A Query Model for Ontology Based Event Processing on RDF Streams

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Darmstadt, Germany, Europe, Earth, Milky Way, Universe……42

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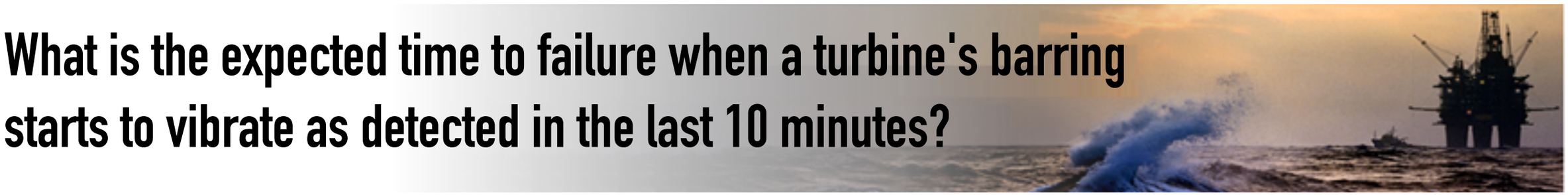
Authors

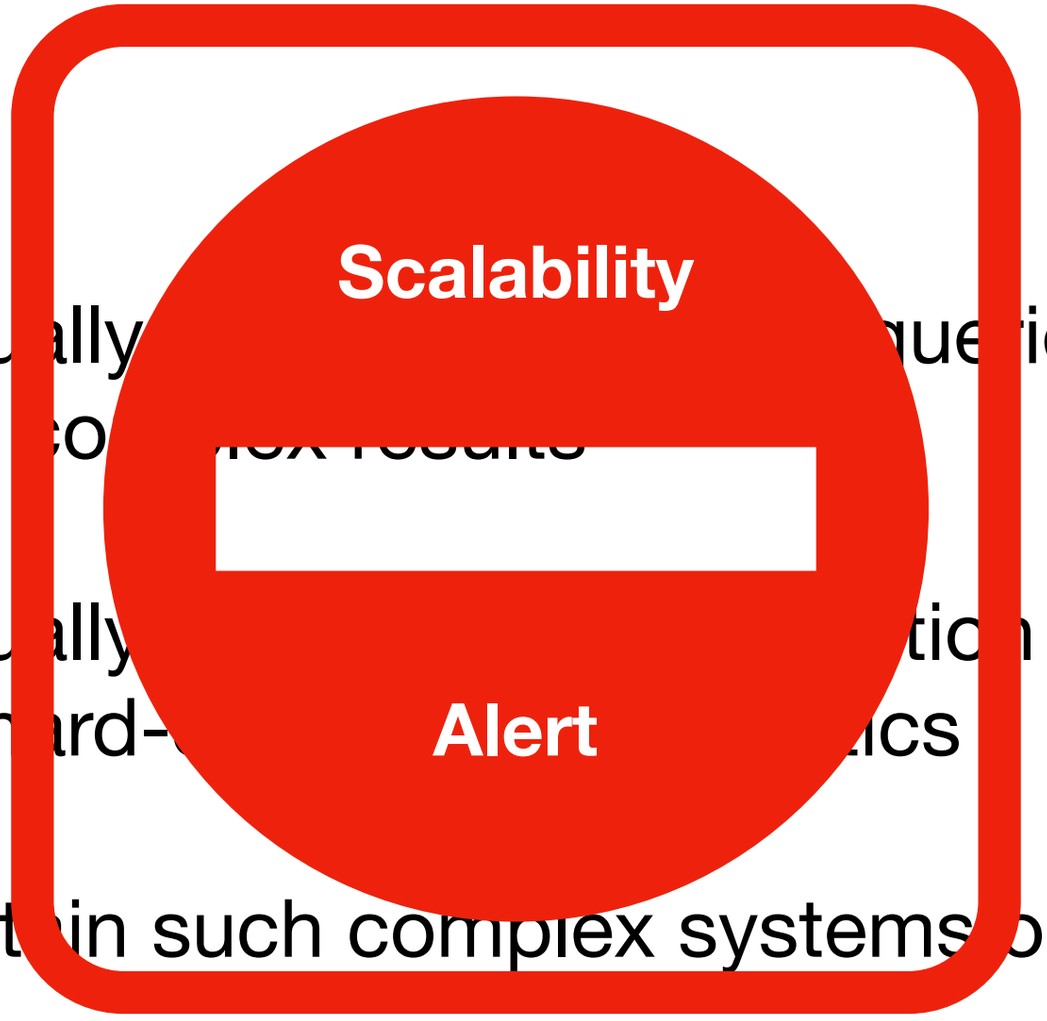
That Asks Complex Questions



Enrich the Streams

Crossing the Streams

Issues



- Need to manu ally qu ies that produced the co lex results
- Need to manu ally tic n adapting sources and h rd- ics
- Need to maint in such complex systems once you have it!

STREAM REASONING RESEARCH QUESTION

Is it possible to **make sense** in **real time** of **multiple**, **heterogeneous**, **gigantic** and inevitably **noisy** and **incomplete data streams** in order to support the **decision** processes of extremely large numbers of concurrent users?

E. Della Valle, S. Ceri, F. van Harmelen & H. Stuckenschmidt, 2010

Stream Reasoning

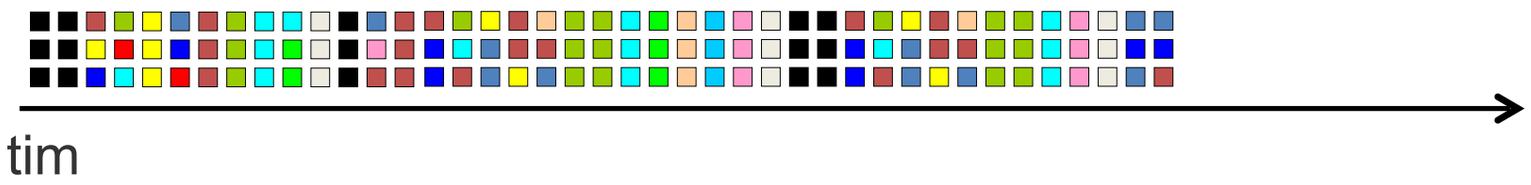
Is there a **primary cool** colour followed by a **secondary warm** one in the last minute

(■ , 13),(■ , 8) , (■, 8)

Which are the top-2 most frequent **cool** colours in the last minute?

