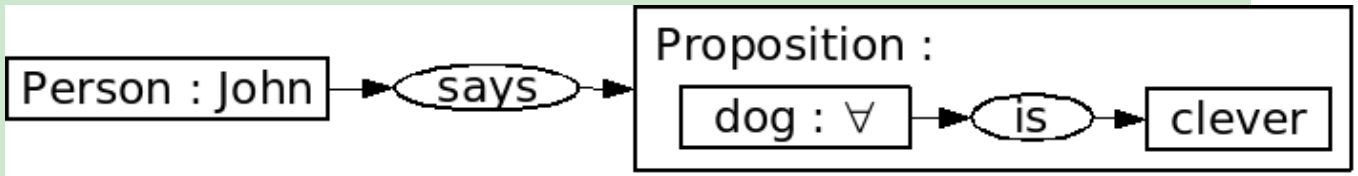

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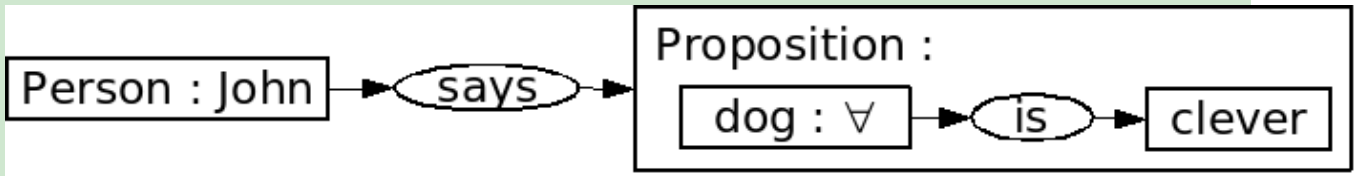

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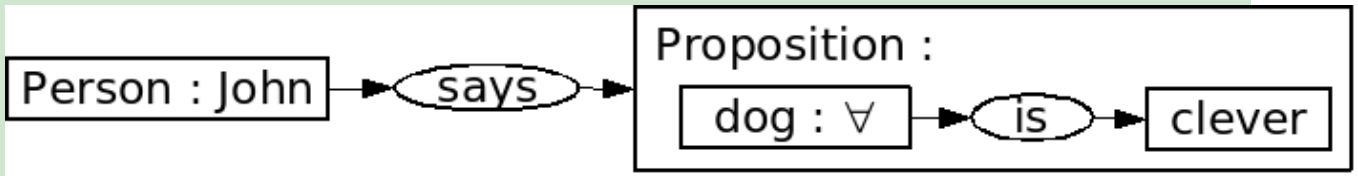

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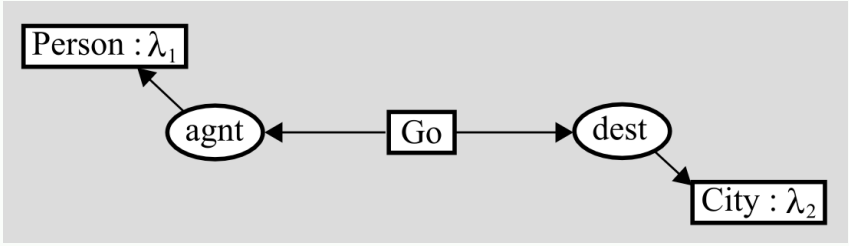
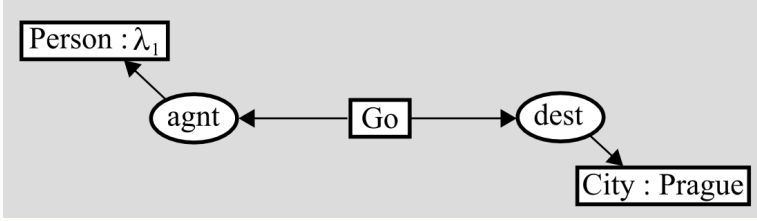


def. binary relation "Go".



