Multi-context logics 20 years on: outcomes & challenges

Luciano Serafini

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Talk overview

1. Motivational Examples
2. Multi-Context Logics and the basic notions of locality and compatibility
3. Propositional Multi-Context Logics
4. Multi-context logics meet Ontologies and Description Logics: Distributed Description Logics
5. Some recent challenges

Motivating examples

"I'm talking about context"

- The truth value of the sentence "I'm talking about context" changes in different contexts. It is true for some pairs $<$*location, speaker*$>$, false for others.
- Actually, not only the truth value, but even the content ("what is said") varies in different contexts!! Now it is about Chiara, at 10AM is about Valeria and/or Natasha.
- Interestingly enough, contexts are related. For example, there is a clear relationship between the content of "I'm talking about context" (where the speaker is Chiara and the date is 18/07.2011) and the content of "Yesterday I was talking about context" (same speaker, but date is 19/07/2011).

Motivating examples

"The Italian Prime Minister is from Bologna"

- The sentence is false in the context of my beliefs (I know that the current Italian Prime Minister is Mr. Berlusconi, and he is not from Bologna).
- However, it might be true in the context of Luciano Serafini's beliefs, who has been in a spacecraft for several years and does not know that Mr. Prodi – who is from Bologna – is no longer the Italian Prime Minister.
- Finally, it may true in the context of some news from an "old" newspaper.

Motivating examples

"The book is on the table"

J. McCarthy, *Generality in Artificial Intelligence*, 1987:

> *"Whenever we write an axiom, a critic can say that the axiom is true only in a certain context. With a little ingenuity the critic can usually devise a more general context in which the precise form of the axiom doesn't hold. [. . .] Consider axiomatizing on so as to draw appropriate consequences from the information expressed in the sentence, 'The book is on the table'. The critic may propose to haggle about the precise meaning of on, inventing difficulties about what can be between the book and the table, or about how much gravity there has to be in a spacecraft in order to use the world 'on' and whether centrifugal force counts. Thus we encounter Socratic puzzles over what the concept mean in complete generality and encounter examples that never arise in life. There simply isn't a most general context."*

To sum up . . .

- A representation may depend on a lot of implicit assumptions.
- There is not such a thing as the “right” representation: different contexts may require to leave implicit / make explicit different collections of assumptions.
- It looks like the “same” fact may be given different representations in different contexts, and these representations are somewhat related.
- This happens in several fields of KR: an important example are *ontologies*. They are shared conceptualization, but they may depend on a lot of implicit assumptions.

Multi-Context Logics: the beginning

1993: Context is proposed as a mean to localize reasoning, plus some rules to combine reasoning across contexts:

F. Giunchiglia. Contextual reasoning. Epistemologia, special issue on I Linguaggi e le Macchine, XVI:345- 364, 1993.

1994: A calculus to perform multi-context reasoning (and apply it to model knowledge and belief) is proposed:

F. Giunchiglia and L. Serafini. Multilanguage hierarchical logics, or: how can we do without modal logics. Artificial Intelligence 65(1):29-70, 1994.

2000: A semantics for multi-context logics is proposed:

C. Ghidini and F. Giunchiglia. Local models semantics, or contextual reasoning = locality + compatibility. Artificial Intelligence, 127(2):221-259, April 2001.

Multi-Context Logics: two simple principles

above theory
$on(a, b)$

ontology of food

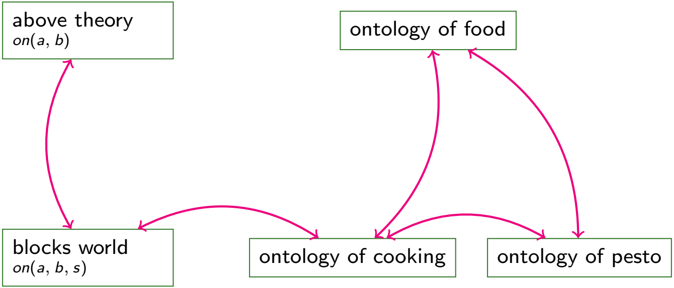
blocks world
$on(a, b, s)$

ontology of cooking

ontology of pesto

I. Knowledge and reasoning are local to a context;

Multi-Context Logics: two simple principles



above theory
on(a, b)

ontology of food

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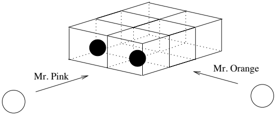
ontology of cooking

ontology of pesto

I. Knowledge and reasoning are local to a context;

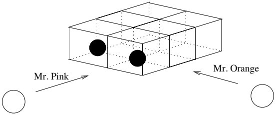
II. Knowledge and reasoning in a context should influence knowledge and reasoning in other contexts. We call this: compatibility.

An example: Viewpoints

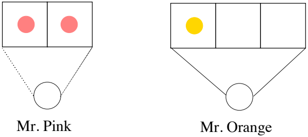


The “magic” box

An example: Viewpoints

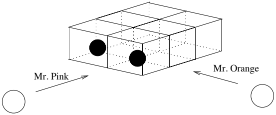


The “magic” box



Different local views

An example: Viewpoints



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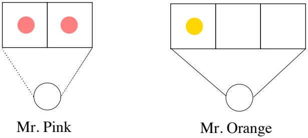
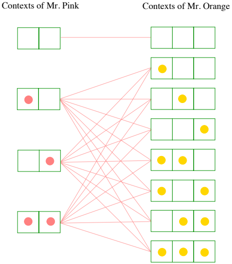