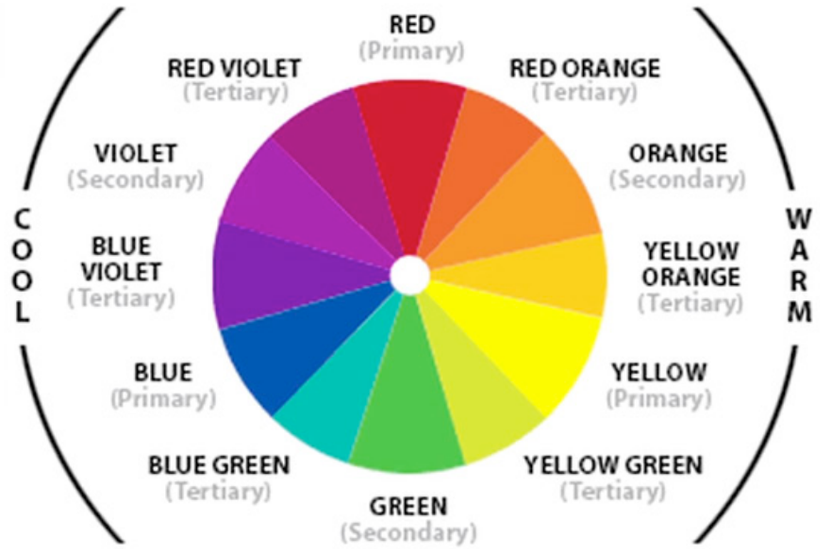
yes, ■ followed by ■

1 minute wide window

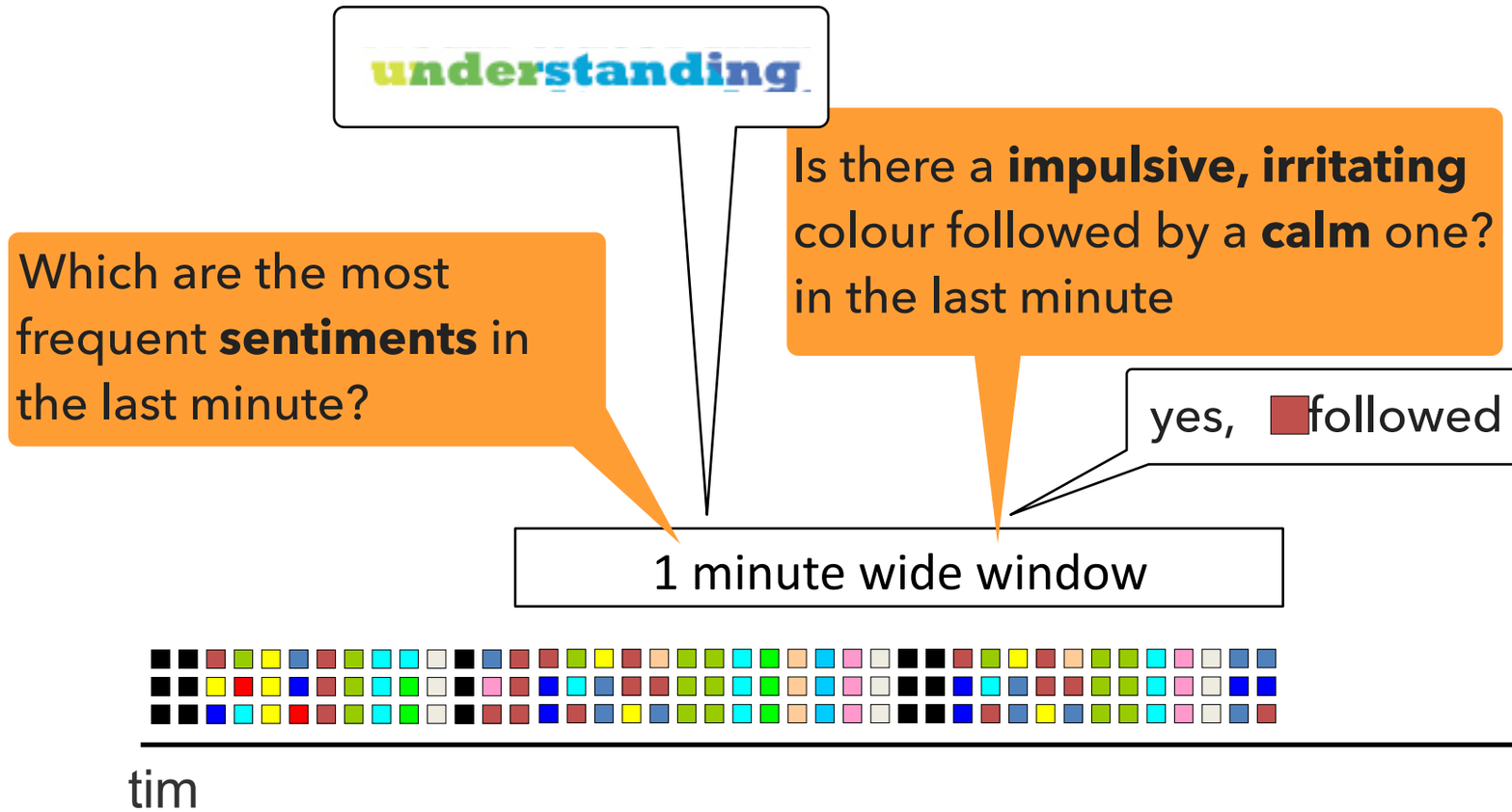


tim

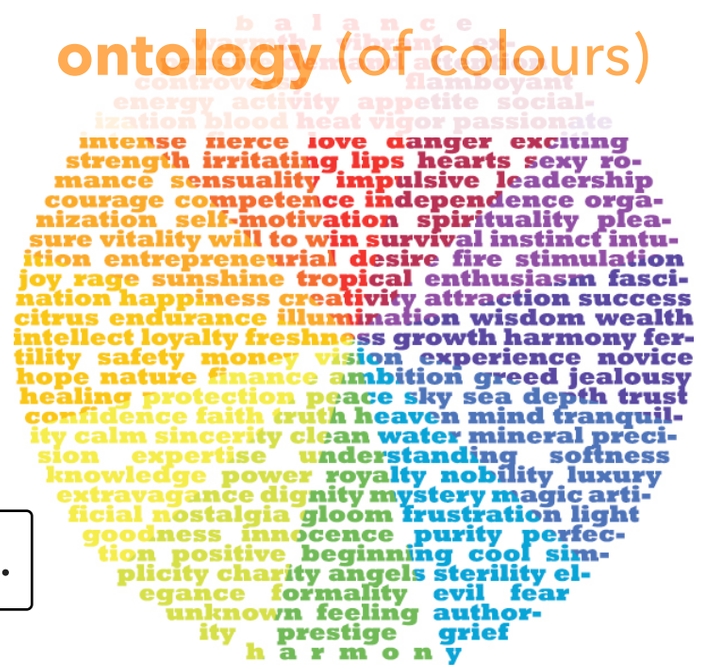
An **ontology** of



Stream Reasoning



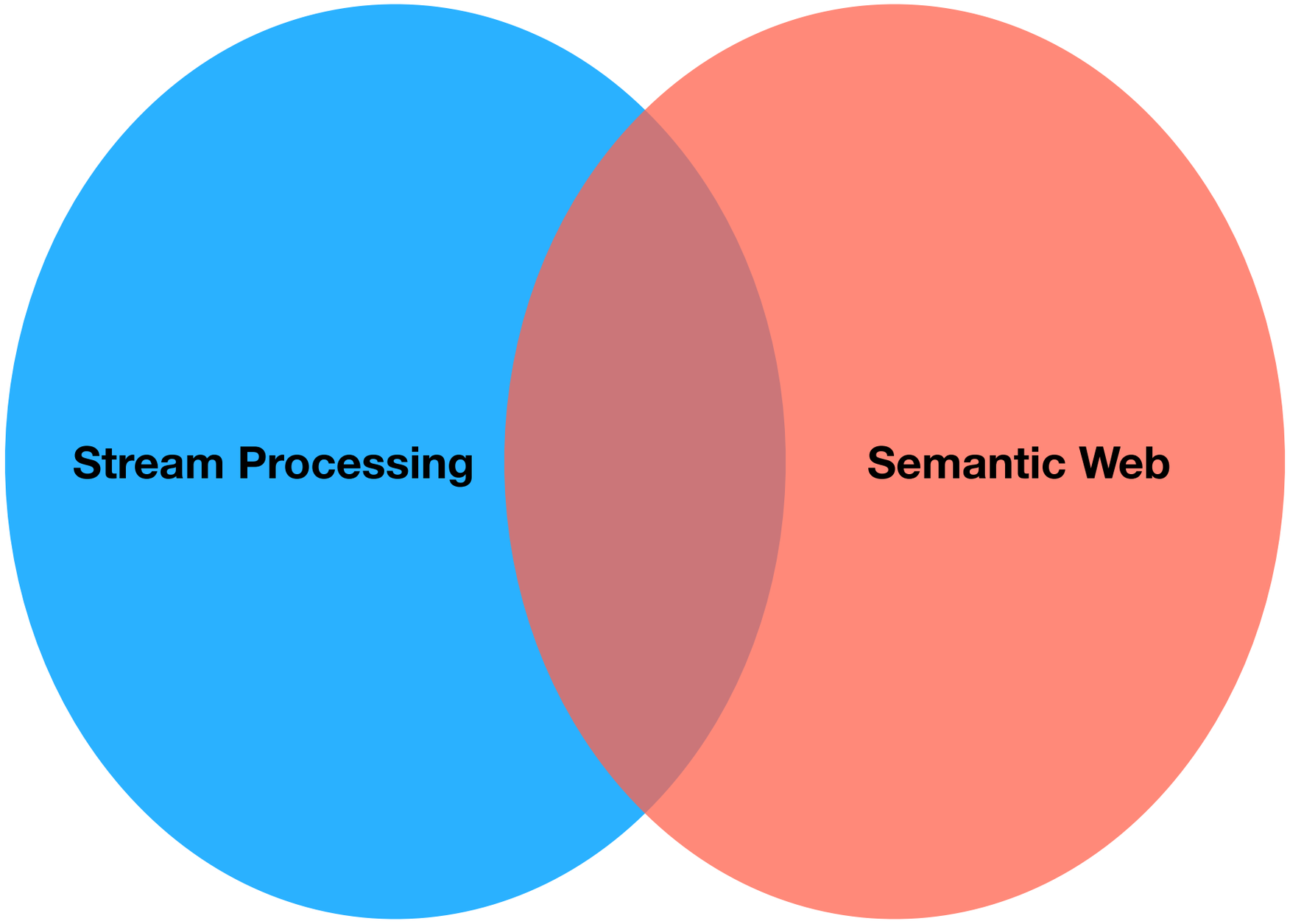
A **different** **ontology** (of colours)



Stream Reasoning

(in practice)

- Addresses data variety employing semantic technologies,
    - RDF, SPARQL, and reasoning methods (materialisation, or query rewriting)
- Addresses data velocity employing stream processing technologies
    - Data Stream Management Systems, Complex Event Processing, and. Big Streaming Systems (check out our tutorial)


Stream Processing
Semantic Web

Research Question

- (Mezzo) Leverage advanced language features in streaming systems to speed up throughput of stream reasoning problems

- (micro) leveraging inheritance in streaming languages to speed up hierarchical stream reasoning

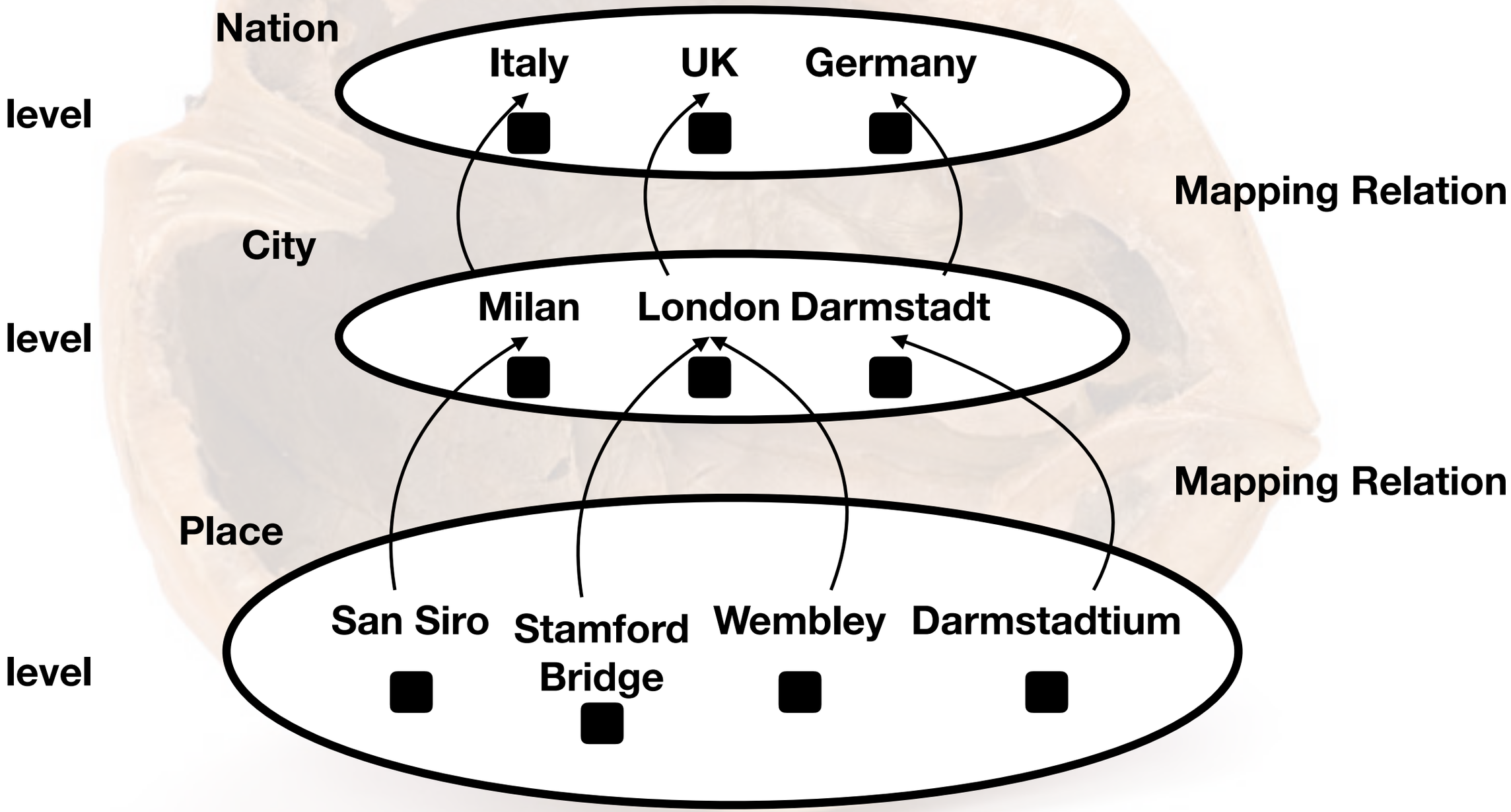
Contributions

- C-TRA, an extension of Taxonomy-Relational Algebra [20] to the continuous semantics