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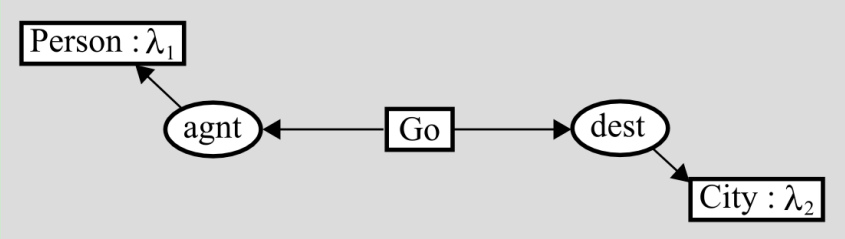

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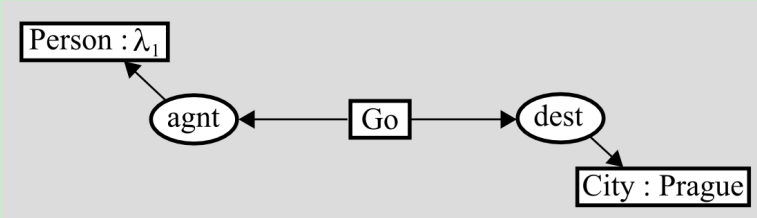

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Conceptual Graphs – Inference

- inference makes use of several forward chaining rules[1] (graph generalization, specialization, equivalent changes).
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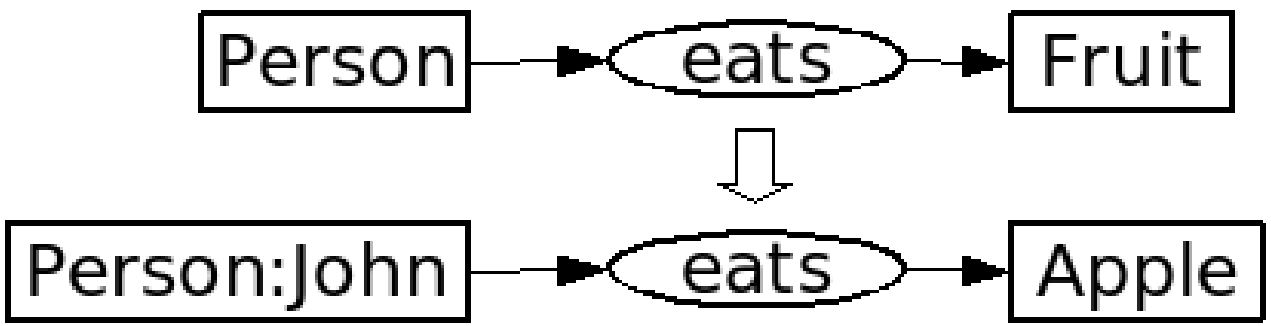
Example – Projection



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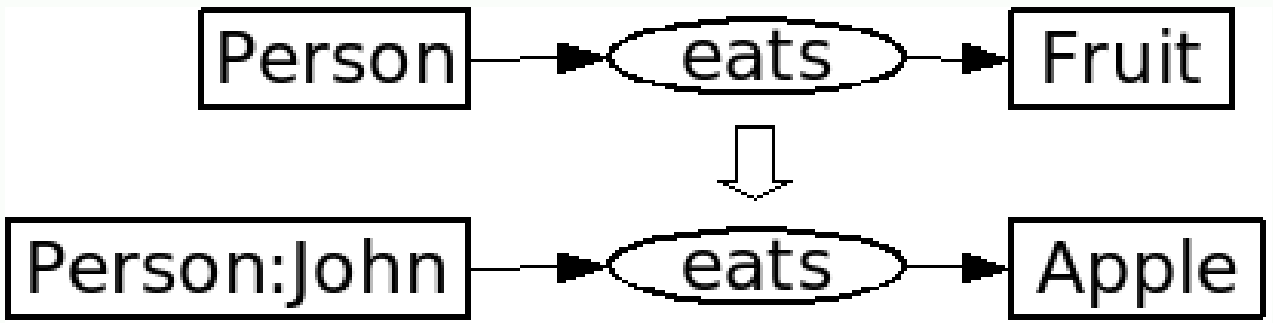

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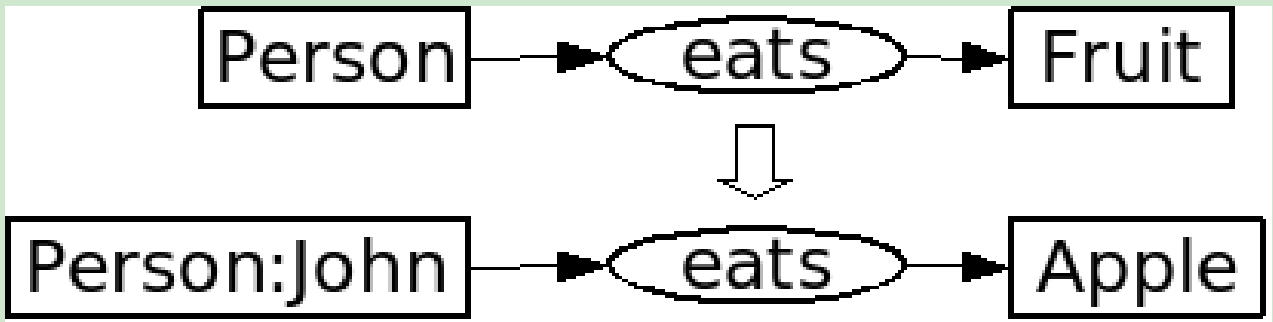