Different local views

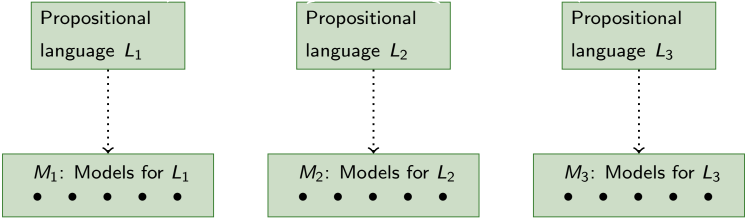


Compatible local views

The beginning of the story:
Propositional Multi-Context Logic

MCL=Multi-Context Logic

Propositional MCL - locality + compatibility



Propositional language L_1

Propositional language L_2

Propositional language L_3

M_1: Models for L_1 ● ● ● ● ●

M_2: Models for L_2 ● ● ● ● ●

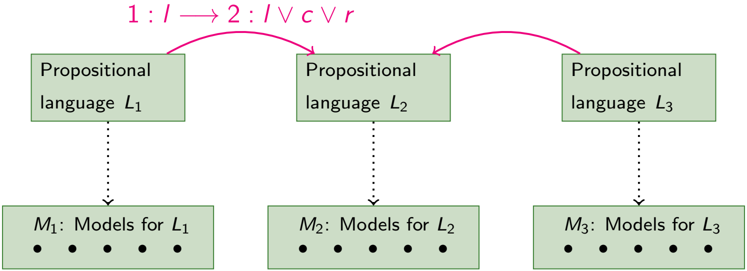
M_3: Models for L_3 ● ● ● ● ●

Local languages
: Context i is described by means of propositional language L_i.

Local models
: M_i is the set of all the models of L_i.

Local satisfiability
: $\models_i$ is the satisfiability relation between L_i and M_i.

Propositional MCL - locality + compatibility



$1 : l \longrightarrow 2 : l \lor c \lor r$

Propositional language L_1

Propositional language L_2

Propositional language L_3

M_1: Models for L_1 ● ● ● ● ●

M_2: Models for L_2 ● ● ● ● ●

M_3: Models for L_3 ● ● ● ● ●

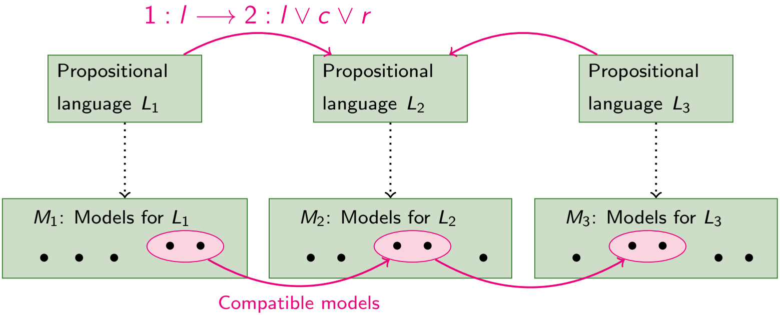
Language

$\{L_1, L_2, L_3, \ldots\}$

Bridge rule

$i : A \longrightarrow j : B$

Propositional MCL - locality + compatibility



$1 : l \longrightarrow 2 : l \vee c \vee r$

Propositional language L_1

Propositional language L_2

Propositional language L_3

M_1: Models for L_1

M_2: Models for L_2

M_3: Models for L_3

Compatible models

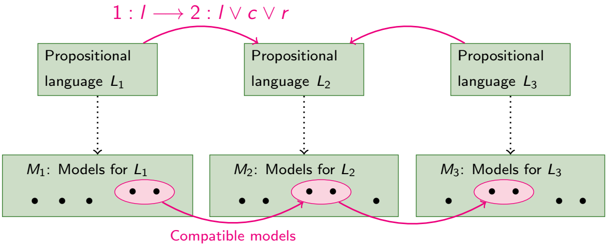
Compatibility sequence

$$\mathbf{c} = \langle \mathbf{c}_1, \mathbf{c}_2, \mathbf{c}_3, \ldots \rangle \qquad [\text{where } \mathbf{c}_i \subseteq M_i],$$

Satisfiability of bridge rule

$$\mathbf{c} \models i : A \longrightarrow j : B \text{ if } \mathbf{c}_i \models A \text{ implies } \mathbf{c}_j \models B.$$

Propositional MCL - locality + compatibility



A model is a set of compatibility sequences **C** such that

- $\mathbf{C} \neq \emptyset$;
- $\langle \emptyset, \emptyset, \ldots, \emptyset, \ldots \rangle \notin \mathbf{C}$;

C satisfies a set of bridge rules *BR* if the compatibility sequences in **C** satisfy all the bridge rules in *BR*

Satisfiability and (simplified) logical consequence

Satisfiability

$\mathbf{C} \models i : \phi$ if,

for all compatibility sequences $\langle \mathbf{c}_1, \mathbf{c}_2, \ldots, \mathbf{c}_n, \ldots \rangle \in \mathbf{C}$, $\mathbf{c}_i \models \phi$;

Logical Consequence

$\Gamma \models i : \phi$ if

for all models $\mathbf{C}$, for all j. $\mathbf{c}_j \models \Gamma_j$ implies $\mathbf{c}_i \models \phi$

The calculus: locality

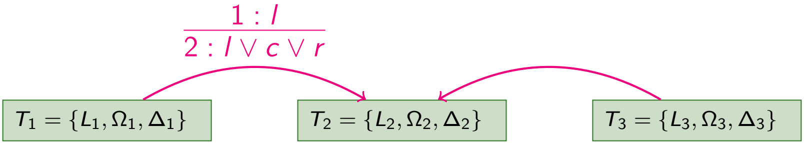
$T_1 = \{L_1, \Omega_1, \Delta_1\}$

$T_2 = \{L_2, \Omega_2, \Delta_2\}$

$T_3 = \{L_3, \Omega_3, \Delta_3\}$

I. Context i is formalised as $T_i = \{L_i, \Omega_i, \Delta_i\}$.

The calculus: locality + compatibility



$$\frac{1 : l}{2 : l \vee c \vee r}$$

$T_1 = \{L_1, \Omega_1, \Delta_1\}$

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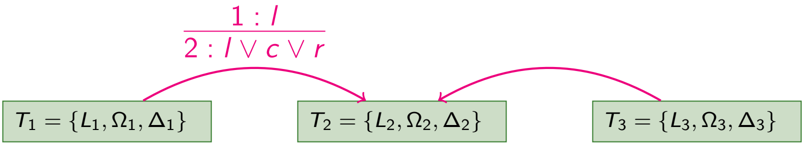
I. Context i is formalised as $T_i = \{L_i, \Omega_i, \Delta_i\}$.

