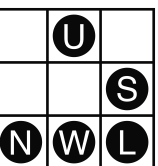


A Query Model for Ontology Based Event Processing on RDF Streams

DEBS - 26.06.2019

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

Pieter Bonte, Riccardo Tommasini,
Filip De Turck, Femke Ongenae, Emanuele Della Valle



Authors



That Asks Complex Questions

Who is driving event in the news right now?

Is public transportation where the people are?

Who are the best agents to route all these unexpected contacts about the tariff plan launched yesterday?

What is the expected time to failure when a turbine's barring starts to vibrate as detected in the last 10 minutes?

Enrich the Streams



Crossing the Streams



Issues

- Need to manually reconfigure queries that produced the incorrect results
- Need to manually reconfigure system adapting sources and hard-coded values
- Need to maintain such complex systems once you have it!

Scalability

Alert

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

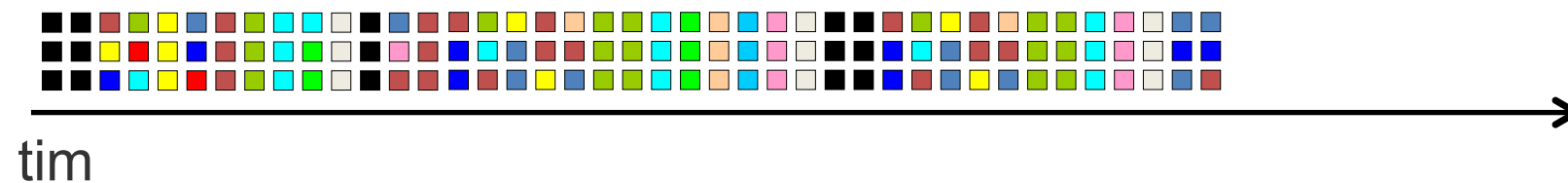
Is there a **primary cool** colour followed by a **secondary warm** one in the last minute

( , 13), ( , 8) , ( , 8)

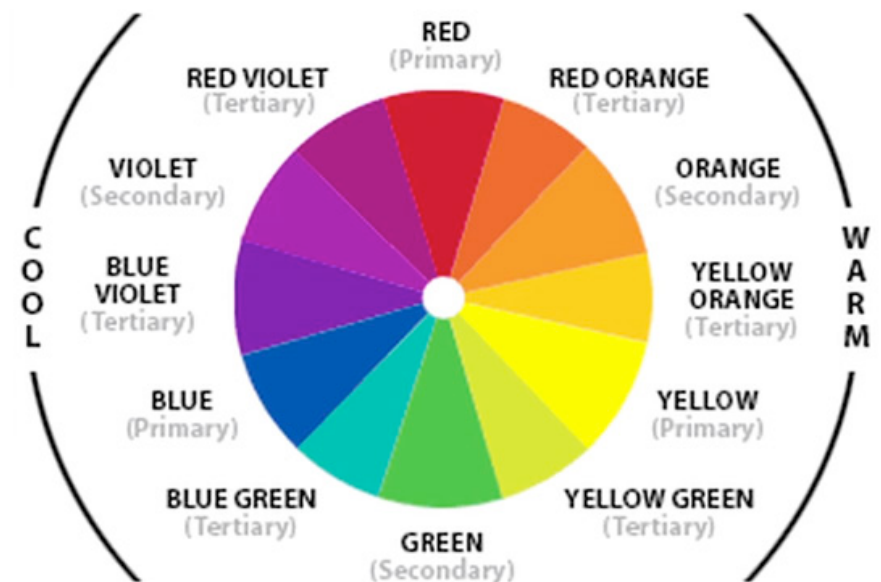
Which are the top-2 most frequent **cool** colours in the last minute?

yes,  followed by 

1 minute wide window

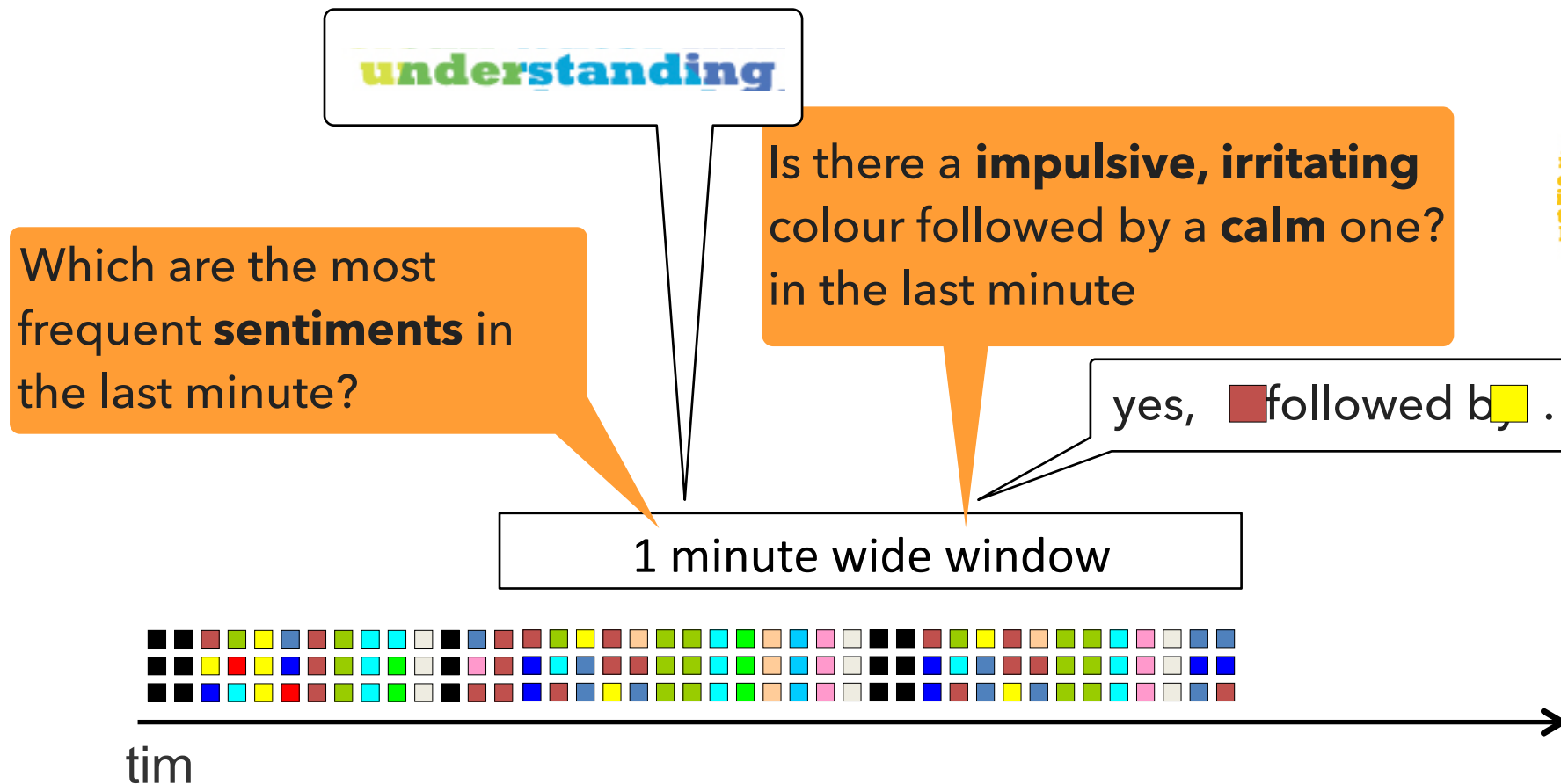


An ontology of



Stream Reasoning

A different
ontology (of colours)