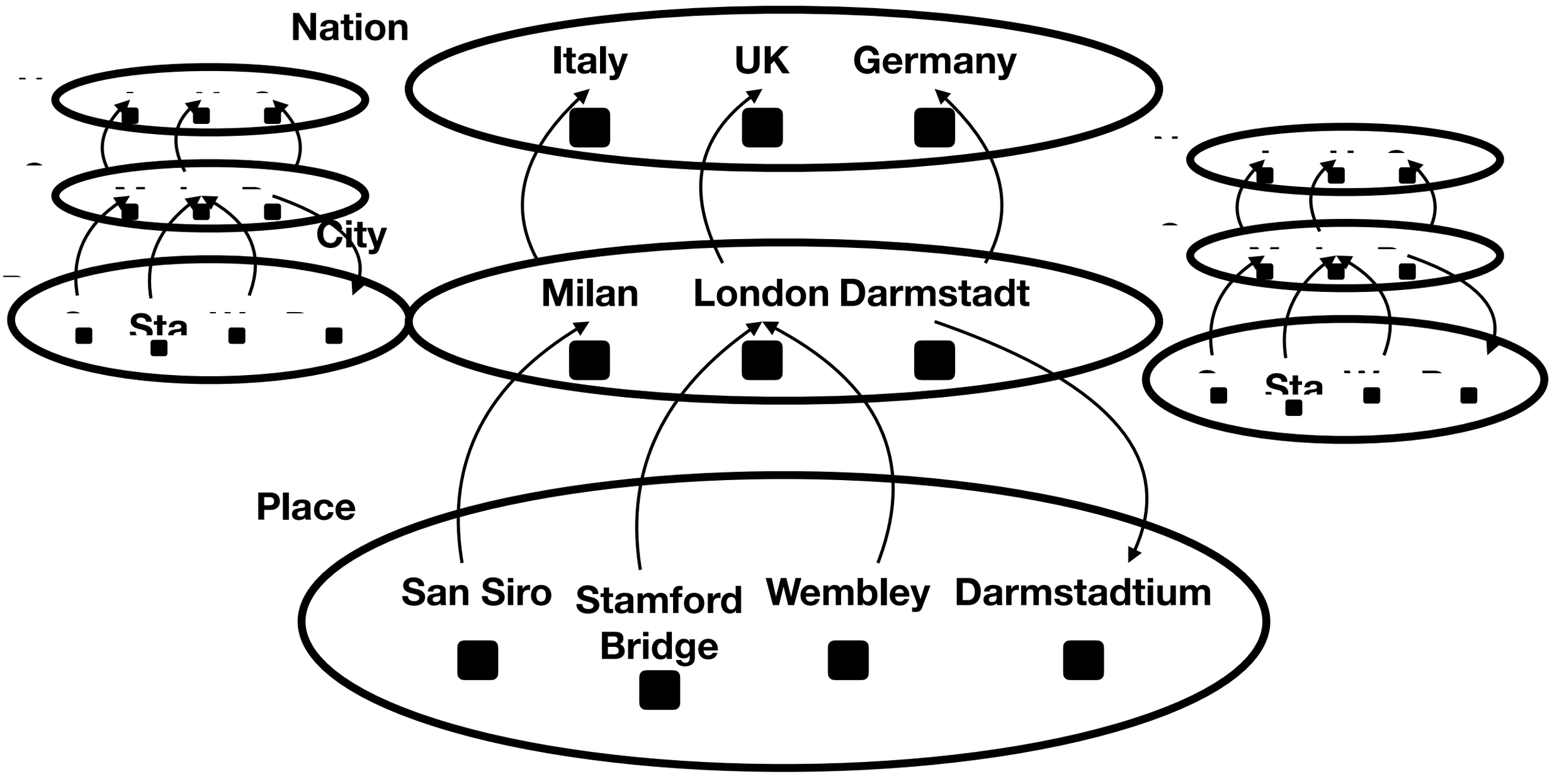
- Alignment of query answering in CTRA to query answering in (continuous) SPARQL under RDFS entailment regime

- CSPRITE: two algorithms to efficient hierarchical reasoning of RDF streams.

h-domain


Nation
level
Italy
UK
Germany
Mapping Relation
City
level
Milan
London
Darmstadt
Mapping Relation
Place
level
San Siro
Stamford Bridge
Wembley
Darmstadtium

taxonomy


Nation
Italy
UK
Germany
City
Milan
London
Darmstadt
Place
San Siro
Stamford Bridge
Wembley
Darmstadtium

T-Schema & T-Relation

Type table

	Subject	obs:l2
t_a	obs_x	WeatherObservation
t_b	obs_y	GeometryObservation

a)

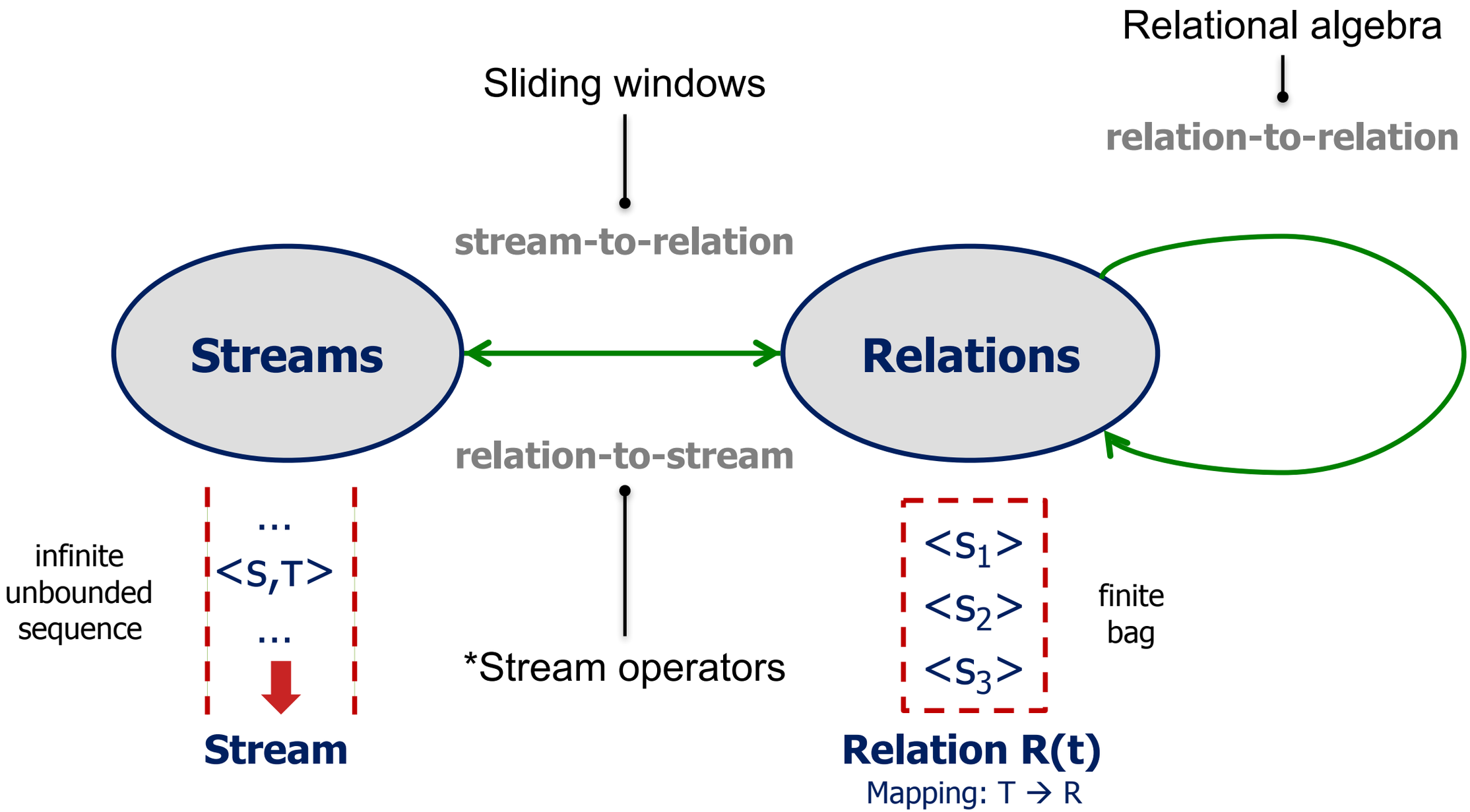
$$\varepsilon^{obs:l1}_{obs:l2} \longrightarrow$$

	Subject	obs:l2	obs:l1
t_a	obs_x	WeatherObservation	Observation
t_b	obs_y	GeometryObservation	Observation