II. Compatibility is formalised as bridge rules (BR):

$$\frac{i : A}{j : B}$$

The calculus: locality + compatibility



I. Context i is formalised as $T_i = \{L_i, \Omega_i, \Delta_i\}$.

II. Compatibility is formalised as bridge rules (BR):

$$\frac{i : A}{j : B}$$

III. An MC system MS is a pair $\langle \{T_i\}, BR \rangle$

The calculus: deductions

$$\dfrac{\dfrac{\boxed{[o : l \vee c \vee r]}\ \mathit{Mr.\ Orange}}{\boxed{\dfrac{p : l \vee r \qquad \dfrac{p : \neg l \wedge \neg r}{p : \neg(l \vee r)}}{p : \bot}}\ \mathit{Mr.\ Pink}}\ br_{op}}{\boxed{\dfrac{o : \neg(l \vee c \vee r)}{o : \neg l \wedge \neg c \wedge \neg r}}\ \mathit{Mr.\ Orange}}\ \bot_{po}$$

Propositional MCL: summary

Definition of a logic with:

- different logical languages;
- different local semantics;
- relations between contexts formalised via bridge rules:

$$i : A \longrightarrow j : B \qquad\qquad \frac{i : A}{j : B}$$

- directionality:

  bridge rule from i to j is distinct from bridge rule from j to i;
- localization of inconsistency:

  $i : \bot \longrightarrow j : \bot$ is not a valid bridge rule.

Then, the story went on . . .

- Extension to first Order Logic (Distributed First Order Logic);

$$1 : x = redBuilding \longrightarrow 2 : x^{1\rightarrow} = Flat1$$

Then, the story went on . . .

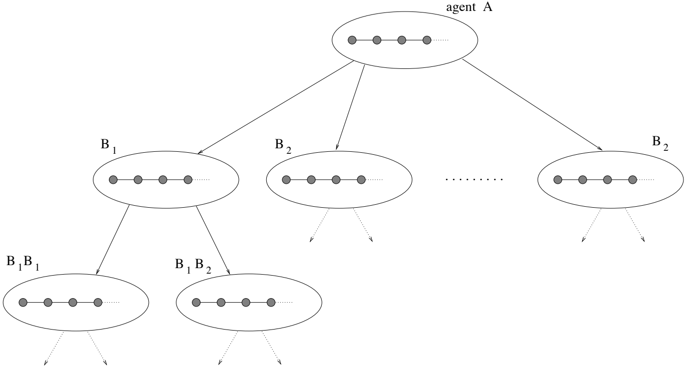
- Extension to first Order Logic (Distributed First Order Logic);
- Object-meta reasoning;

$$meta : Th(\text{“}A'') \longrightarrow object : A$$

$$object : A \longrightarrow meta : Th(\text{“}A'')$$

Then, the story went on . . .

- Extension to first Order Logic (Distributed First Order Logic);
- Object-meta reasoning;
- Propositional attitudes and Multi-agent systems:



Then, the story went on . . .

- Extension to first Order Logic (Distributed First Order Logic);
- Object-meta reasoning;
- Propositional attitudes and Multi-agent systems:
- Information integration;

DB1

`Car`

Id	Type	Price
001	Fiat TIPO	14.000
002	Fiat UNO	12.000

DB2

`Product`

Id	Type	Price
001	TIPO	15.000
002	UNO	13.000

Then, the story went on . . .

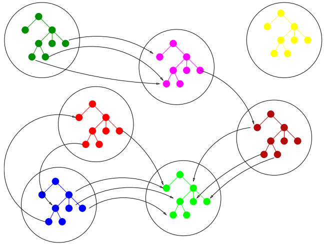
- Extension to first Order Logic (Distributed First Order Logic);
- Object-meta reasoning;
- Propositional attitudes and Multi-agent systems:
- Information integration;
- . . . and then the Semantic Web arrived . . .

Multi-Context Logics meet the Description Logics

Distributed Description Logic (DDL)

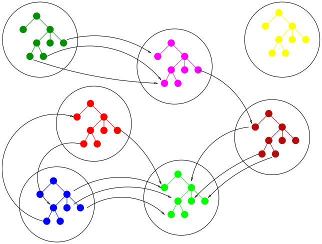
Motivations

- Distributed ontologies: In real applications ontologies are often fragmented and connected via semantic mappings.



Motivations

- Distributed ontologies: In real applications ontologies are often fragmented and connected via semantic mappings.



- Distributed Description Logics (DDLs) formalizes the notion of distributed ontology and reasoning, based on:
  - local T-boxes
  - bridge rules between pairs of local T-boxes
- Takes advantage of a context based approach:
  - localized inconsistency and directionality.

Semantic mappings: an example

- **Thing**
  - **Person**
    - **Employ**
      - **AcademicStuff**
        - **FacultyMember**
          - **AssistantProfessor**
          - **AssociateProfessor**
          - **FullProfessor**
        - **AdministrativeStaff**
        - **TechnicalStaff**
    - **Student**
      - **Graduate**
        - **PhdStudent**
      - **Undergraduate**
  - **Publication**
    - **Article**
    - **Book**
    - **InBook**
    - **InCollection**
    - **InProceedings**
    - **TechReport**
    - **Thesis**
      - **MasterThesis**
      - **PhdThesis**