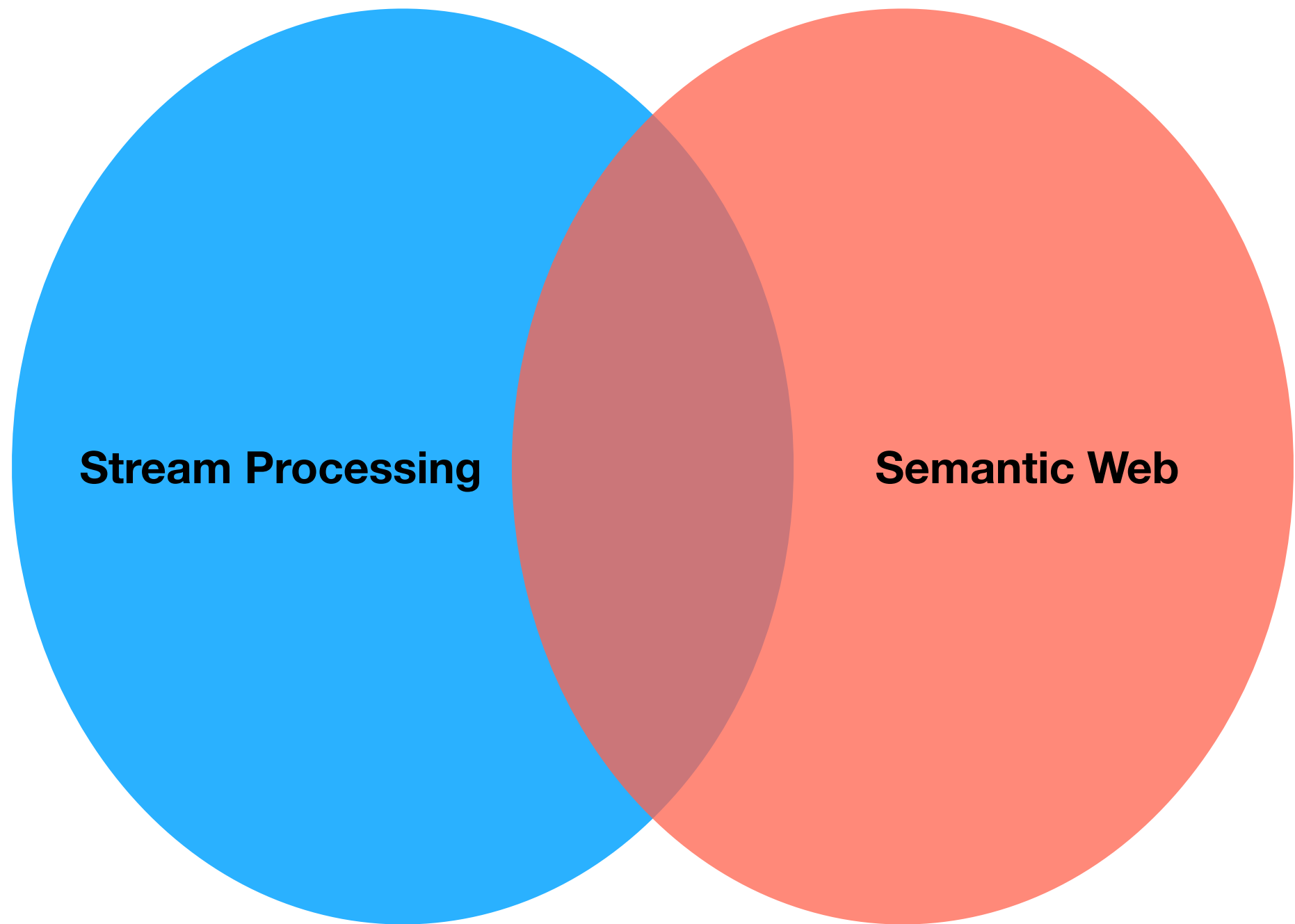


balance
strength
controversy
energy activity appetite social-
ization blood heat vigor passionate
intense fierce love danger exciting
strength irritating lips hearts sexy ro-
mance sensuality impulsive leadership
courage competence independence orga-
nization self-motivation spirituality plea-
sure vitality will to win survival instinct intu-
ition entrepreneurial desire fire stimulation
joy rage sunshine tropical enthusiasm fasci-
nation happiness creativity attraction success
citrus endurance illumination wisdom wealth
intellect loyalty freshness growth harmony fer-
tility safety money vision experience novice
hope nature finance ambition greed jealousy
healing protection peace sky sea depth trust
confidence faith truth heaven mind tranquil-
ity calm sincerity clean water mineral preci-
sion expertise understanding softness
knowledge power royalty nobility luxury
extravagance dignity mystery magic arti-
ficial nostalgia gloom frustration light
goodness innocence purity perfec-
tion positive beginning cool sim-
plicity charity angels sterility el-
egance formality evil fear
unknown feeling author-
ity prestige grief
harmony

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)