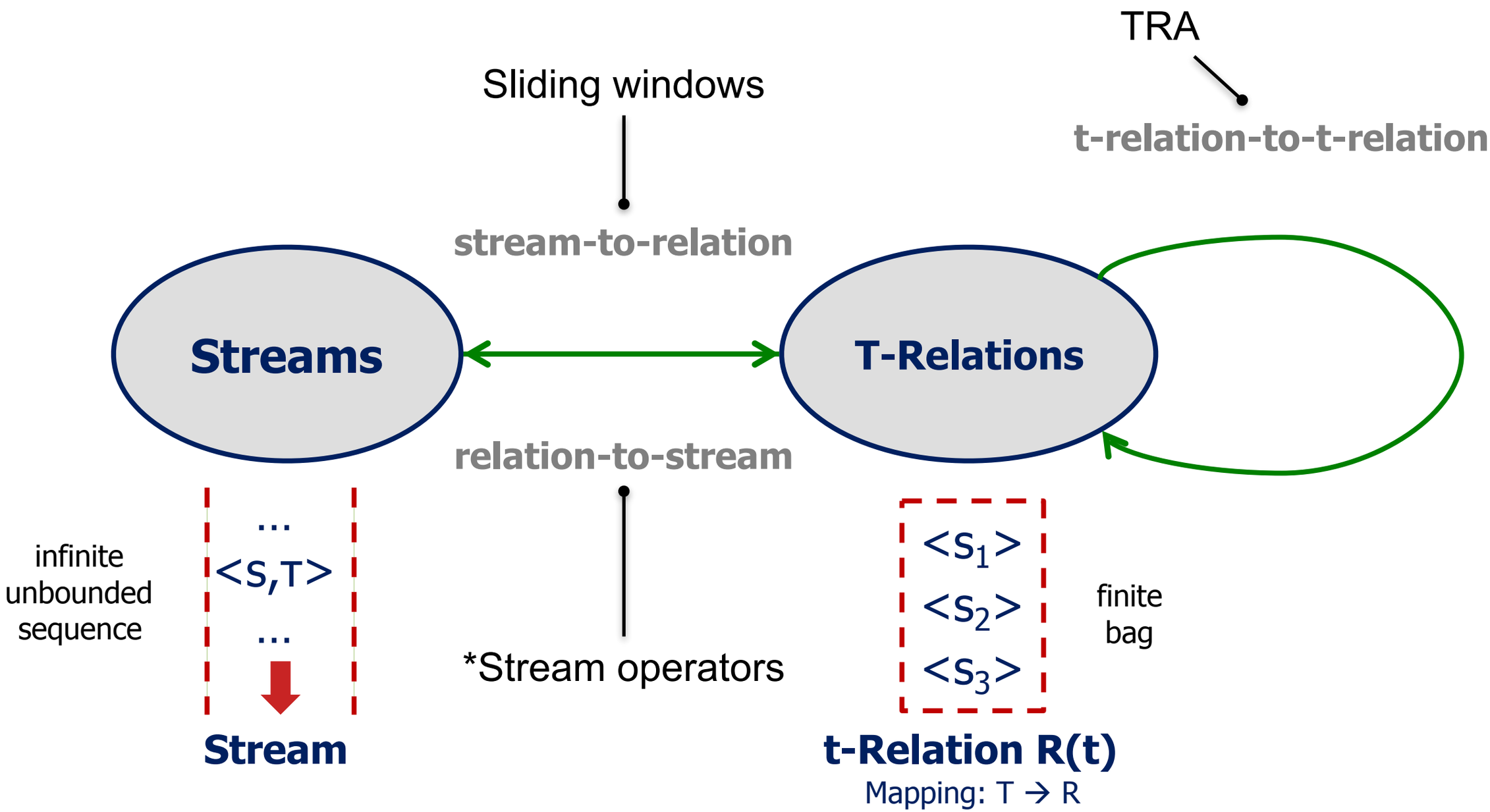
b)