- **Thing**
  - **Person**
    - **Student**
      - **GraduateStudent**
      - **UndergraduateStudent**
    - **Employee**
      - **AdministrativeStaff**
        - **Director**
        - **SystemsStaff**
      - **Assistant**
      - **Faculty**
        - **Professor**
          - **AssistantProfessor**
          - **AssociateProfessor**
          - **FullProfessor**
  - **Article**
  - **Book**
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  - **ConferencePaper**
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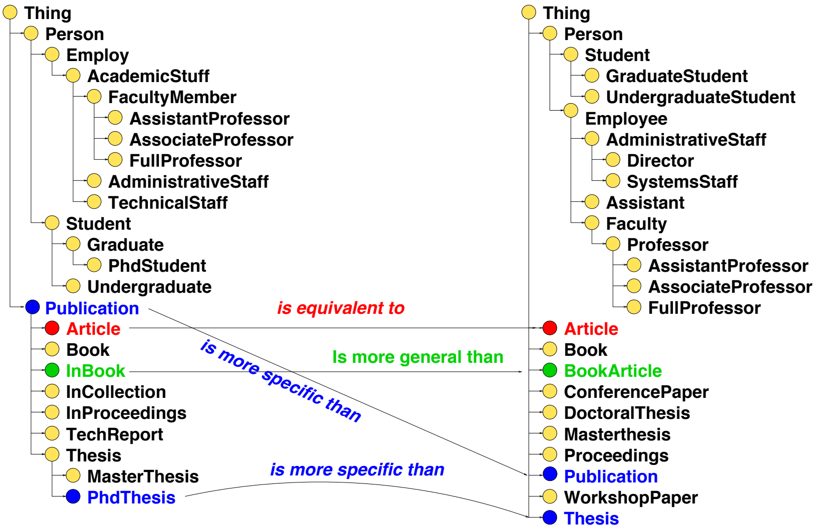
  - **WorkshopPaper**
  - **Thesis**

Semantic mappings: an example



- Thing
  - Person
    - Employ
      - AcademicStuff
        - FacultyMember
          - AssistantProfessor
          - AssociateProfessor
          - FullProfessor
        - AdministrativeStaff
        - TechnicalStaff
    - Student
      - Graduate
        - PhdStudent
      - Undergraduate
  - Publication
    - Article
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    - InCollection
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- Thing
  - Person
    - Student
      - GraduateStudent
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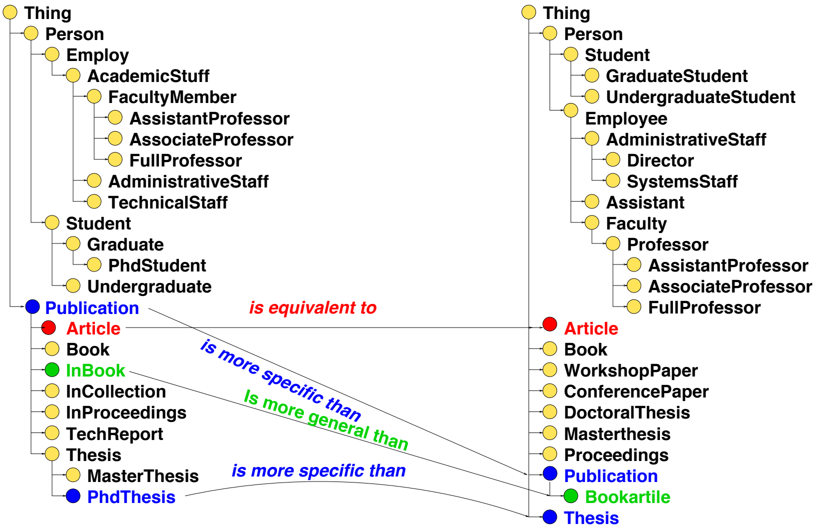
Effects of semantic mappings: an example



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  - **Thesis**

is equivalent to

is more specific than

Is more general than

is more specific than

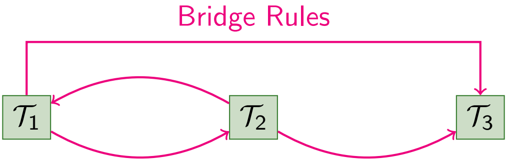
A semantics for semantic mappings

- Subsumption propagation via semantic mappings
- Directionality: mappings from a source ontology to a target ontology do not affect the source ontology
- Local inconsistency: inconsistent not necessarily propagates through semantic mapping.

DDL in a picture - syntax

$\mathcal{T}_1$ $\mathcal{T}_2$ $\mathcal{T}_3$

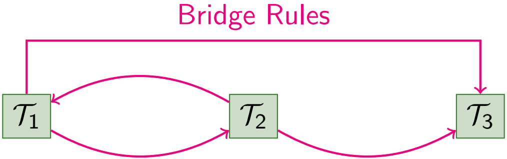
DDL in a picture - syntax



$i : X \xrightarrow{\sqsubseteq} j : Y$ (into bridge rule)

$i : X \xrightarrow{\sqsupseteq} j : Y$ (onto bridge rule)

DDL in a picture - syntax



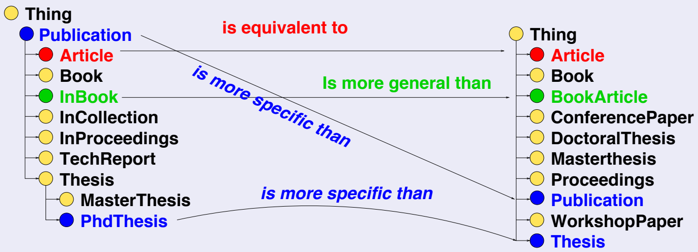
$$i : X \xrightarrow{\sqsubseteq} j : Y \qquad \text{(into bridge rule)}$$
$$i : X \xrightarrow{\sqsupseteq} j : Y \qquad \text{(onto bridge rule)}$$

Distributed T-box $\mathfrak{T}$:

- a set of T-boxes $\mathcal{T}_1, \ldots \mathcal{T}_n$;
- a set of bridge rules.