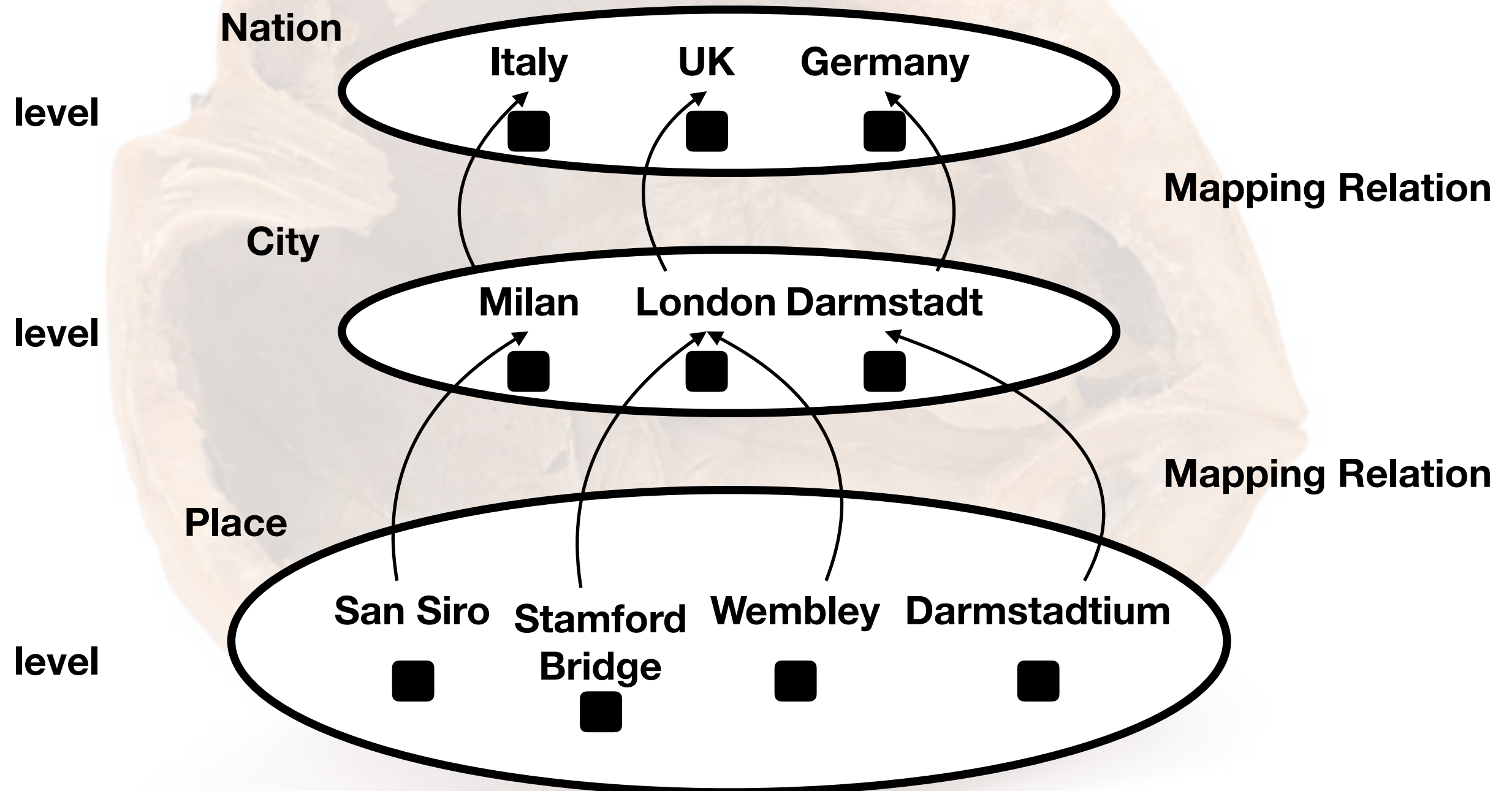
Research Question

- (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

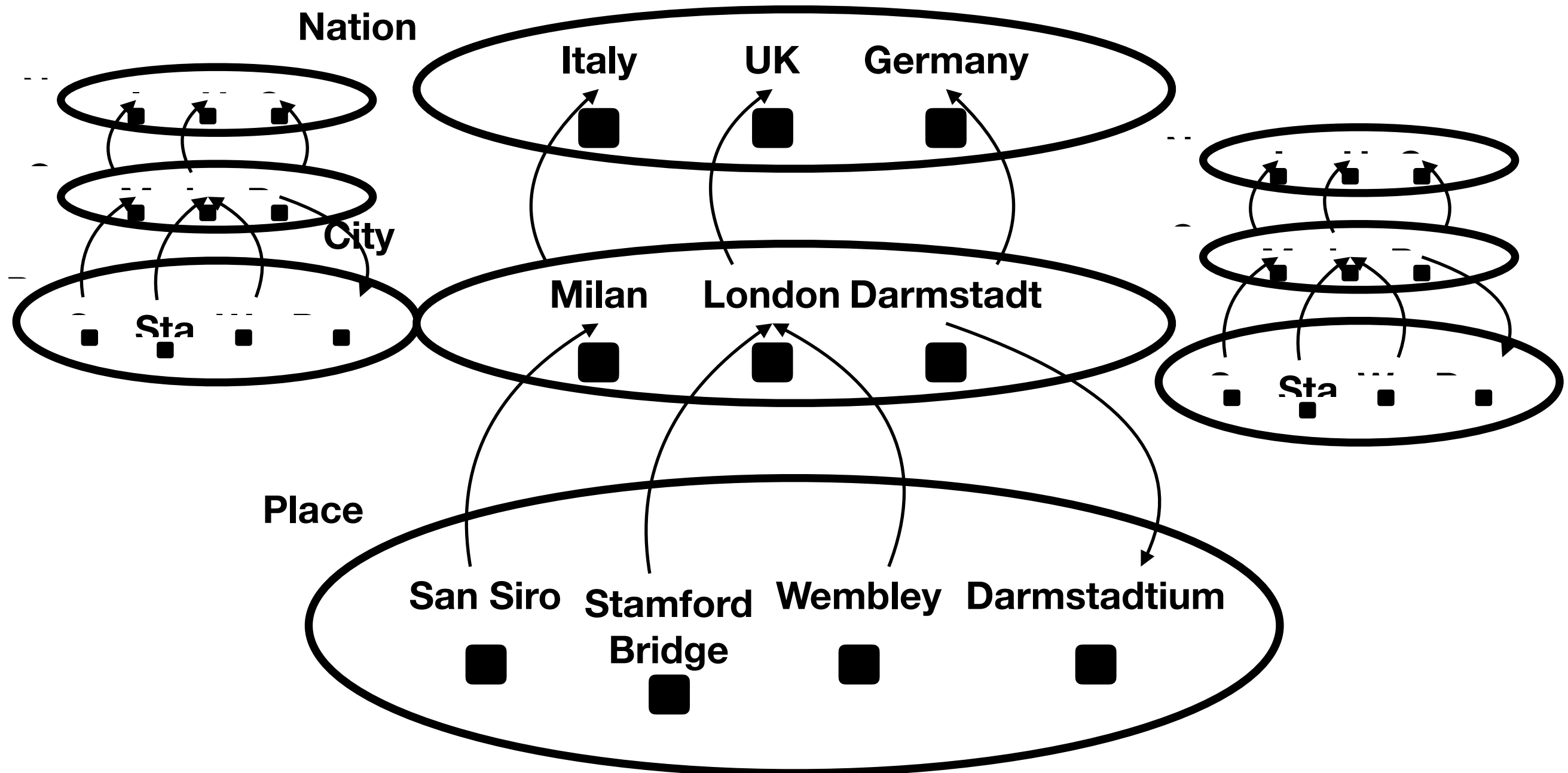
Contributions

- 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



taxonomy



T-Schema & T-Relation

Type table

	Subject	obs:l2
t_a	obs_x	WeatherObservation
t_b	obs_y	GeometryObservation

a)