upward extension

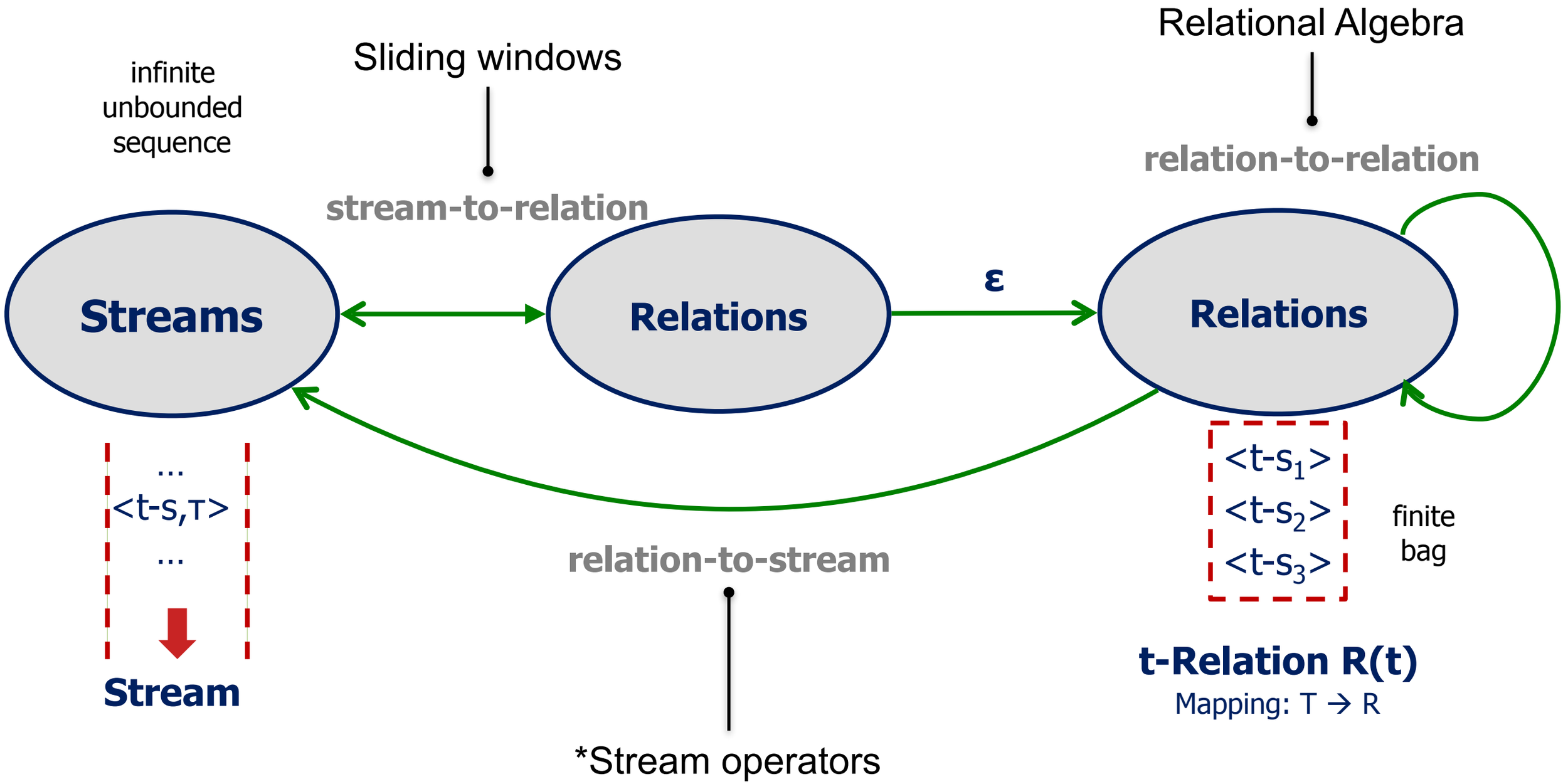
The CQL model



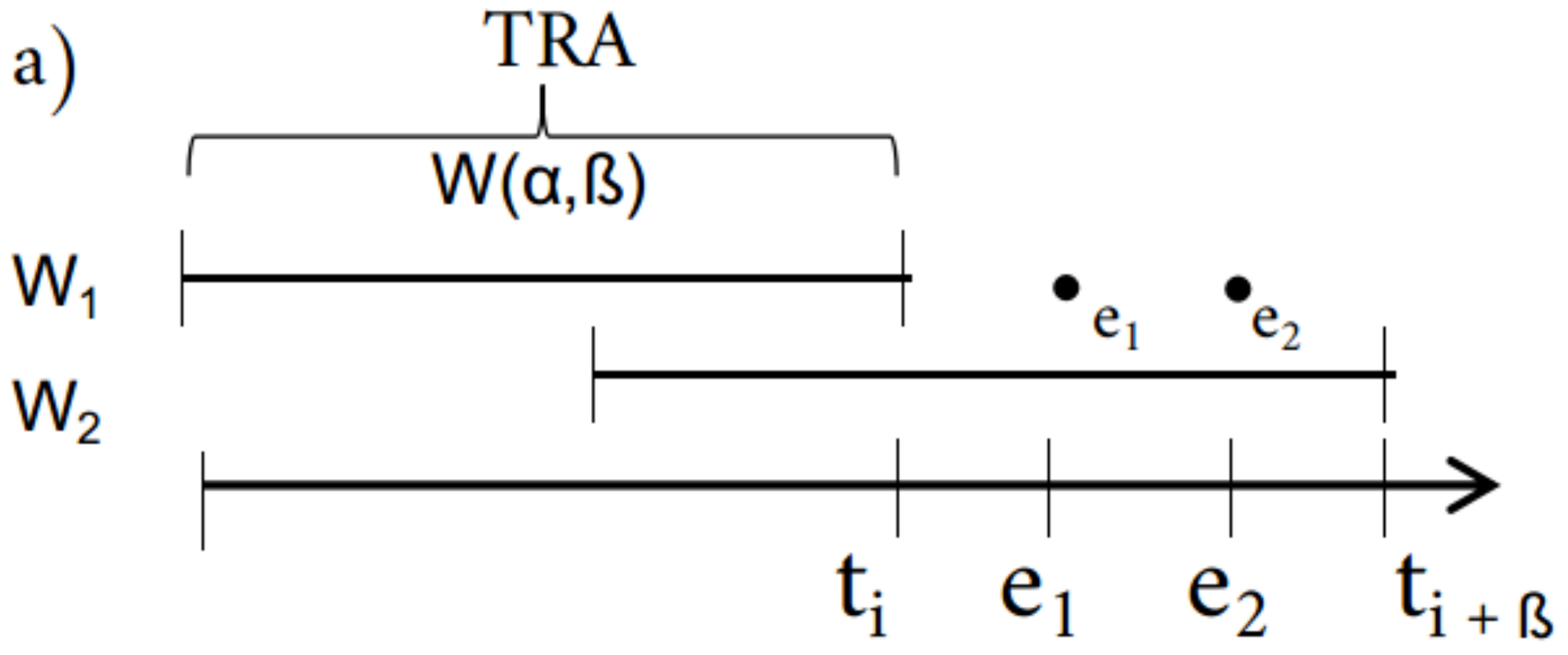
The CTQL model



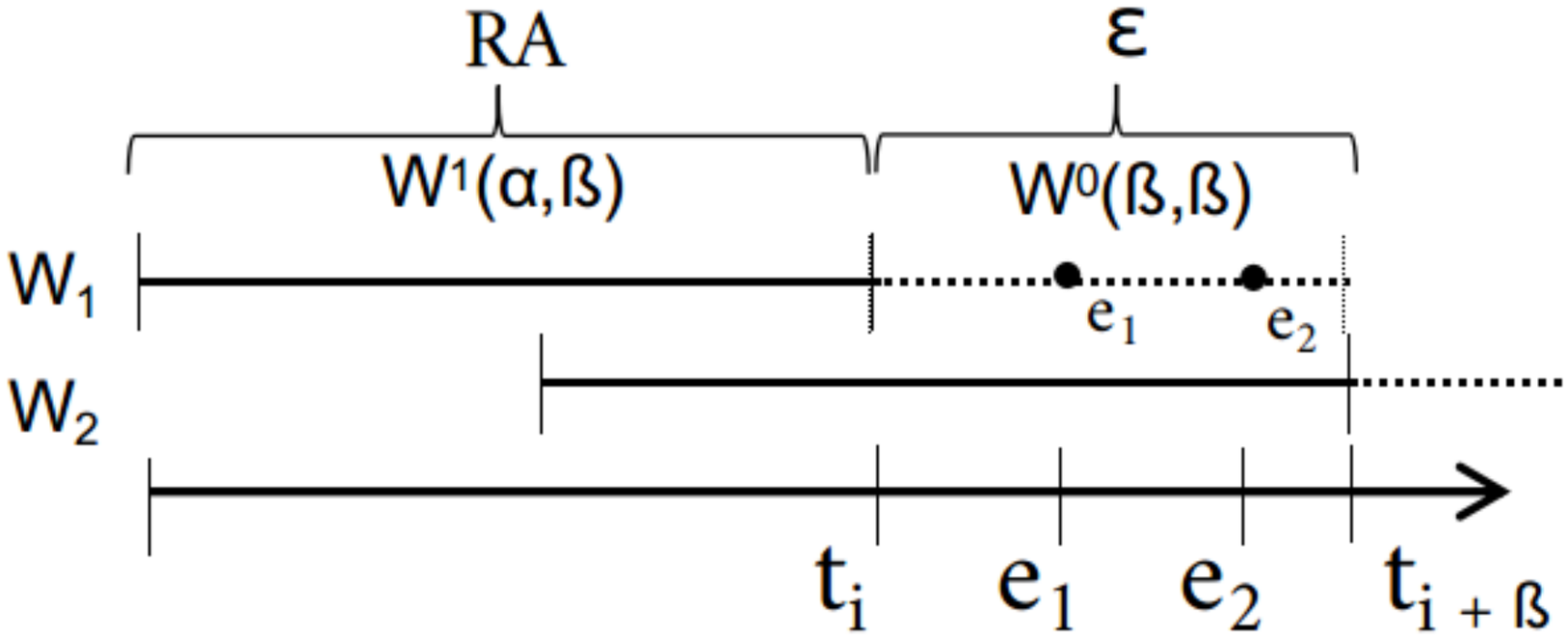
The CTQL model



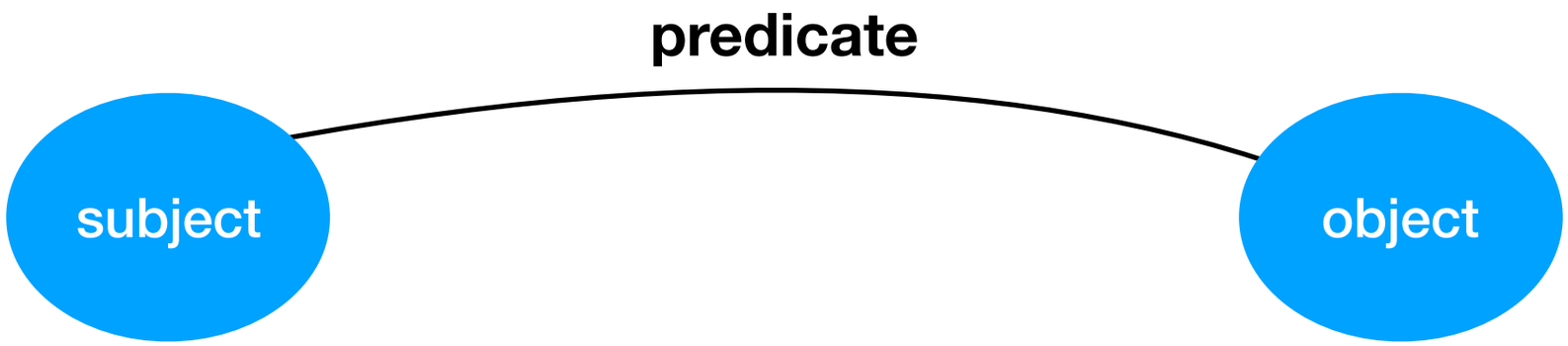
a)

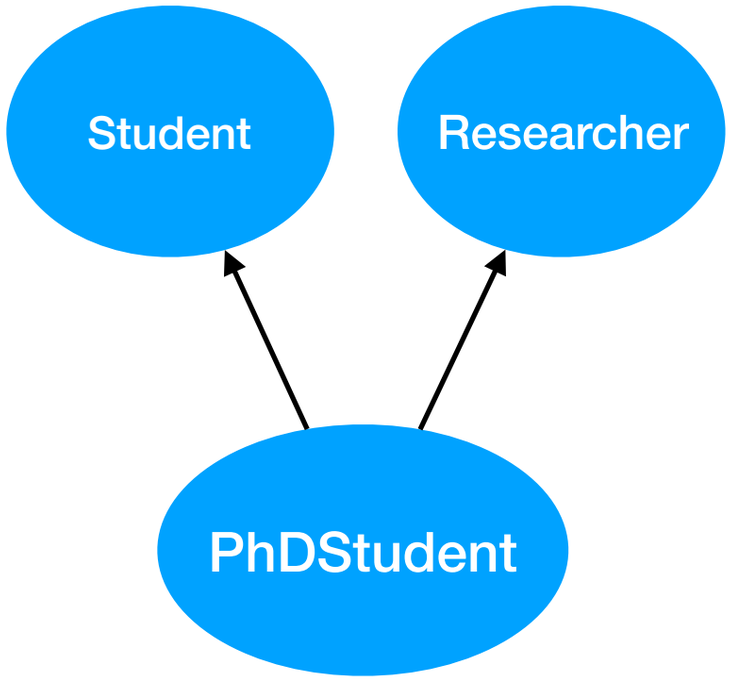

TRA
W(α,ß)
W1
W2
e1
e2
ti
e1
e2
ti + ß

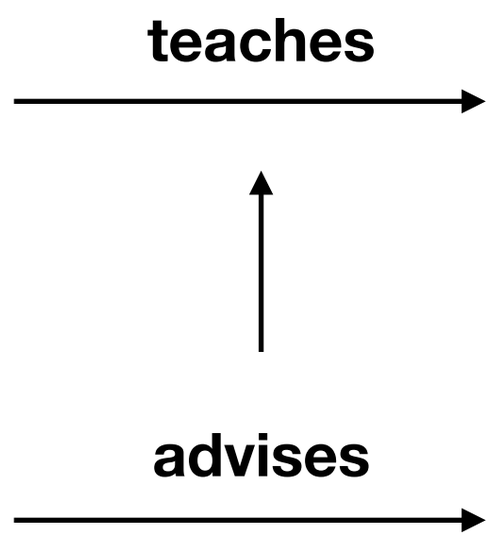
b)