An example

Semantic mappings



Thing
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Bridge rules

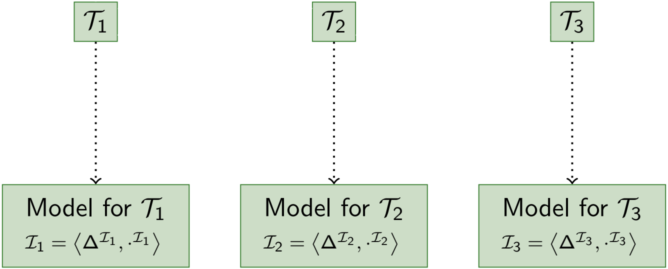
$1{:}\text{Publication} \xrightarrow{\sqsubseteq} 2{:}\text{Publications}$

$1{:}\text{PhdThesis} \xrightarrow{\sqsubseteq} 2{:}\text{Thesis}$

$1{:}\text{InBook} \xrightarrow{\sqsupseteq} 2{:}\text{BookArticle}$

$1{:}\text{Article} \xrightarrow{\sqsubseteq} 2{:}\text{Article}$ $1{:}\text{Article} \xrightarrow{\sqsupseteq} 2{:}\text{Article}$

DDL in a picture - semantics



$\mathcal{T}_1$

$\mathcal{T}_2$

$\mathcal{T}_3$

Model for $\mathcal{T}_1$

$\mathcal{I}_1 = \langle \Delta^{\mathcal{I}_1}, \cdot^{\mathcal{I}_1} \rangle$

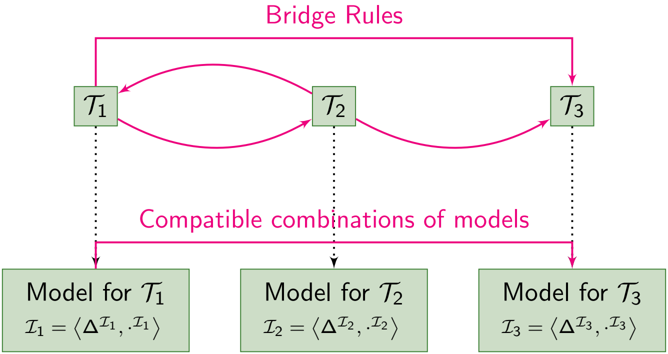
Model for $\mathcal{T}_2$

$\mathcal{I}_2 = \langle \Delta^{\mathcal{I}_2}, \cdot^{\mathcal{I}_2} \rangle$

Model for $\mathcal{T}_3$

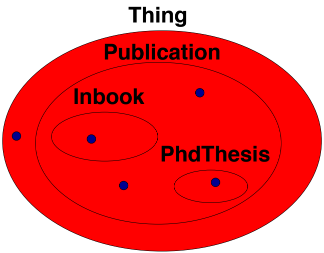
$\mathcal{I}_3 = \langle \Delta^{\mathcal{I}_3}, \cdot^{\mathcal{I}_3} \rangle$

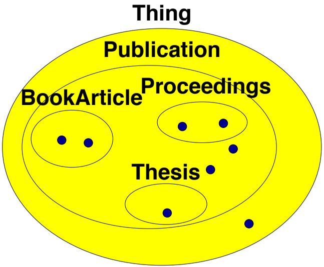
DDL in a picture - semantics



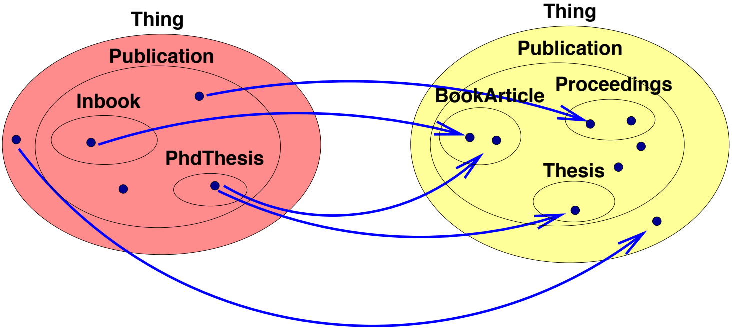
To constrain the combinations of models we introduce relations between the domains of interpretation $\Delta^{\mathcal{I}_i}$ of the different $\mathcal{T}_i$'s.

Domain relations

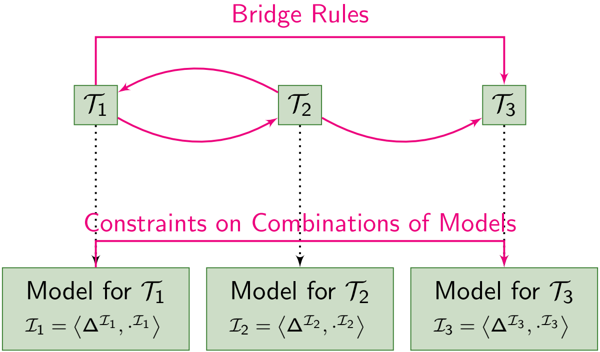




Domain relations



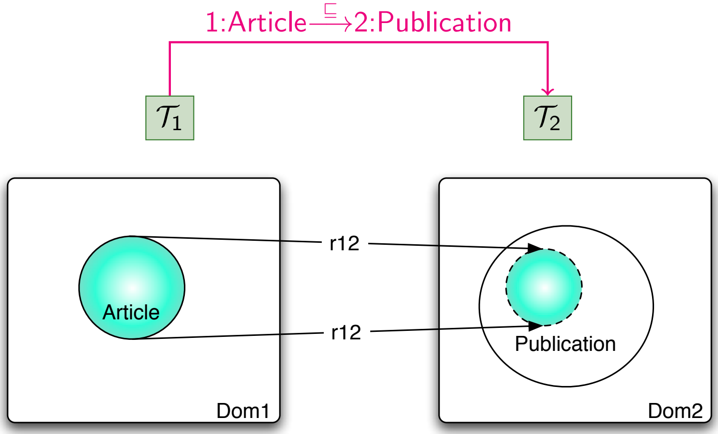
DDL: Semantics



Distributed interpretation $\mathfrak{I} = \langle \{\mathcal{I}_i\}_{i \in I}, \{r_{ij}\}_{i \neq j \in I} \rangle$

- local interpretations $\mathcal{I}_i = \left\langle \Delta_i, \cdot^{\mathcal{I}_i} \right\rangle$
- domain relations $r_{ij} \subseteq \Delta_i \times \Delta_j$