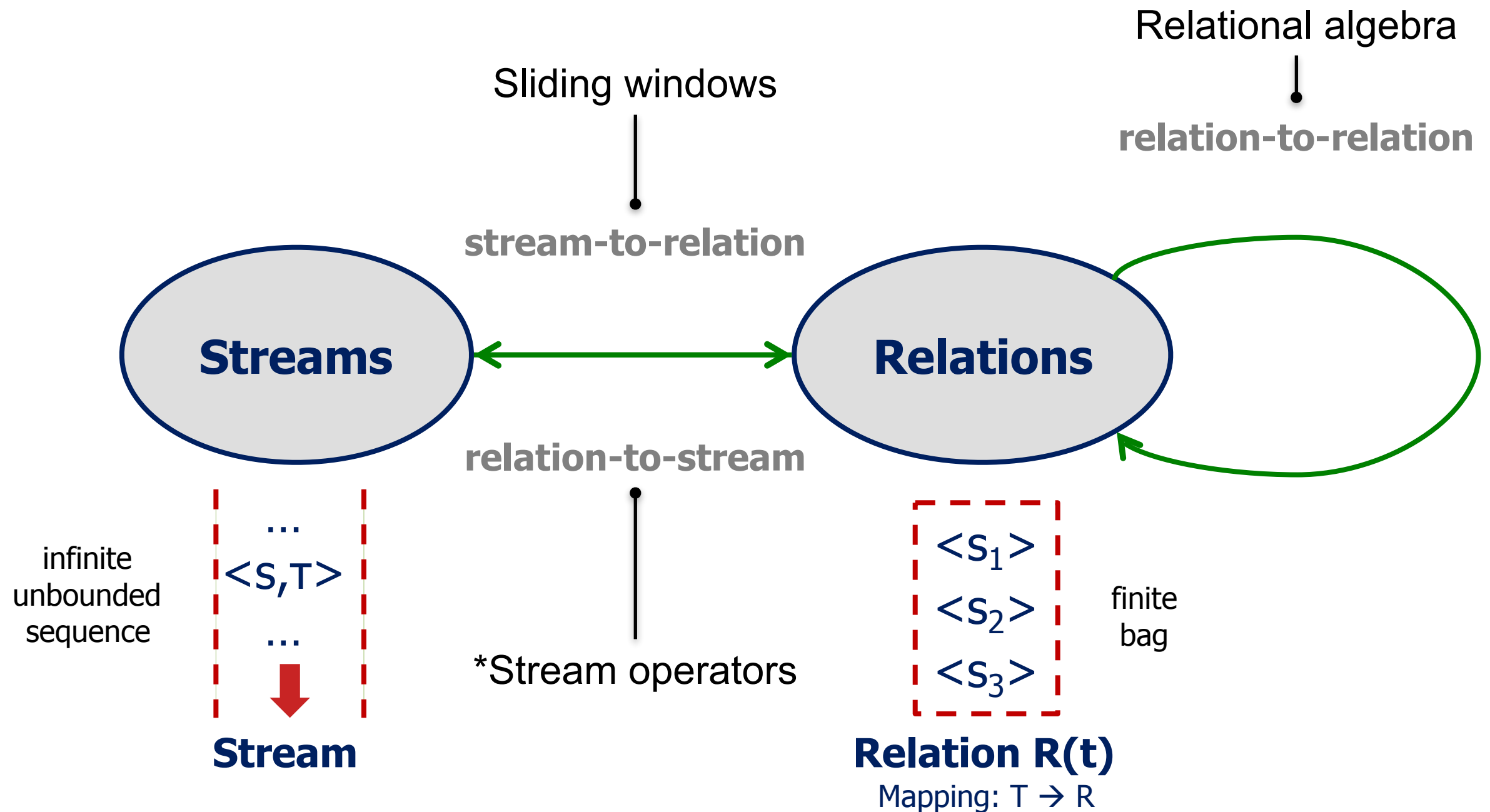
$\epsilon_{obs:l2}^{obs:l1}$
→

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

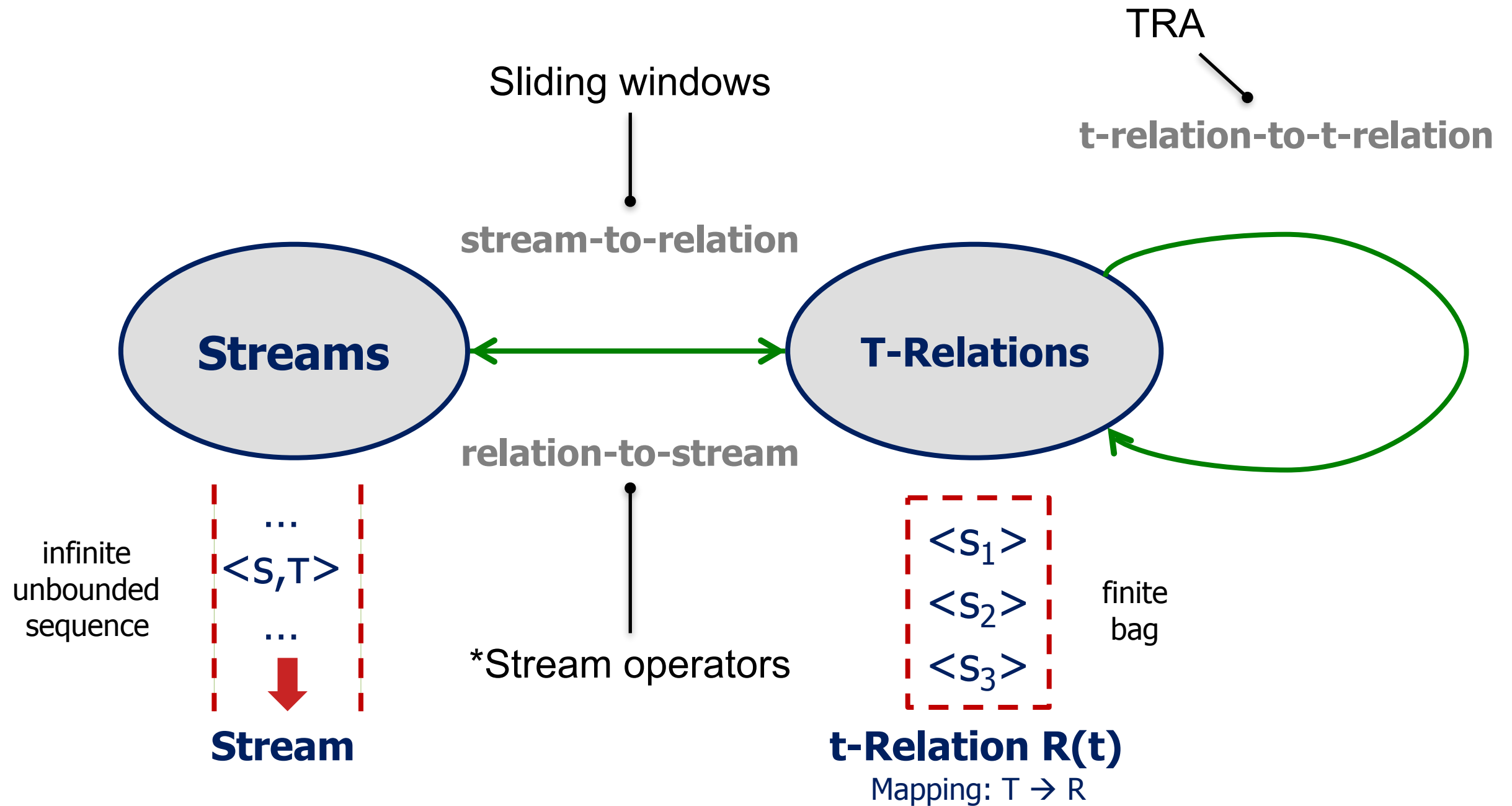
b)