RA
ε
W1(α,ß)
W0(ß,ß)
W1
W2
e1
e2
ti
e1
e2
ti + ß

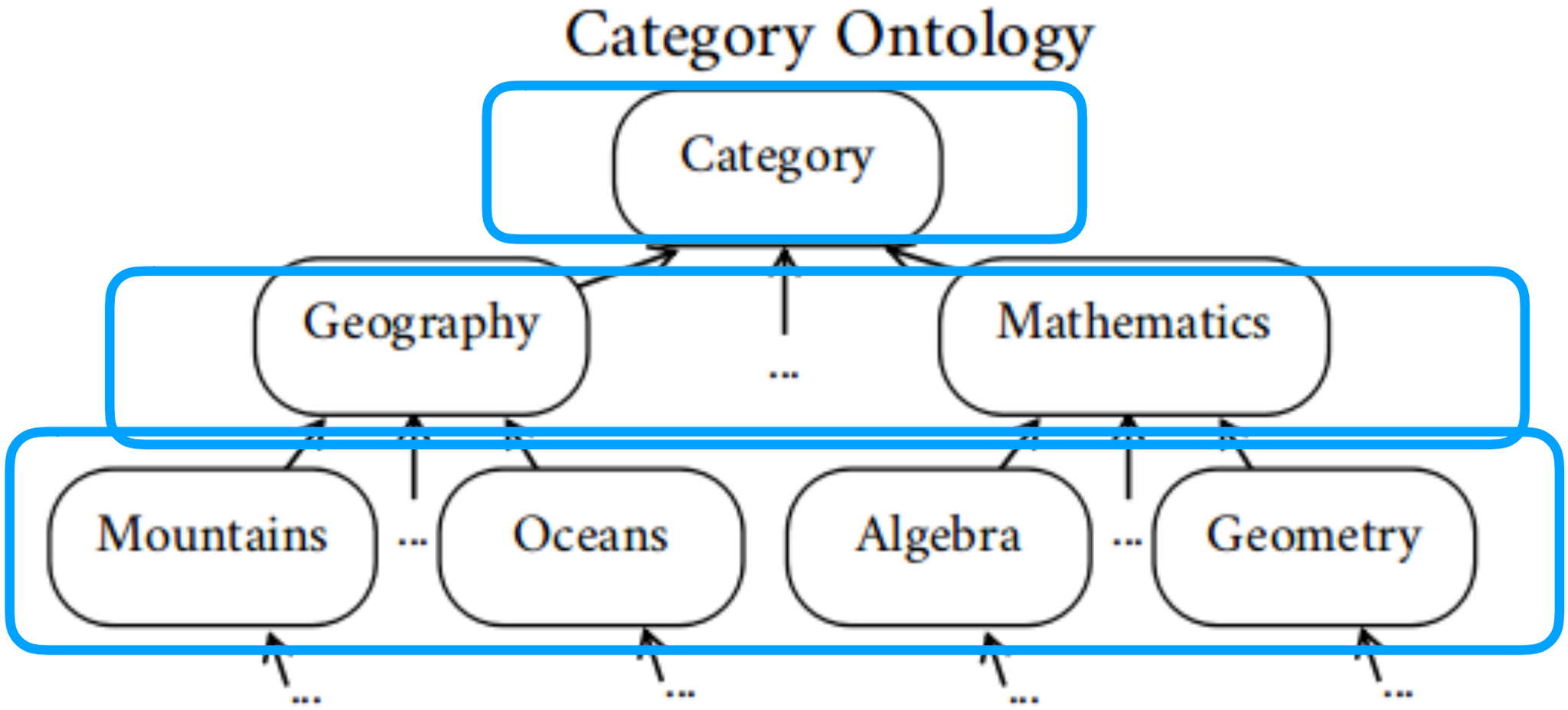
RDF and RDFS Ontologies







TRA and RDFS Ontologies

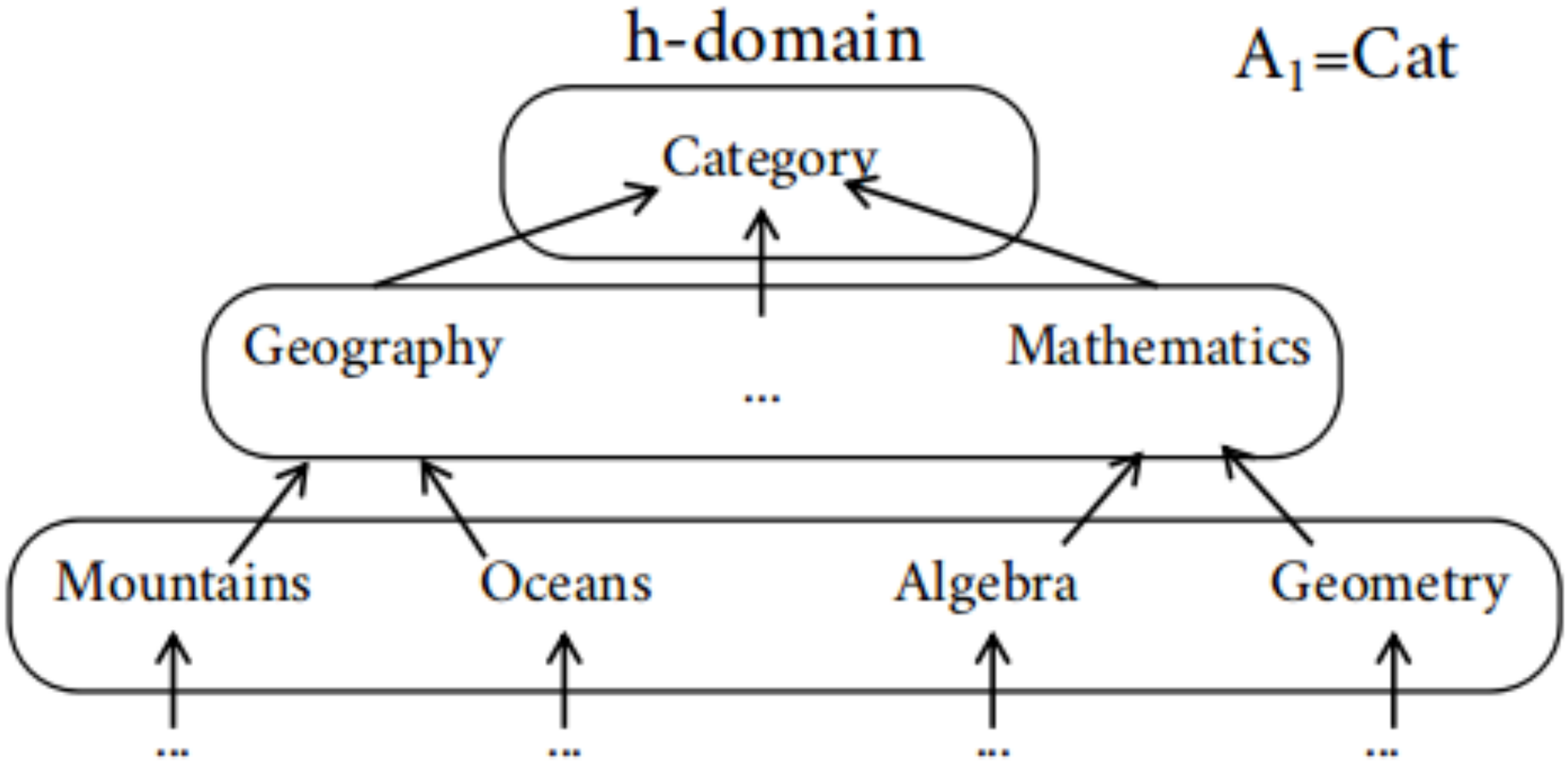


TRA and RDFS Ontologies

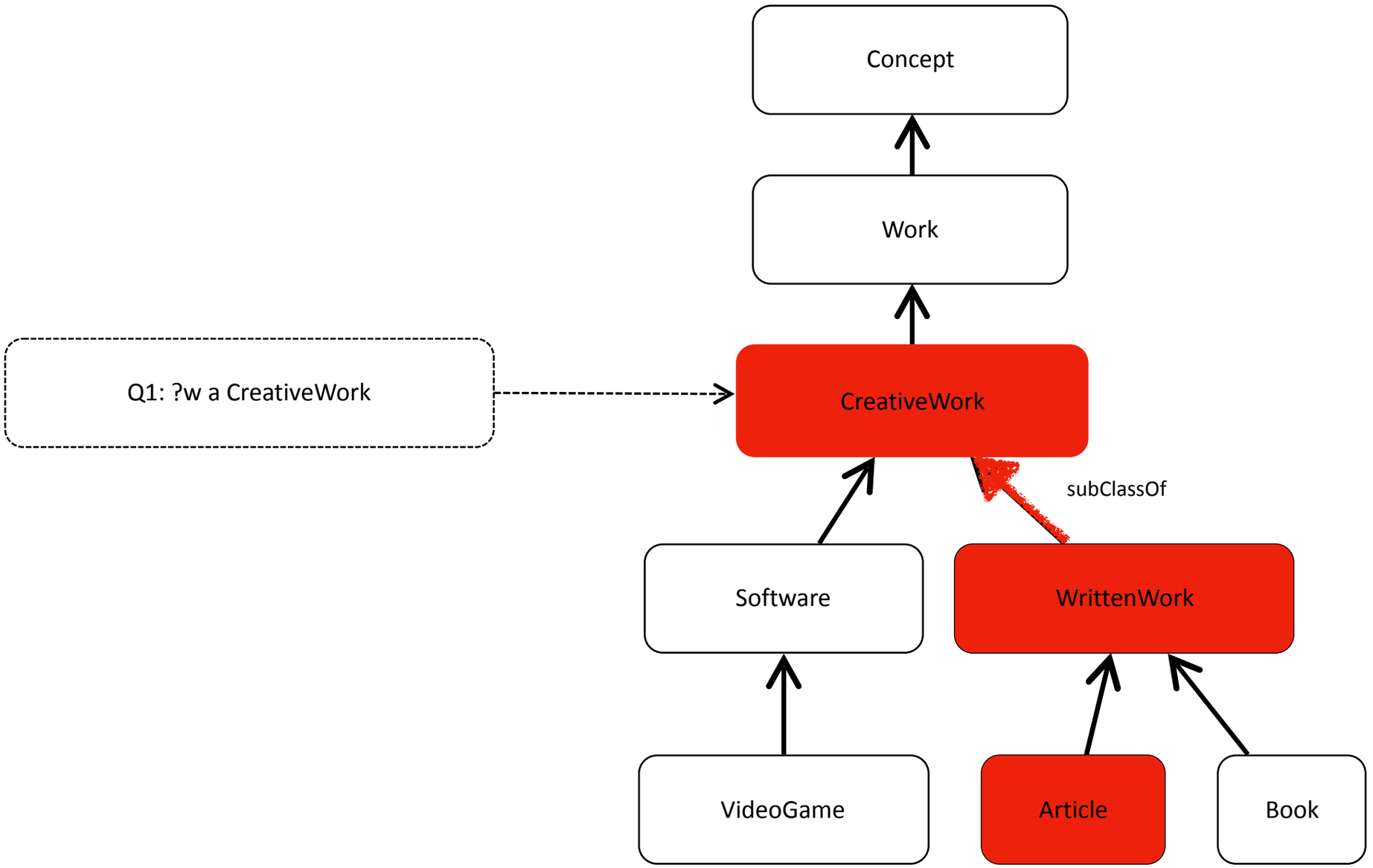
I1

I2

I3



RDF Stream Processing UE



a1 a Article

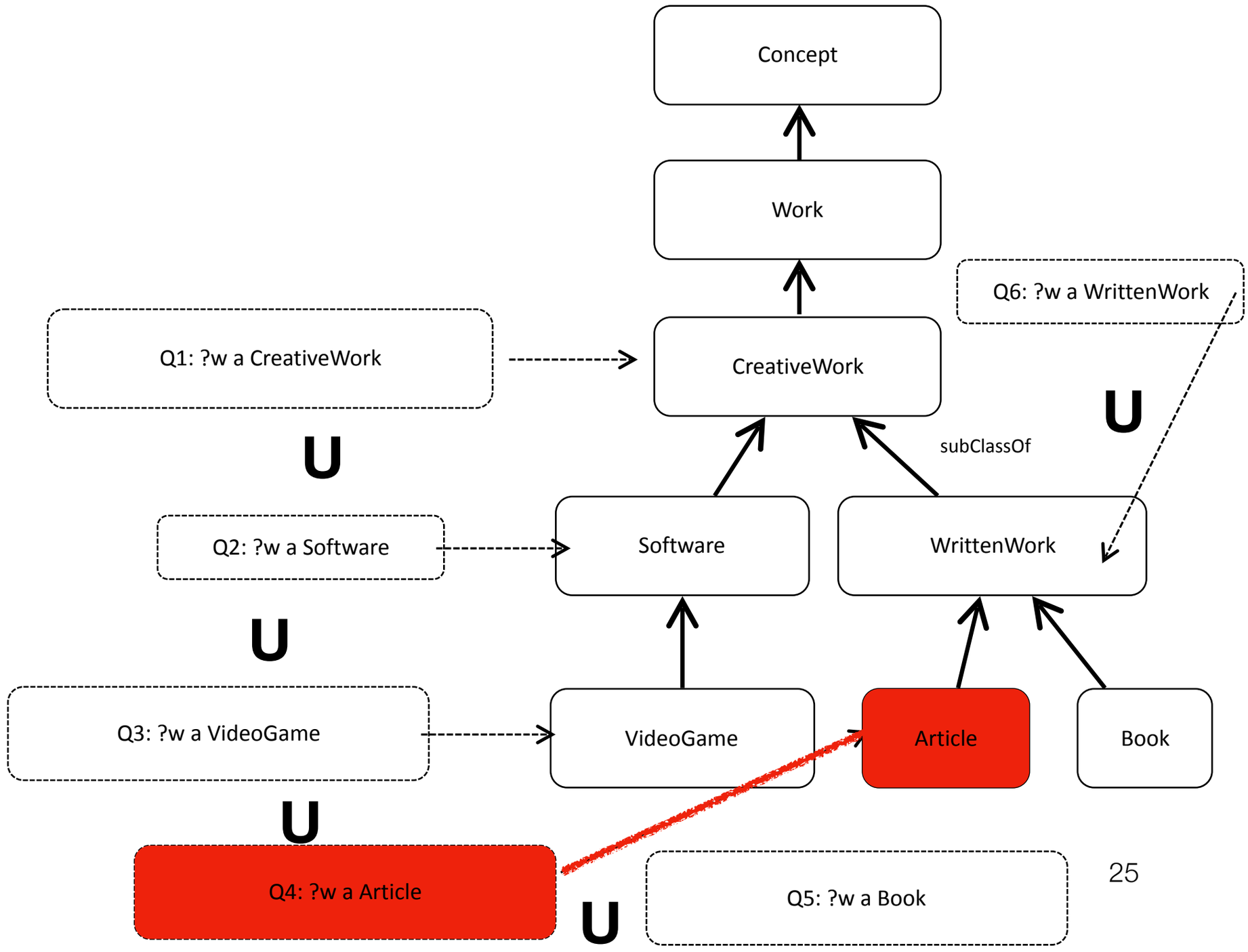
a1 a WrittenWork

a1 a CreativeWork

Materialisation!