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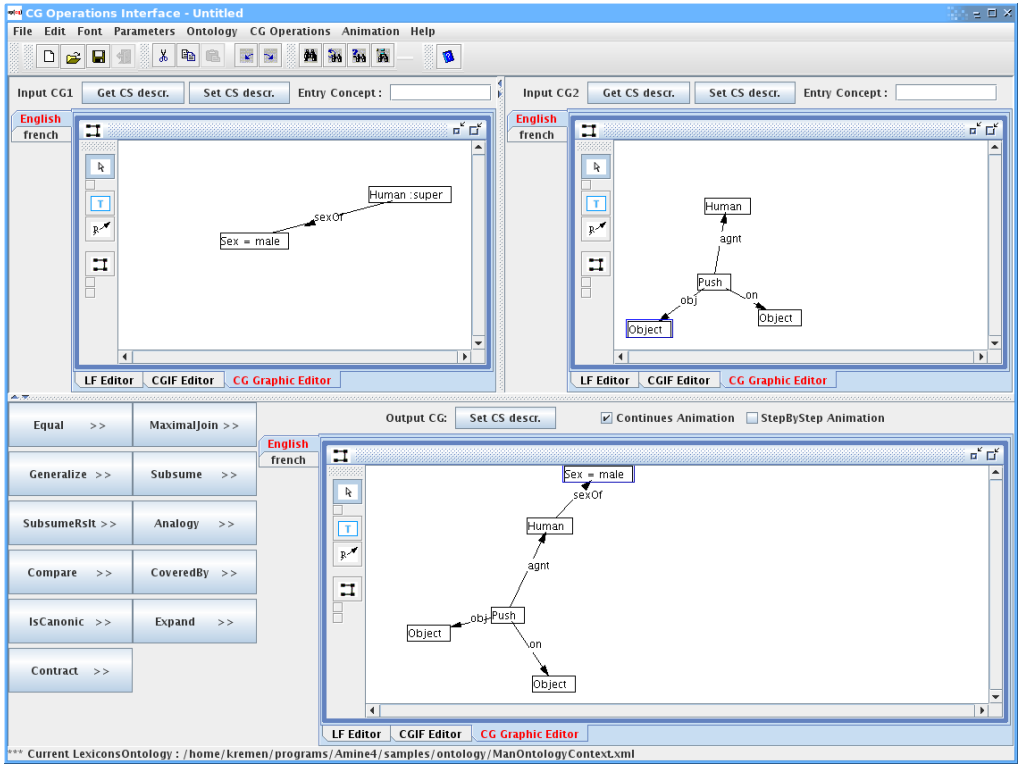

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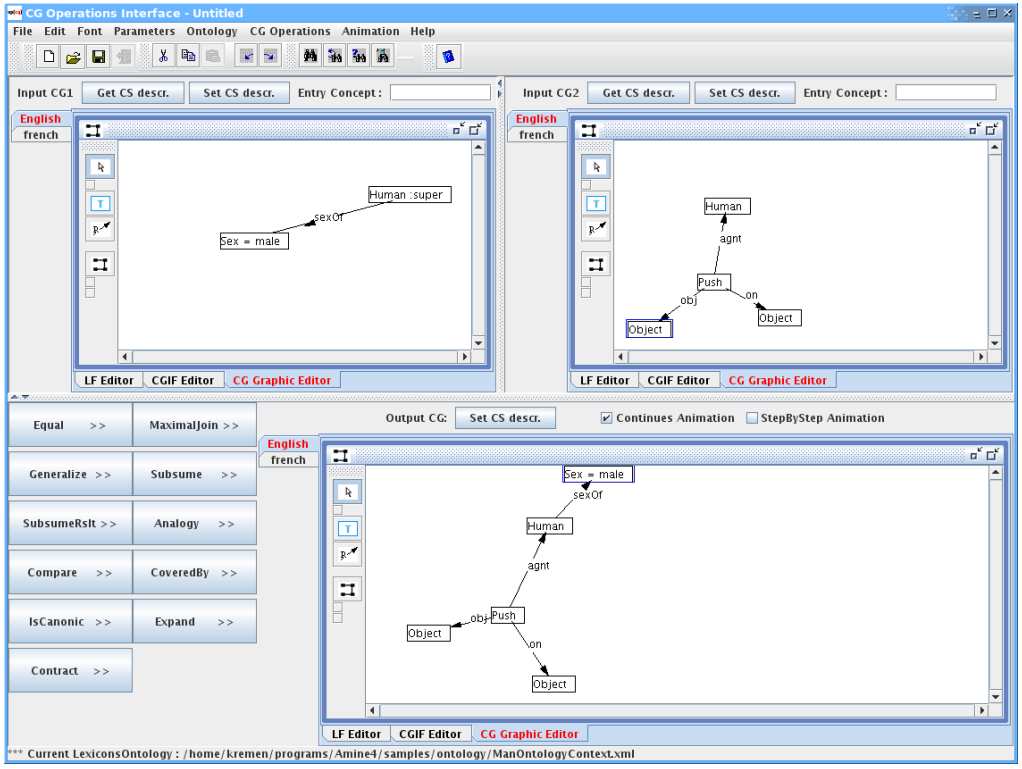