upward extension

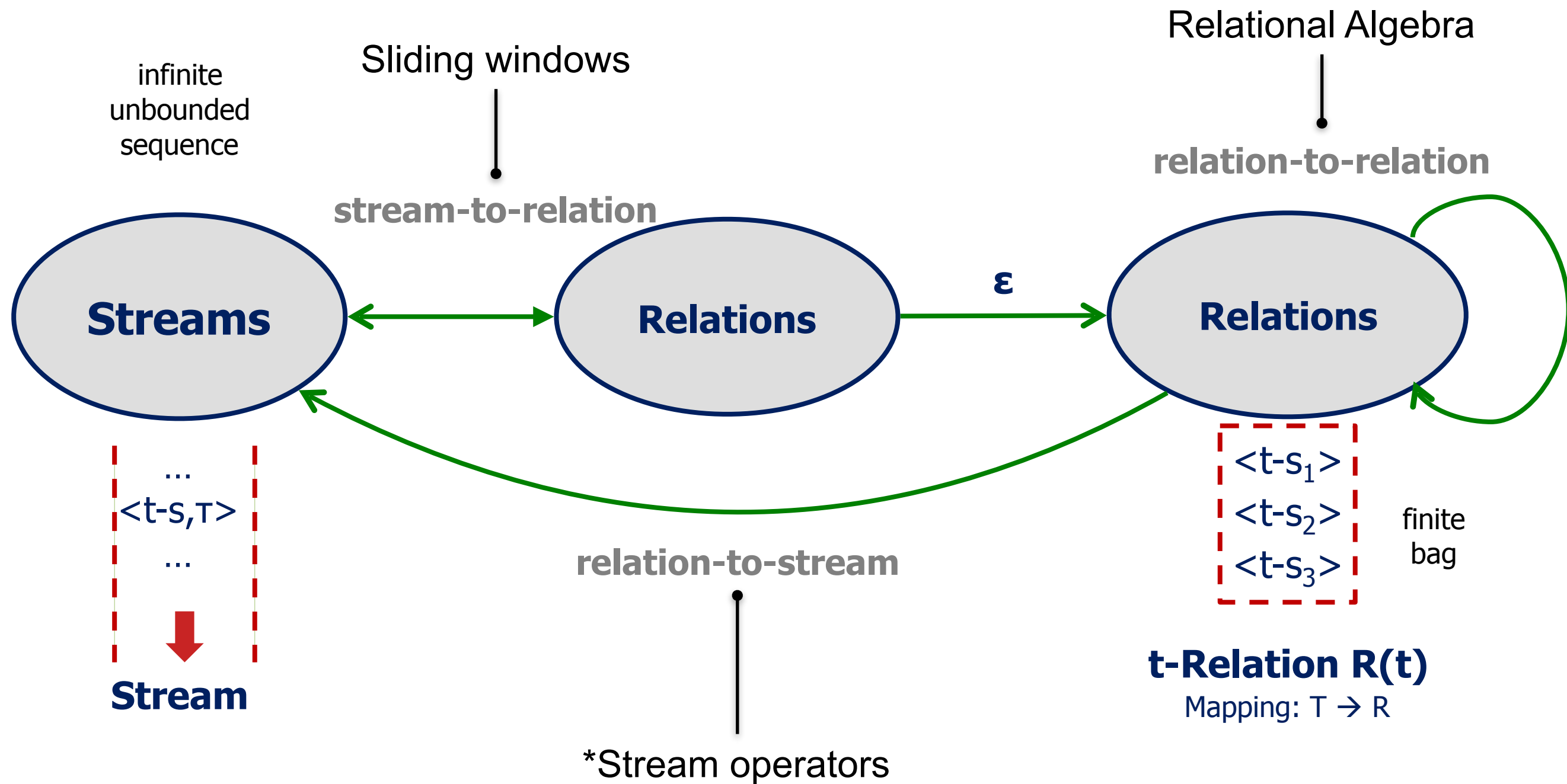
The CQL model

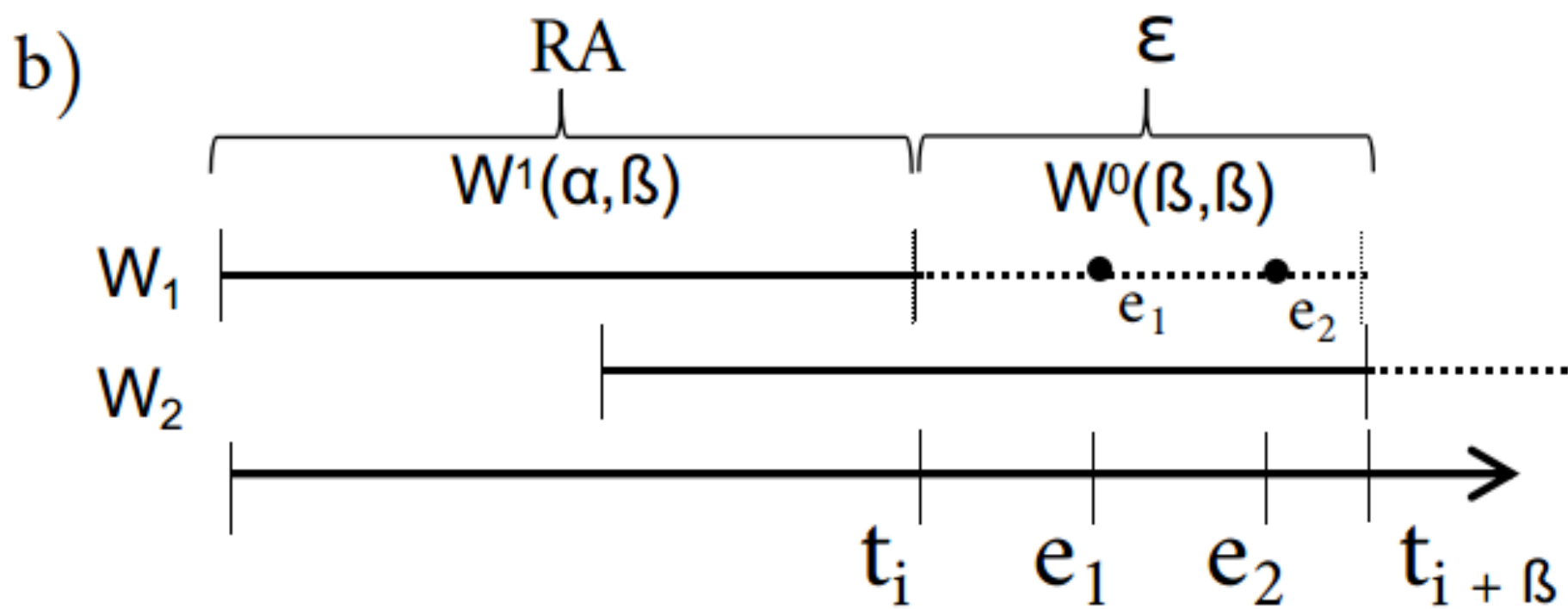
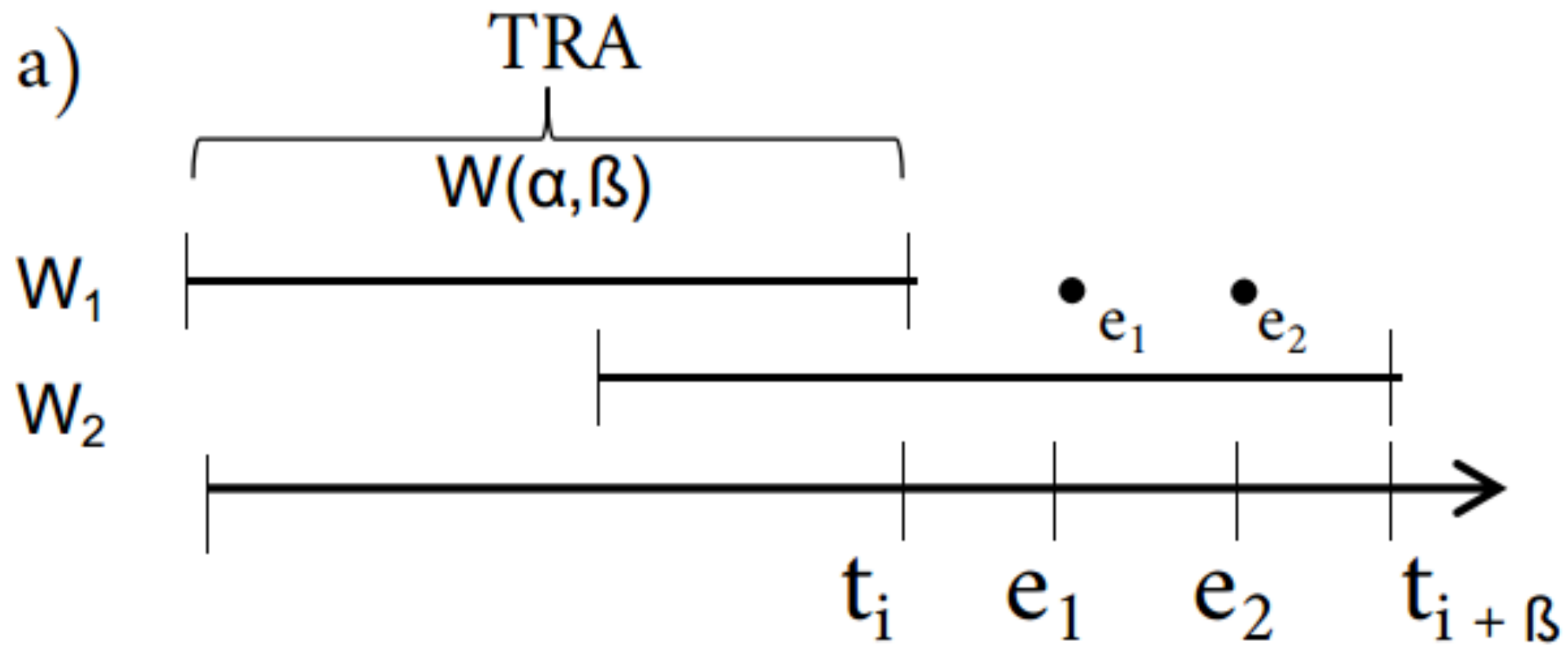