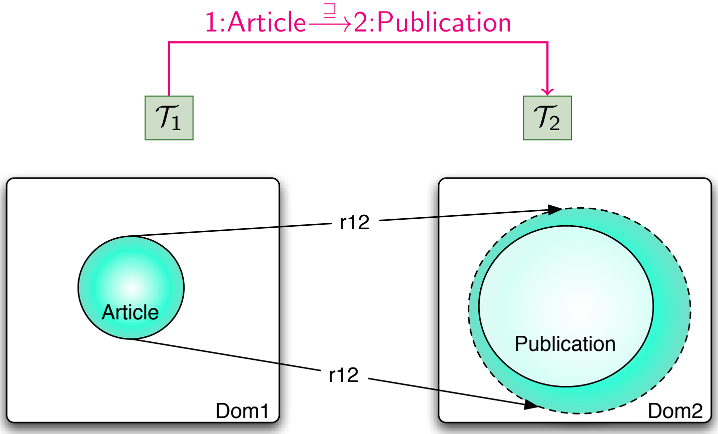
Into Bridge rules: Satisfiability



$1{:}\text{Article} \xrightarrow{\sqsubseteq} 2{:}\text{Publication}$

$$\mathfrak{I} \models 1 : \text{Article} \xrightarrow{\sqsubseteq} 2 : \text{Publication}, \text{ iff } r_{12}(\text{Article}^{\mathcal{I}_1}) \subseteq \text{Publication}^{\mathcal{I}_2}$$

Onto Bridge rules: Satisfiability



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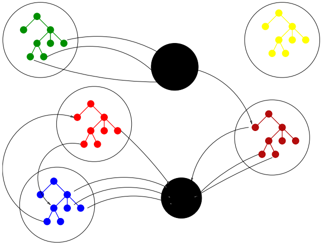

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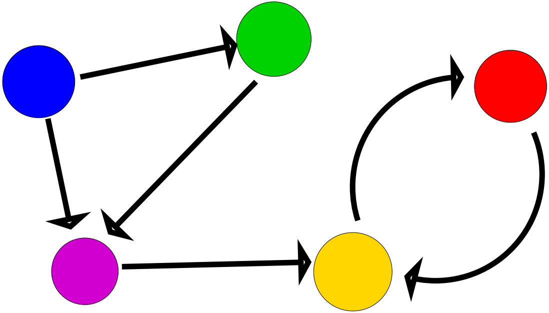
- We define $C^{\mathcal{H}} = \emptyset$ and $R^{\mathcal{H}} = \emptyset$ for every concept and role.
- Thus, $\mathcal{H} \models T$ for every T-box T

Directionality

Semantic mappings have a direction from a source ontology to a target ontology, and support knowledge propagation only in such a direction.



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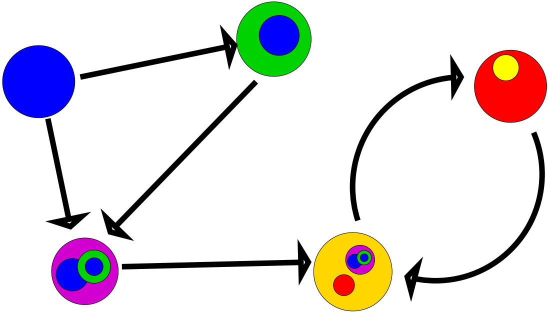

Directionality

Example (Backward propagation in classical semantics)

The bridge rule

$$\texttt{SportCar} : \mathsf{car} \xrightarrow{\sqsupseteq} \top : \mathsf{Ferrari}$$

forces the concept `SportCar` in the ontology of $\mathcal{T}_{\mathsf{car}}$ to be non empty.

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Directionality with Holes

If $\mathcal{I}_{\mathsf{Ferrari}} = \mathcal{H}$ then

$$\mathtt{SportCar} : \mathsf{car} \xrightarrow{\sqsupseteq} \top : \mathsf{Ferrari}$$

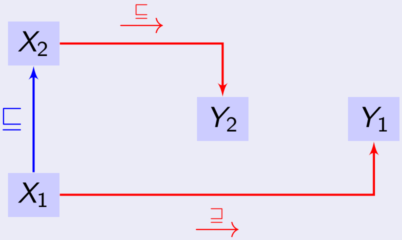
can be satisfied with an empty `SportCar`, since $\top^{\mathcal{H}} = \emptyset$.

Effects of bridge rules: propagation of hierarchies

Propagation Rule

$$\frac{\begin{array}{l} s : X_1 \sqsubseteq X_2 \\ s : X_1 \xrightarrow{\sqsupseteq} t : Y_1 \\ s : X_2 \xrightarrow{\sqsubseteq} t : Y_2 \end{array}}{t : Y_1 \sqsubseteq Y_2}$$

Graphically



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Graphically

$$\begin{tikzcd} X_2 \arrow[r, "\xrightarrow{\sqsubseteq}"] & Y_2 \\ X_1 \arrow[u, "\sqsubseteq"] \arrow[r, "\xrightarrow{\sqsupseteq}"'] & Y_1 \arrow[u, "\sqsubseteq"'] \end{tikzcd}$$

Propagation of hierarchies: the general case

Propagation Rule

$$\frac{\begin{array}{l} s : X_1 \sqsubseteq X_2 \sqcup \cdots \sqcup X_n \\ s : X_1 \xrightarrow{\sqsupseteq} t : Y_1 \\ s : X_2 \xrightarrow{\sqsubseteq} t : Y_2 \\ \vdots \\ s : X_n \xrightarrow{\sqsubseteq} t : Y_n \end{array}}{t : Y_1 \sqsubseteq Y_2 \sqcup \cdots \sqcup Y_n}$$

Bridge rules as an operator

$$\mathfrak{B}_{st}(\mathcal{T}_s) = \left\{ Y_1 \sqsubseteq \bigsqcup_{k=2}^{n} Y_k \;\middle|\; \begin{array}{l} \mathcal{T}_s \models X_1 \sqsubseteq \bigsqcup_{k=2}^{n} X_k \\ X_1 : 1 \xrightarrow{\sqsupseteq} Y_1 : 2 \quad \in \mathfrak{B}_{12} \\ X_2 : 1 \xrightarrow{\sqsubseteq} Y_2 : 2 \in \mathfrak{B}_{12} \\ \vdots \\ X_n : 1 \xrightarrow{\sqsubseteq} Y_n : 2 \in \mathfrak{B}_{st} \end{array} \right\}$$

Theorem (Soundness and completeness)

$\mathfrak{T}_{12} = \langle \mathcal{T}_1, \mathcal{T}_2, \mathfrak{B}_{12} \rangle$ *be a distributed T-box,*

$$\mathfrak{T}_{12} \models_{DDL} X \sqsubseteq Y : 2 \quad \Longleftrightarrow \quad \mathcal{T}_2 \cup \mathfrak{B}_{12}(\mathcal{T}_1) \models_{DL} X \sqsubseteq Y$$

The DRAGO system

The Distributed Reasoning Architecture for a Galaxy of Ontologies is a peer-to-peer like system in which every peer registers a set of OWL ontologies and semantic mappings (expressed in C-OWL), that support distribute reasoning services.