RDF Stream Processing UE

a1 a Article



C-Sprite

Algorithm 1 Query registering

Precondition: Q a collections of queries, each interested in one or more types.

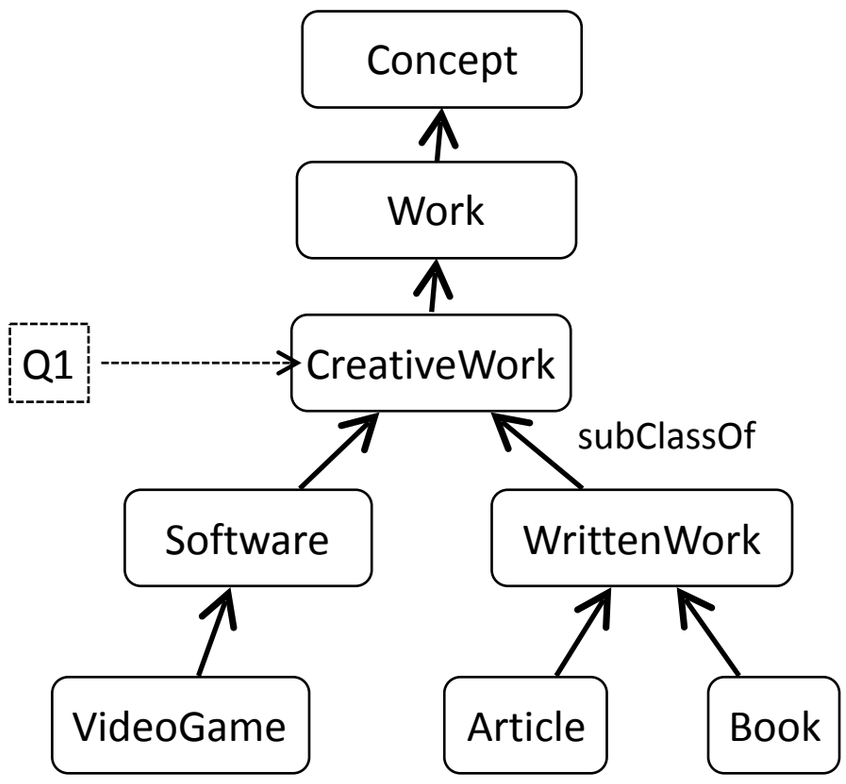
```
1  H ← ConvertToHierarchy(O) ▷ Stores parents for each class in the Ontology O
2  function PrepareHierarchy(H, Q)
3      H' ← []
4      for q ∈ Q do
5          for (concept, parents) ∈ H do
6              if q ∈ parents then
7                  H'[concept].append(q)
8              end if
9          end for
10     end for
11     return H'
12 end function
```

Algorithm 2 Calculate the query matches on a hierarchical level

Precondition: Q a collections of queries, each interested in one or more types.

```
1  H ← ConvertToHierarchy(O) ▷ Stores parents for each class in the Ontology O
   (preprocessing step)
2  H' ← PrepareHierarchy(H, Q)                    ▷ (preprocessing step)
3  triple ← ClassAssertion(type,subject)
4  function CheckHierarchyMatch(H', triple)
5      QueryMatches ← H'(types(triple))   ▷ types extracts the type assertions of a
   triple
6      return QueryMatches
7  end function
```

C-Sprite



Concept: [Concept]

Work: [Work, Concept]

CreativeWork: [CreativeWork, Work, Concept]

WrittenWork: [WrittenWork, CreativeWork, Work, Concept]

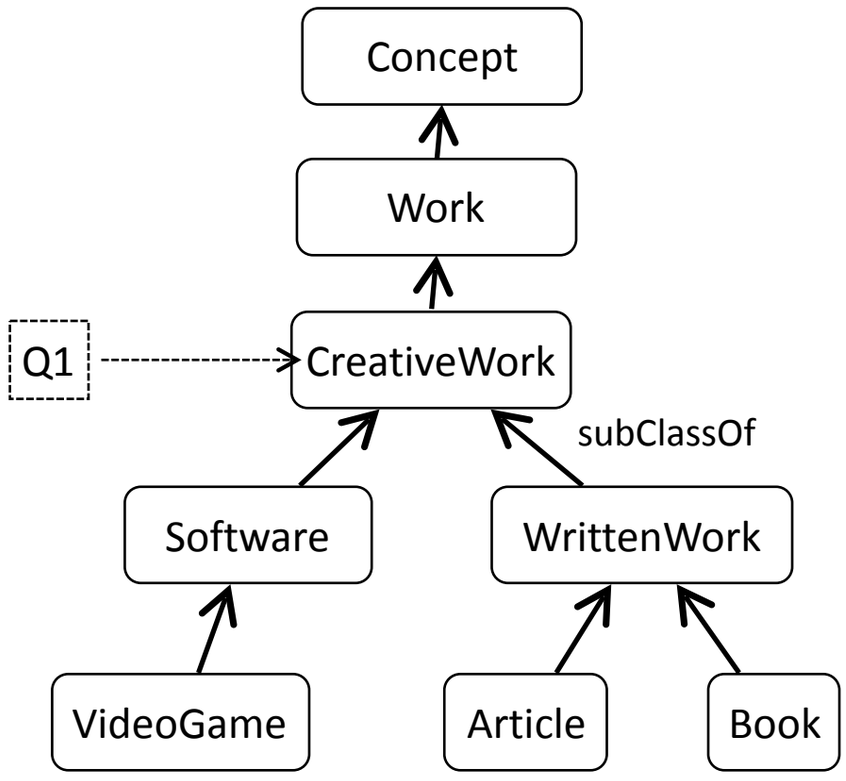
Article: [Article, WrittenWork, CreativeWork, Work, Concept]

Book: [Book, WrittenWork, CreativeWork, Work, Concept]

Software: [Software, CreativeWork, Work, Concept]

VideoGame: [VideoGame, Software, CreativeWork, Work, Concept]

C-Sprite



~~Concept: [Concept]~~

~~Work: [Work, Concept~~]

CreativeWork: [CreativeWork~~, Work, Concept~~]

WrittenWork: [~~WrittenWork,~~ CreativeWork~~, Work, Concept~~]

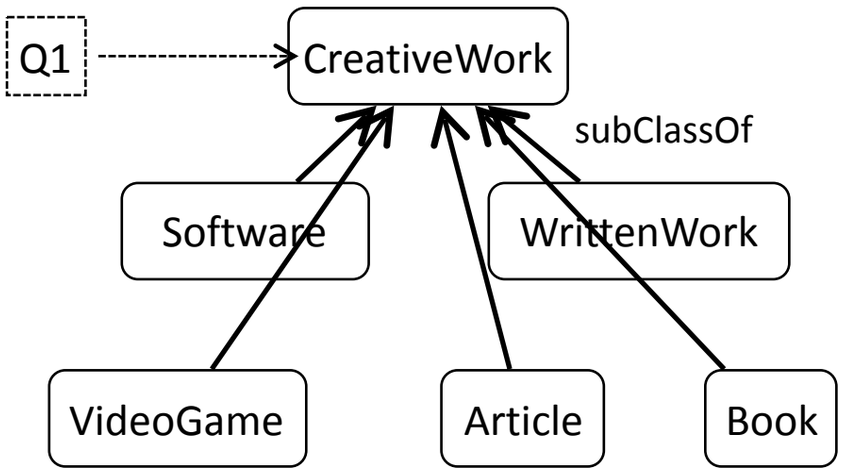
Article: [~~Article, WrittenWork,~~ CreativeWork~~, Work, Concept~~]

Book: [~~Book, WrittenWork,~~ CreativeWork~~, Work, Concept~~]

Software: [~~Software~~, CreativeWork, ~~Work, Concept~~]

VideoGame: [~~VideoGame, Software,~~ CreativeWork~~, Work, Concept~~]

C-Sprite



~~Concept: [Concept]~~

~~Work: [Work, Concept~~]

CreativeWork: [CreativeWork~~, Work, Concept~~t]

WrittenWork: [~~WrittenWork,~~ CreativeWork~~, Work, Concept~~]

Article: [~~Article, WrittenWork,~~ CreativeWork~~, Work, Concept~~]

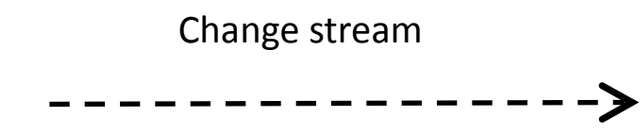
Book: [~~Book, WrittenWork,~~ CreativeWork~~, Work, Concept~~]

Software: [~~Software~~, CreativeWork,~~ Work, Concept~~]

VideoGame: [~~VideoGame, Software,~~ CreativeWork~~, Work, Concept~~]