The CTQL model

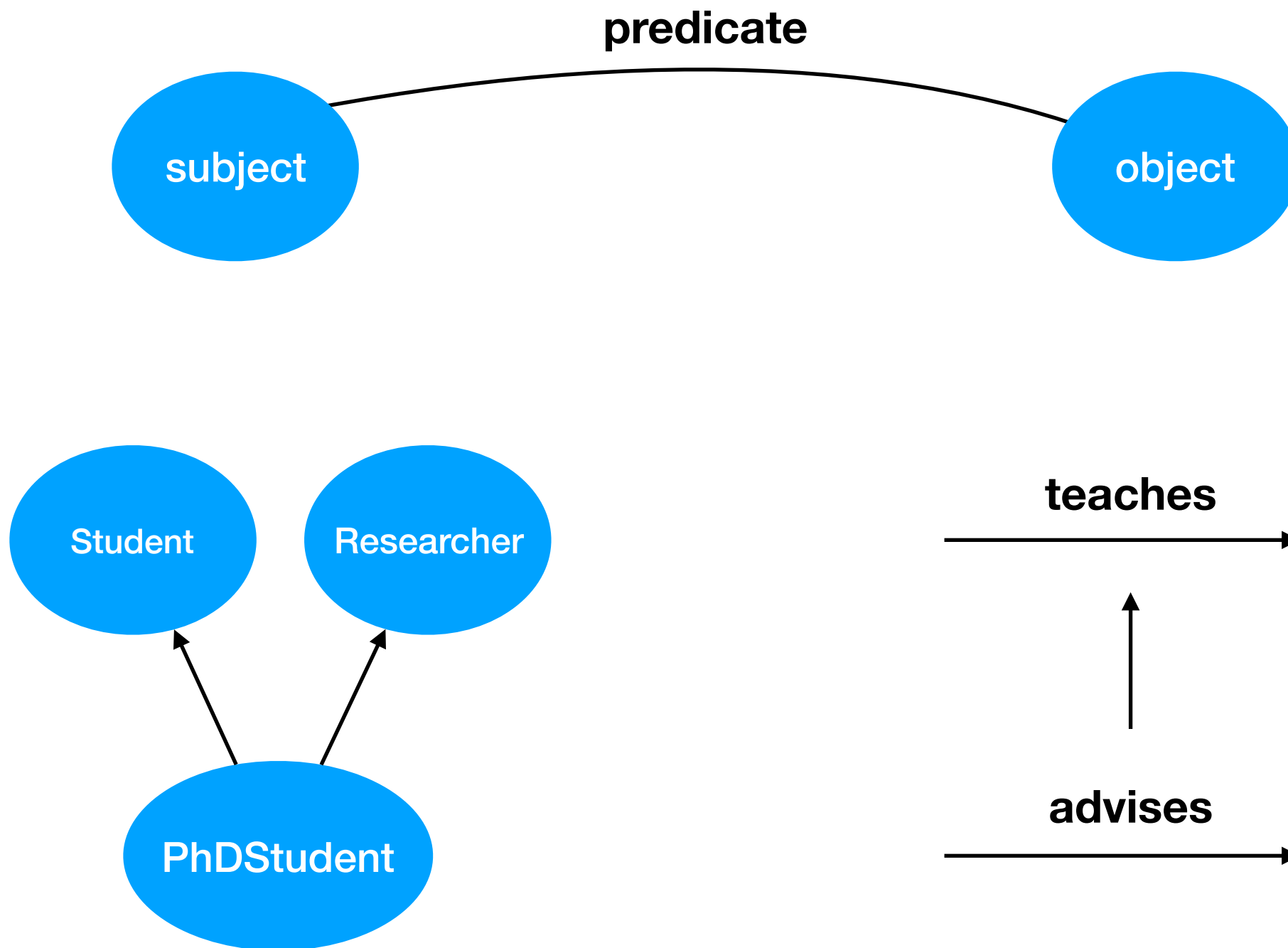


The CTQL model

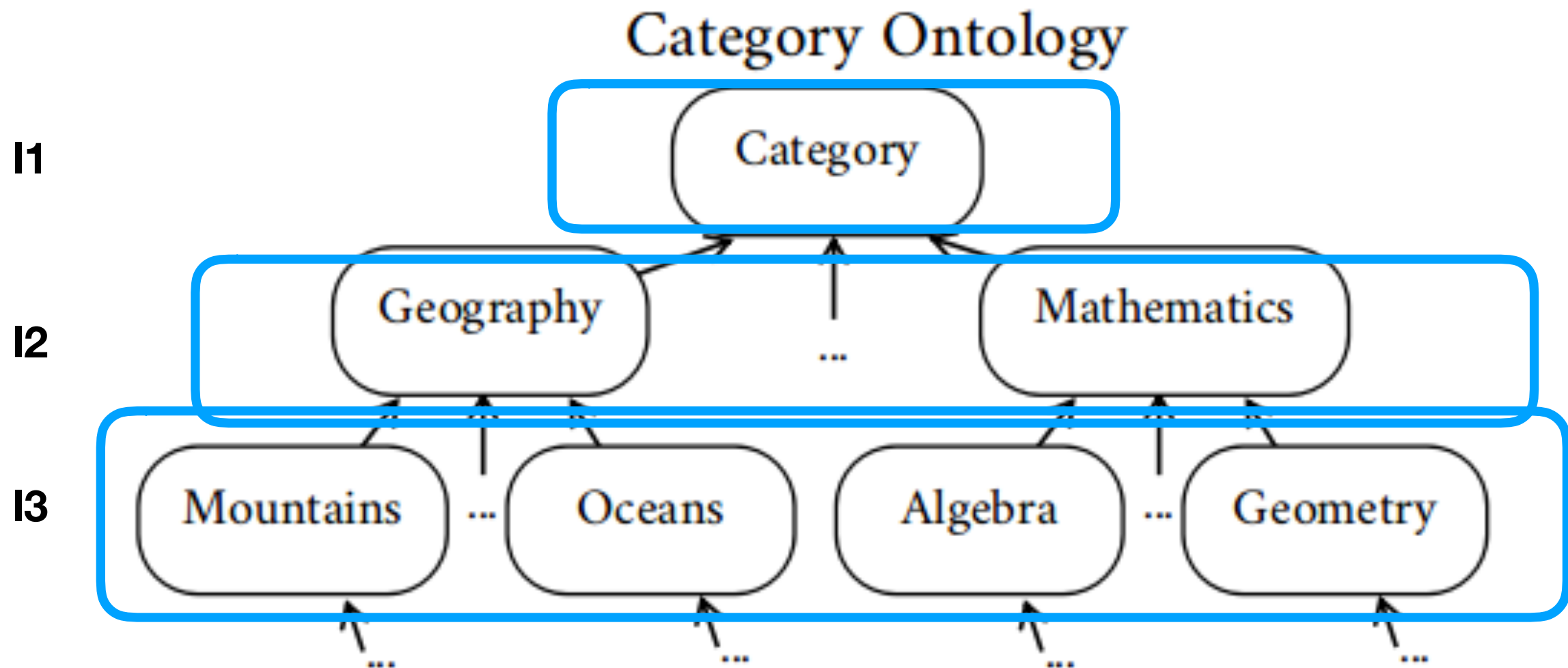




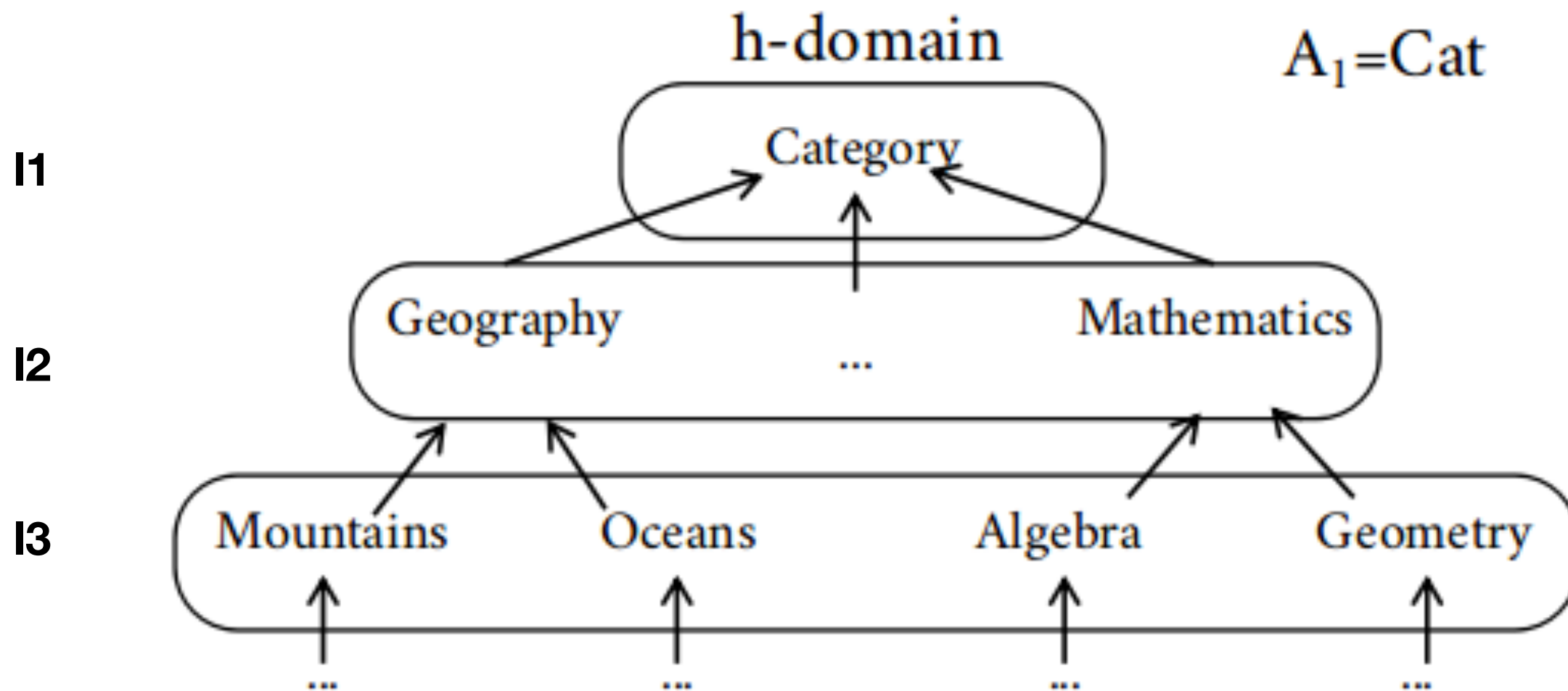
RDF and RDFS Ontologies



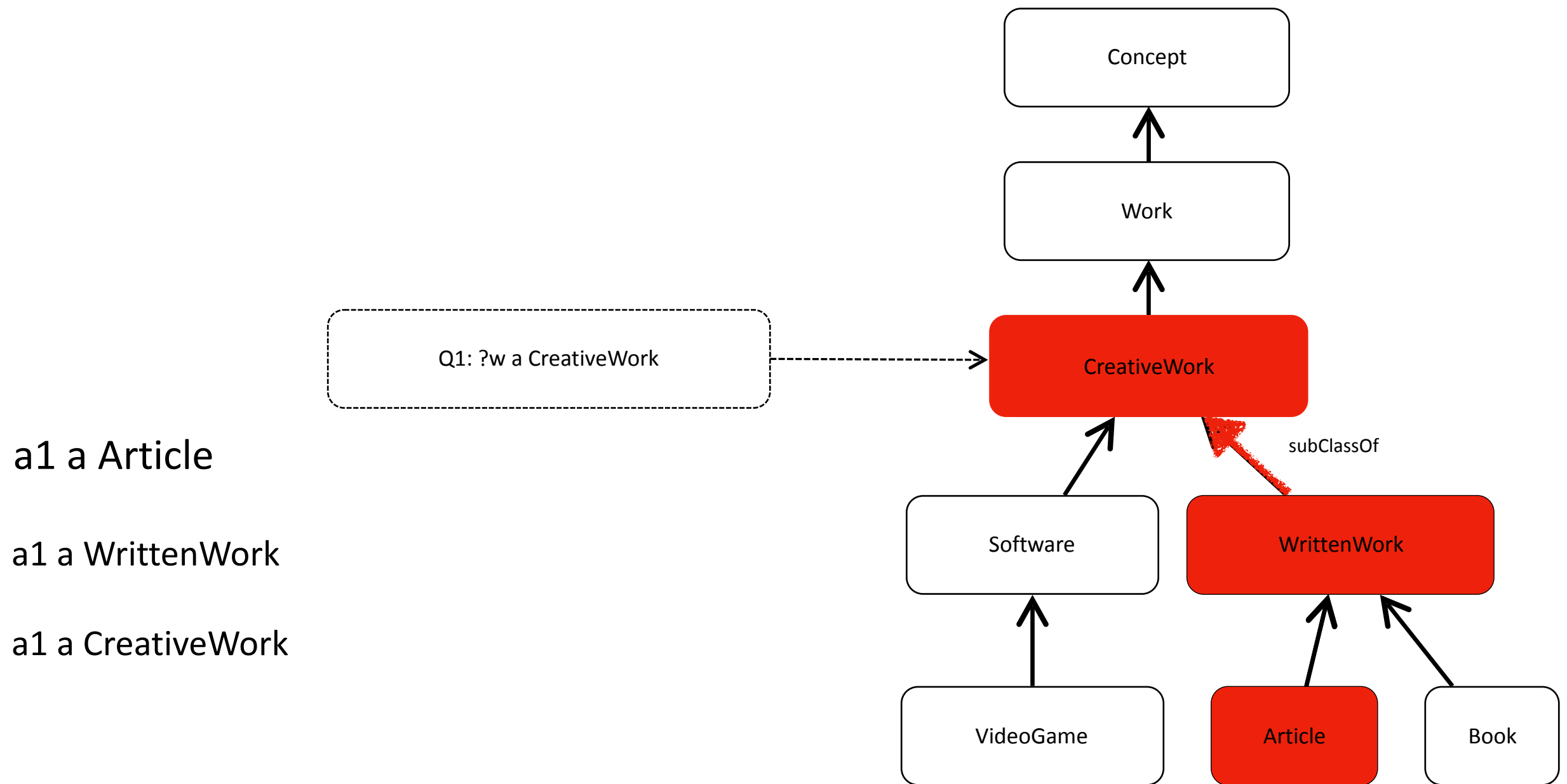
TRA and RDFS Ontologies



TRA and RDFS Ontologies

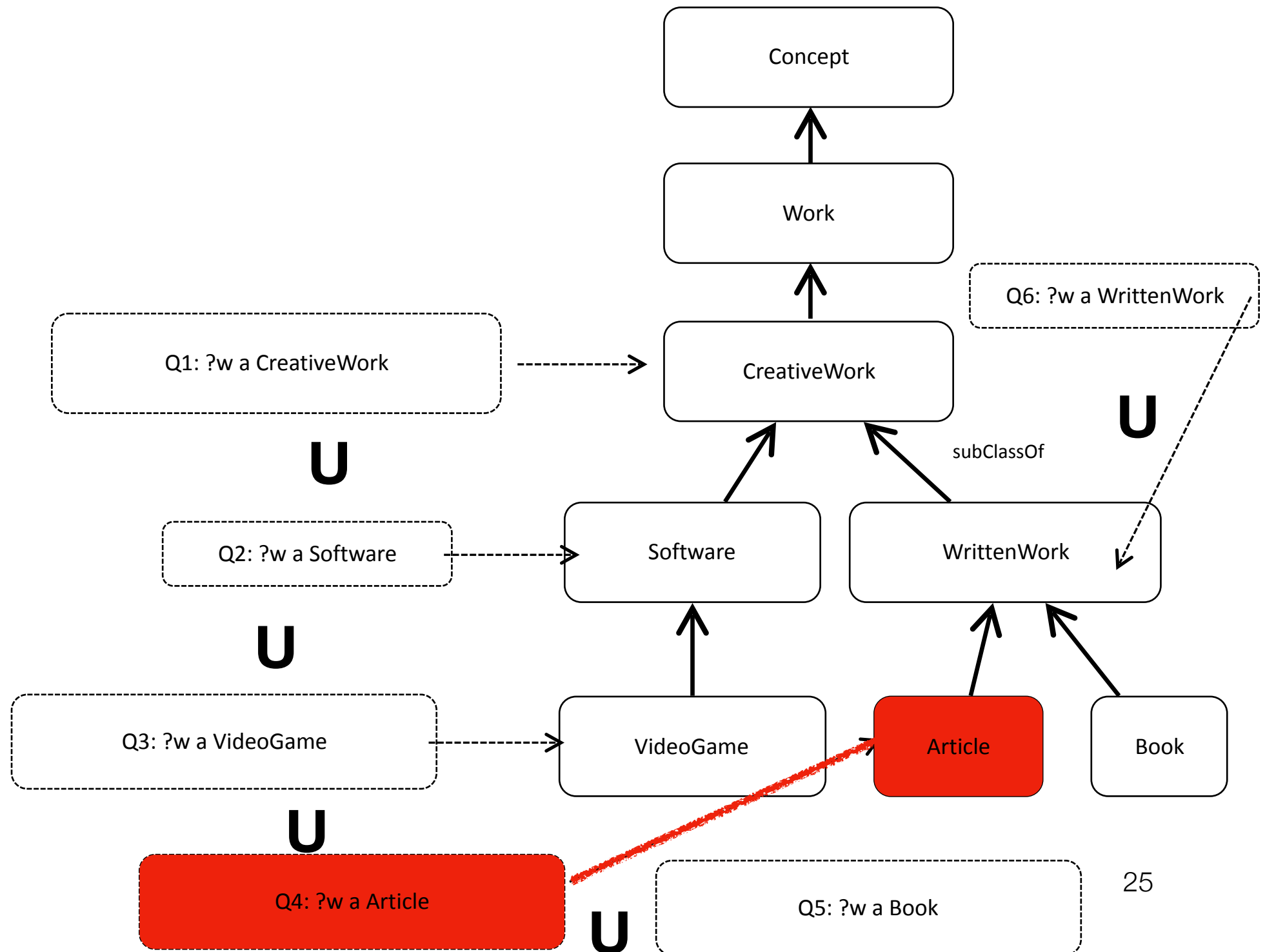


RDF Stream Processing UE



Materialisation!

RDF Stream Processing UE



C-Sprite

Algorithm 1 Query registering

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

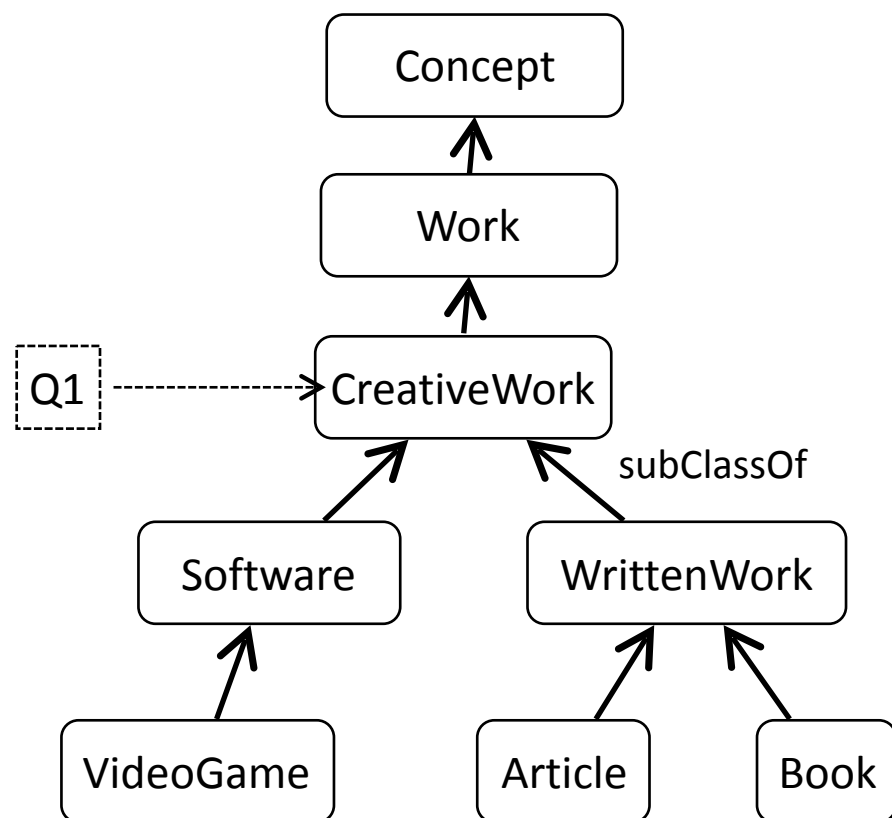
```