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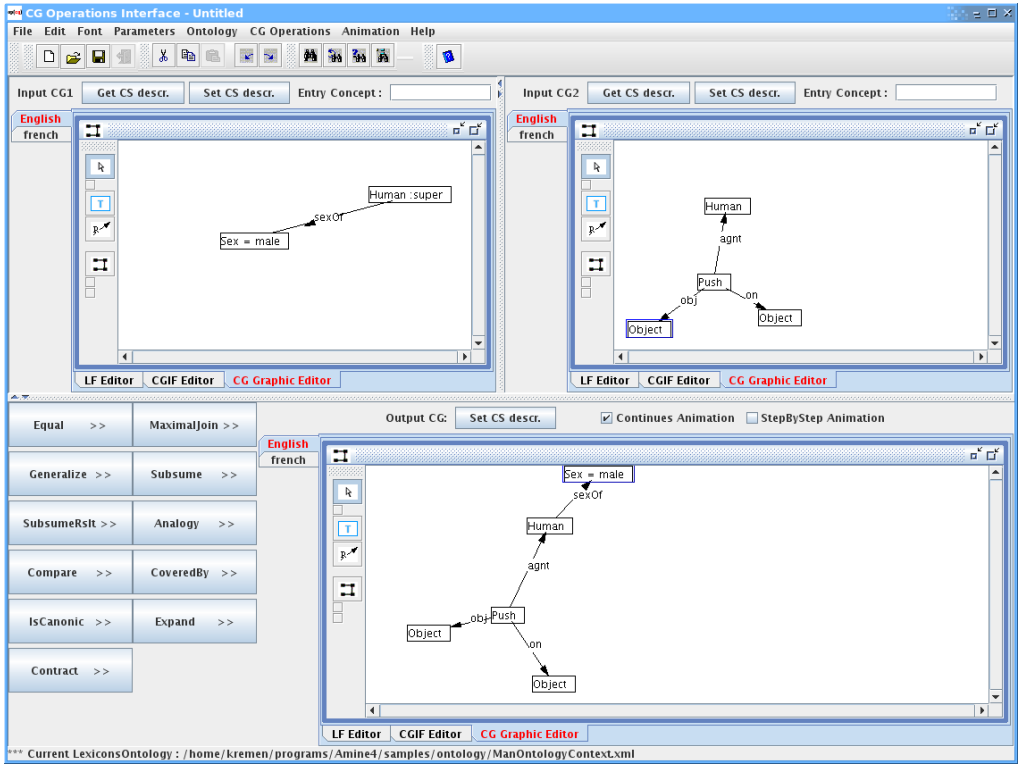