Evaluation

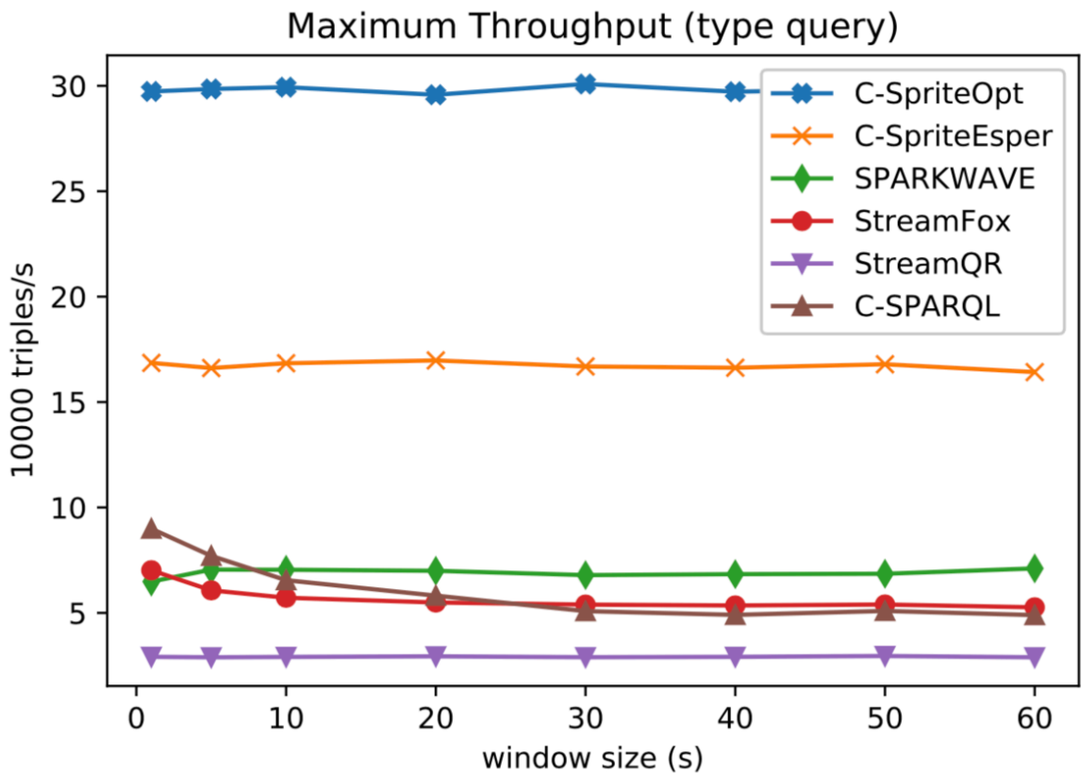
Change stream

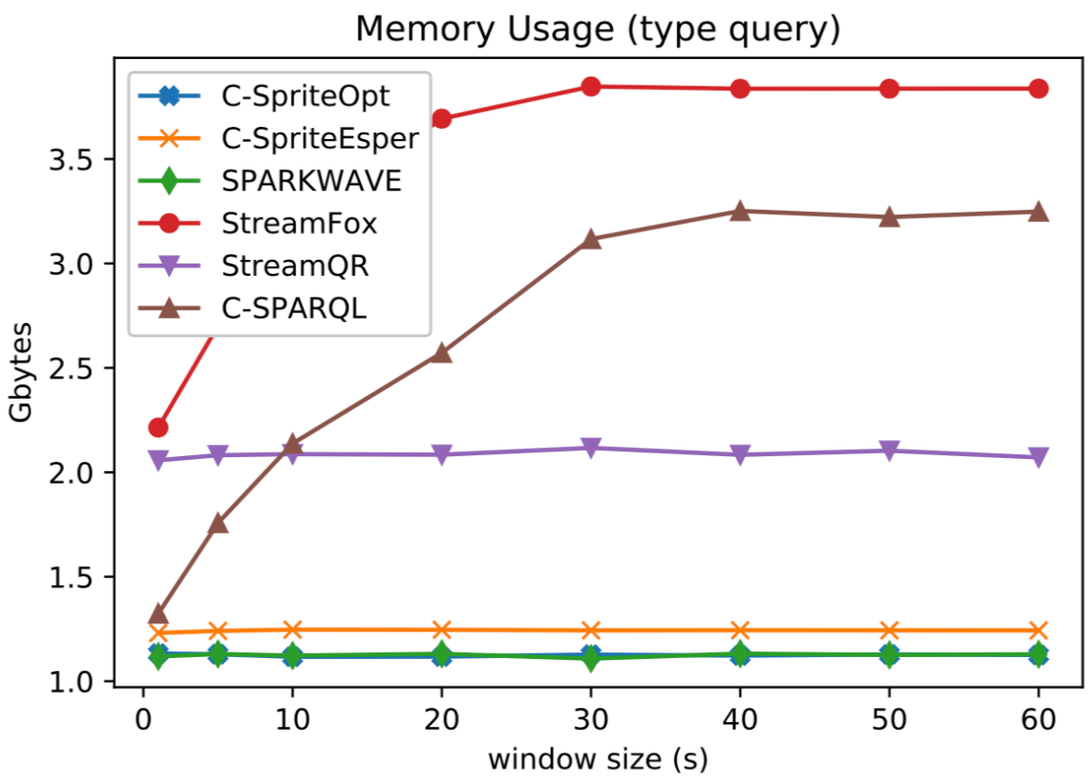


Q1: ?w a CreativeWork

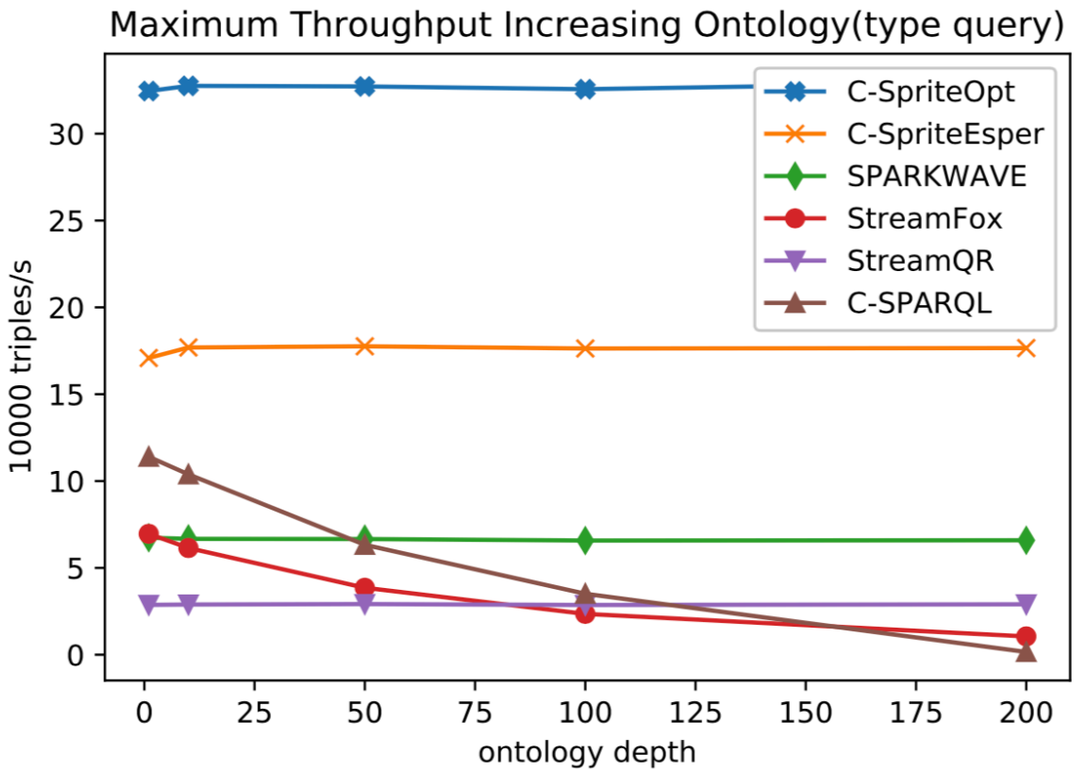
	Absolute Number	Relative Number
all triples	3.511.629	100%
Creative Works	56.581	1,61%
Top 5 Creative Works:		
MusicalWork	21.438	0,61%
Film	13.890	0,40%
WrittenWork	6.814	0,19%
TelevisionShow	4.579	0,13%
Software	4.493	0,13%

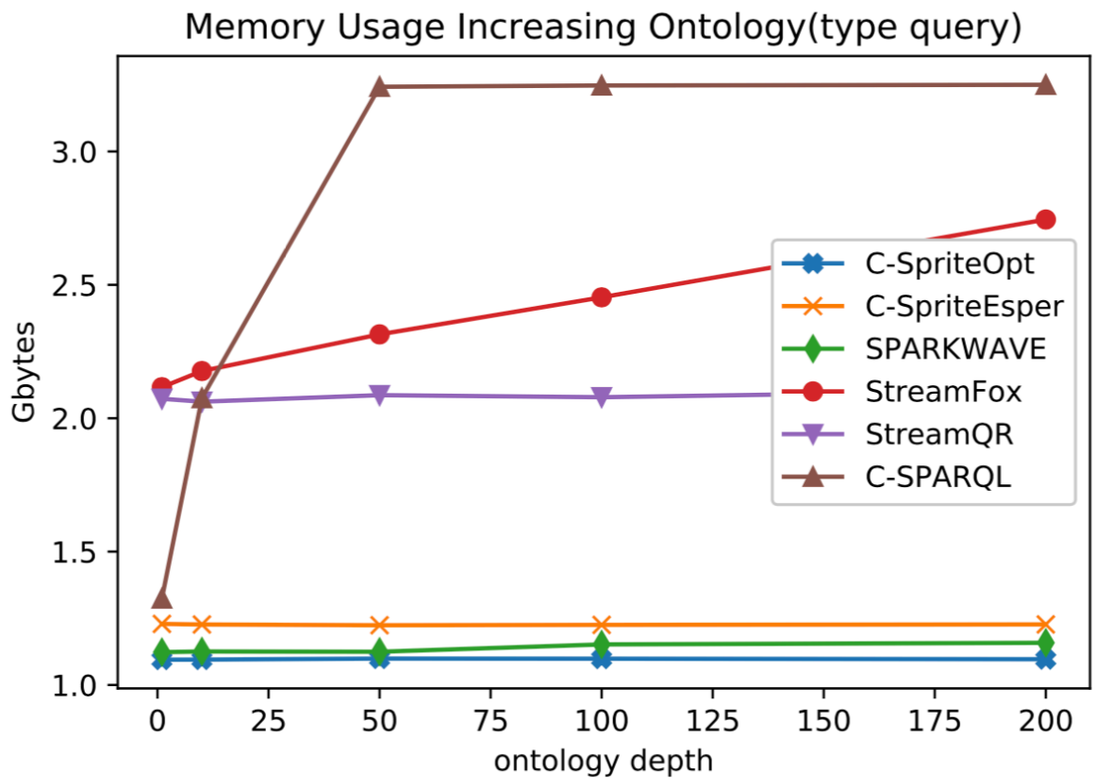
Evaluation: Increasing window size





Evaluation: Increasing ontology depth





Future Work

- TRA @ Apache Spark

- Query Containment

Questions?

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- **Web1**: riccardotommasini.com
- **Web2:** streamreasoning.org
- **Web3:** **streaminglang.io**