Free download at

`http://trinity.dit.unitn.it/drago/`

Distributed Description Logics - Summary

Definition of a logic with:

- DDL formal semantics for distributed partially inconsistent and heterogeneous ontologies
- Theoretical characterization of subsumption in DDL with atomic bridge rules
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Further developments of DDL:

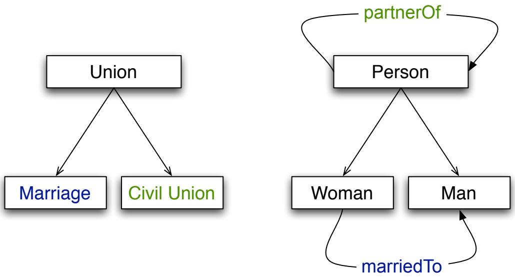
- Representation of heterogeneous mappings;
- Contextualized OWL (C-OWL).

Mapping Heterogeneous Ontolgies

- Mapping languages focus mainly on mappings between concepts from different ontologies; Very few address mappings between roles;
  - s : Article less general than t : Publication
  - s : *partnerOf* more general than t : *marriedTo*

Mapping Heterogeneous Ontolgies

- Mapping languages focus mainly on mappings between concepts from different ontologies; Very few address mappings between roles;
  - s : Article less general than t : Publication
  - s : *partnerOf* more general than t : *marriedTo*
- Mismatches due to schematic differences exist in different ontologies; A typical example is the representation of an element as a concept in one ontology and as a role in another ontology.



Heterogeneous Bridge Rules

- Rules mapping concepts to roles (or the other way around)

$$s : \mathsf{Marriage} \xrightarrow{\sqsubseteq} t : \mathit{partnerOf}$$

- both into and onto versions
- Semantics provided by means of two additional domain relations
  - concept-role cr_{st}
  - role-concept rc_{st}
- Theoretical characterization of subsumption with atomic bridge rules and investigation of complexity of reasoning.

Context OWL (C-OWL)

- Proposal to include DDL mappings into OWL
- A contextual ontology is a pair:
  - OWL contextual ontology;
  - set of mappings (bridge rules).
- A mapping is a 4-tuple:
  - A mapping identifier (URI);
  - A source context containing an OWL ontology;
  - A target context containing an OWL ontology;
  - A set of bridge rules from the source ontology to the target ontology.

Current efforts & challenges:

Contextualized knowledge repositories for the SW

- Most of the data available in the semantic web (linked data) are provided in an unspecified context.
- the standard languages of the semantic web (RDF, RDFS, . . . OWL2.0) do not explicitly support the representation and reasoning of context sensitive knowledge.
- Contextual dimension is usually "handcrafted" in the implementation.

Example

FreeBase: Contexts representation for events The URI:

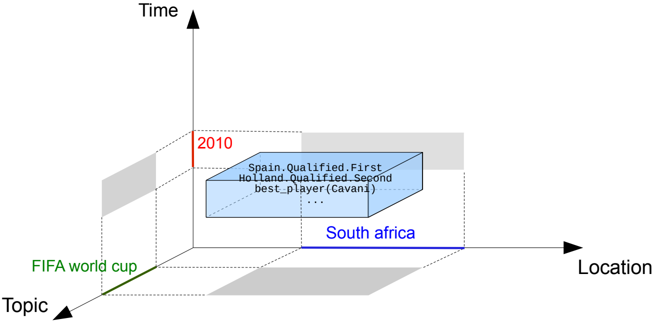
```
<fb:base.x2010fifaworldcupsouthafrica.
                              world_cup_team.qualifed_as>
```

is used to encode the binary relation `qualified_as`, that connects each team with the qualification it obtained, in the context:

```
x2010fifaworldcupsouthafrica
```

The "Context as a box" representation paradigm

- a context is a theory—set of sentences in a logical language, closed under logical consequence—associated with a region in a contextual space;



Context as a box

$$\begin{array}{rl} & \text{time}(\mathcal{C}, \text{2010-06-14}),\ \text{location}(\mathcal{C}, \text{World}),\ \text{topic}(\mathcal{C}, \text{FIFA\_WC\_Match\_11}) \\ \mathcal{C} = & \boxed{\begin{array}{l} \text{TeamA(Team\_Italy)} \\ \text{TeamB(Team\_Paraguay)} \\ \text{Referee(Benito\_Archundia)} \\ \text{scored}(\text{Daniele\_Derossi}, 63^{\circ}) \\ \text{scored}(\text{Antolin\_Alcaraz}, 39^{\circ}) \\ \text{match\_document}(\mathit{http://www.fifa.com/mm/document/.../...5fstart.pdf}) \\ \text{match\_document}(\mathit{http://www.fifa.com/mm/document/.../...5lineup.pdf}) \\ \text{photo}(\mathit{http://www.fifa.com/mm/pict/.../...xyz.jpg}) \\ \dots \end{array}} \end{array}$$

Context as a box

time($\mathcal{C}$, 2010-06-14), location($\mathcal{C}$, World), topic($\mathcal{C}$, FIFA_WC_Match_11)