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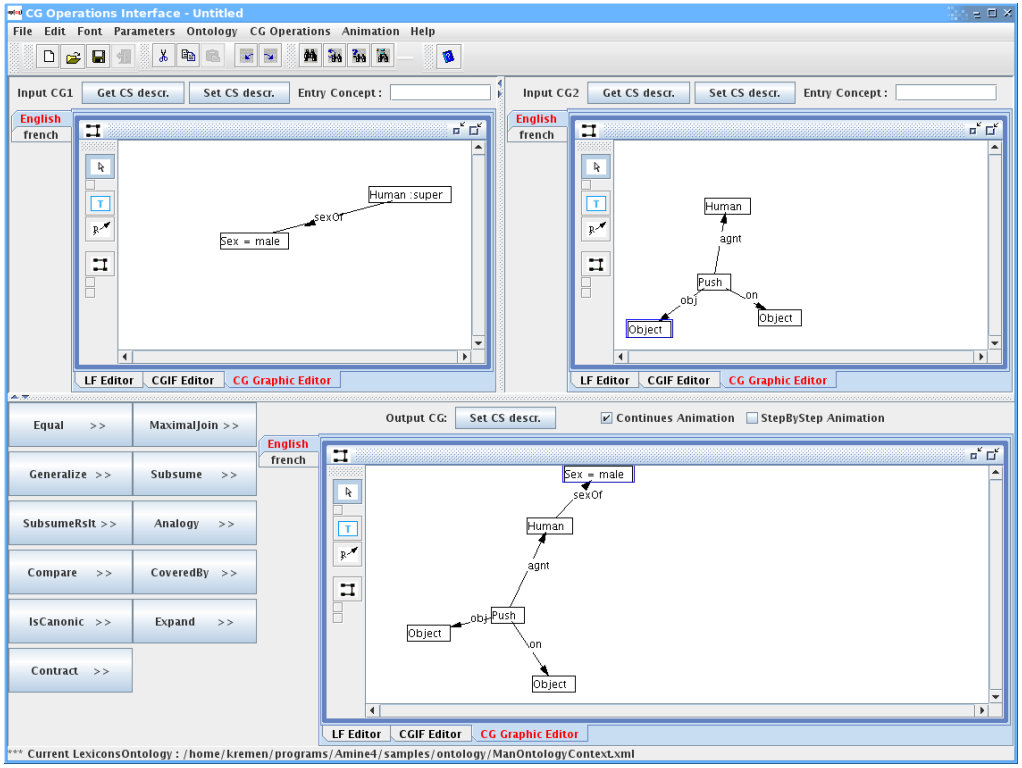

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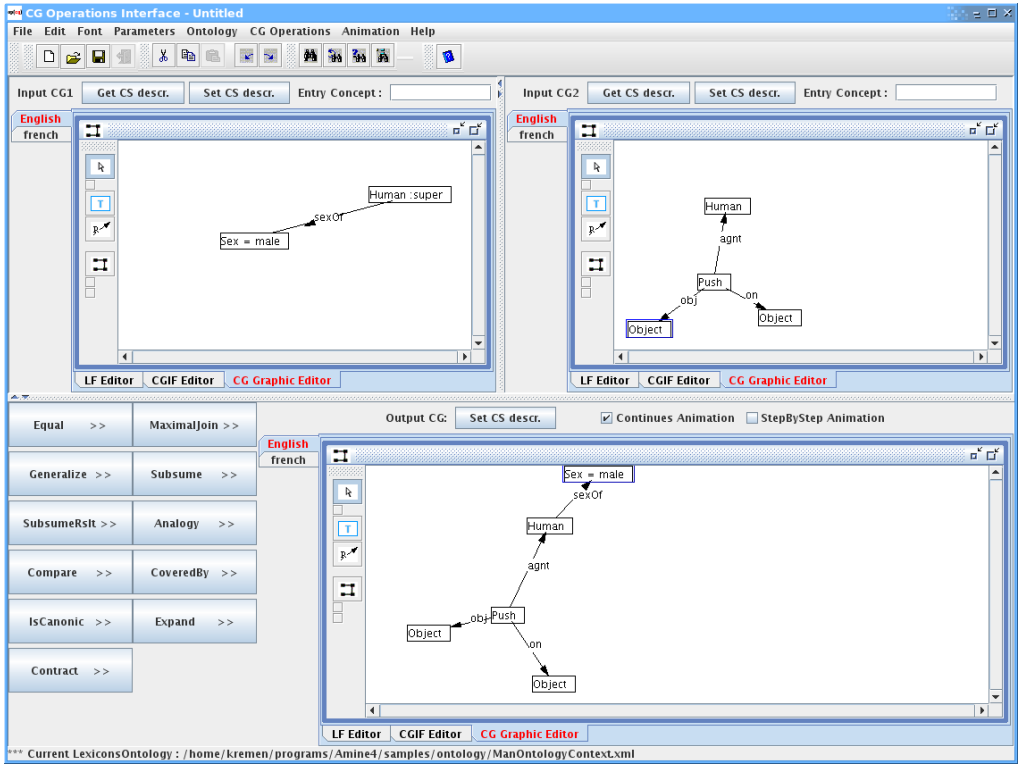

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