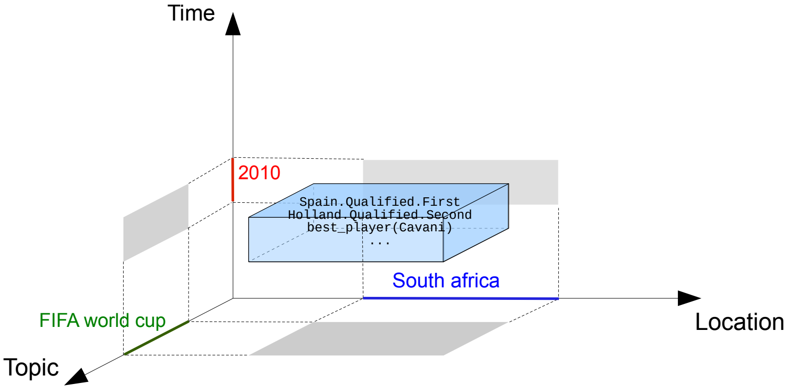
$\mathcal{C} =$

TeamA(Team_Italy)
TeamB(Team_Paraguay)
Referee(Benito_Archundia)
scored(Daniele_Derossi, 63°)
scored(Antolin_Alcaraz, 39°)
match_document($http : //www.fifa.com/mm/document/.../...5fstart.pdf$)
match_document($http : //www.fifa.com/mm/document/.../...5lineup.pdf$)
photo($http : //www.fifa.com/mm/pict/.../...xyz.jpg$)
...

- Lenat, Doug. The Dimensions of Context-Space (in CYC);
- Dimensions from Semantic Web requirements (Time,Provenance, Access Control, Propositional attitudes, Versioning)

Broader and narrower contexts

Contexts can be related via a narrower/broader relation, also called context coverage.



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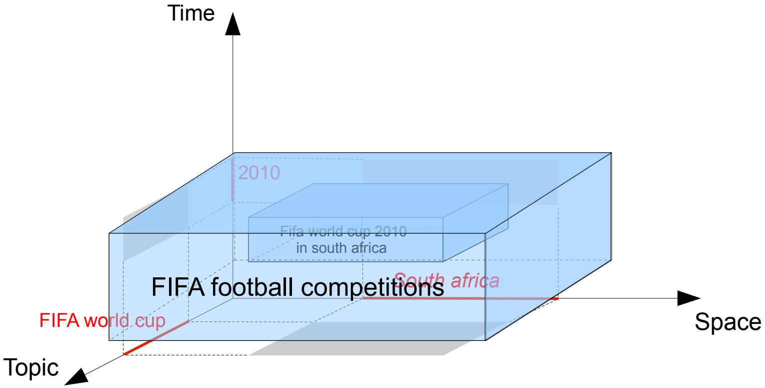

References to other contexts

In a context we sometimes need to refer to entities outside of the context.

$$\text{time}(\mathcal{C}, \text{2010-06-14}),\ \ \text{location}(\mathcal{C}, \text{World}),\ \ \text{topic}(\mathcal{C}, \text{FIFA\_WC\_Match\_11})$$

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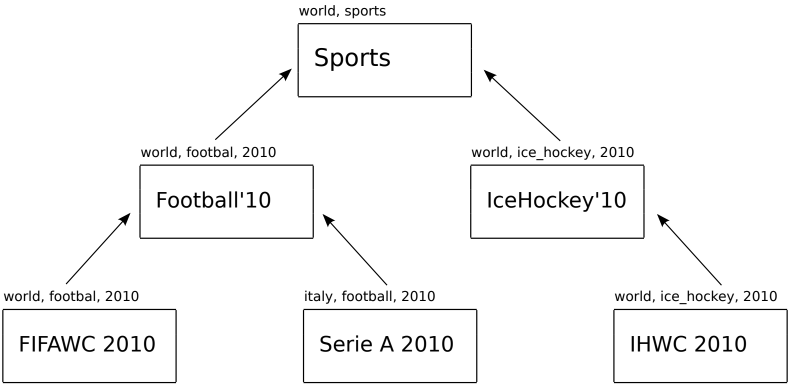
\text{plays\_with}_{\text{italian\_league}}(\text{Daniele\_Derossi, AC\_Roma}) \\
\text{scored}(\text{Antolin\_Alcaraz}, 39^\circ) \\
\text{plays\_with}_{\text{english\_league}}(\text{Antolin\_Alcaraz, Wigan}) \\
\ldots
\end{array}}$$

The contexts structure

Contexts are organized in a hierarchical structure, from broader contexts to narrower ones and can refer to other contexts.



world, sports

Sports

world, footbal, 2010

Football'10

world, ice_hockey, 2010

IceHockey'10

world, footbal, 2010

FIFAWC 2010

italy, football, 2010

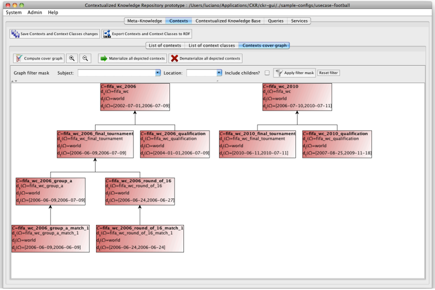
Serie A 2010

world, ice_hockey, 2010

IHWC 2010

The research plan

- Define a contextualised knowledge repository with a clear formal semantics;
- Investigate (axomatize) the inferences in the contextualised knowledge repository;
- Define the query language to access it;
- Provide the tool.



Nonmonotonic Multi-Context Systems

What if knowledge in a Multi-Context System is revised?

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An Answer Set Programming based approach:

- Gerhard Brewka, Thomas Eiter: *Equilibria in Heterogeneous Nonmonotonic Multi-Context Systems*. AAAI 2007: 385-390
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- Gerhard Brewka, Thomas Eiter, Michael Fink, Antonius Weinzierl: *Managed Multi-Context Systems*. IJCAI-2011

Conclusions

1. A logic for context based on the notions of locality and compatibility
2. Propositional Multi-Context Logics
3. Distributed Description Logics:
   - localization of inconsistency
   - directionality
4. Recent and ongoing efforts:
   - Contextualised knowledge repository
   - Nonmonotonic multi-context logics (Brewka, Eiter, et al)