1  $H \leftarrow \text{ConvertToHierarchy}(O)$   $\triangleright$  Stores parents for each class in the Ontology  $O$ 
2 function PREPAREHIERARCHY( $H, Q$ )
3    $H' \leftarrow []$ 
4   for  $q \in Q$  do
5     for  $(\text{concept}, \text{parents}) \in H$  do
6       if  $q \in \text{parents}$  then
7          $H'[\text{concept}].\text{append}(q)$ 
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  $H \leftarrow \text{ConvertToHierarchy}(O)$   $\triangleright$  Stores parents for each class in the Ontology  $O$ 
   (preprocessing step)
2  $H' \leftarrow \text{PrepareHierarchy}(H, Q)$   $\triangleright$  (preprocessing step)
3  $\text{triple} \leftarrow \text{ClassAssertion}(\text{type}, \text{subject})$ 
4 function CHECKHIERARCHYMATCH( $H', \text{triple}$ )
5    $\text{QueryMatches} \leftarrow H'(\text{types}(\text{triple}))$   $\triangleright$  types extracts the type assertions of a
   triple
6   return  $\text{QueryMatches}$ 
7 end function
```

C-Sprite



Concept: [Concept]

Work: [Work, Concept]

CreativeWork: [CreativeWork, Work, Concept]

WrittenWork: [WrittenWork, CreativeWork, Work, Concept]

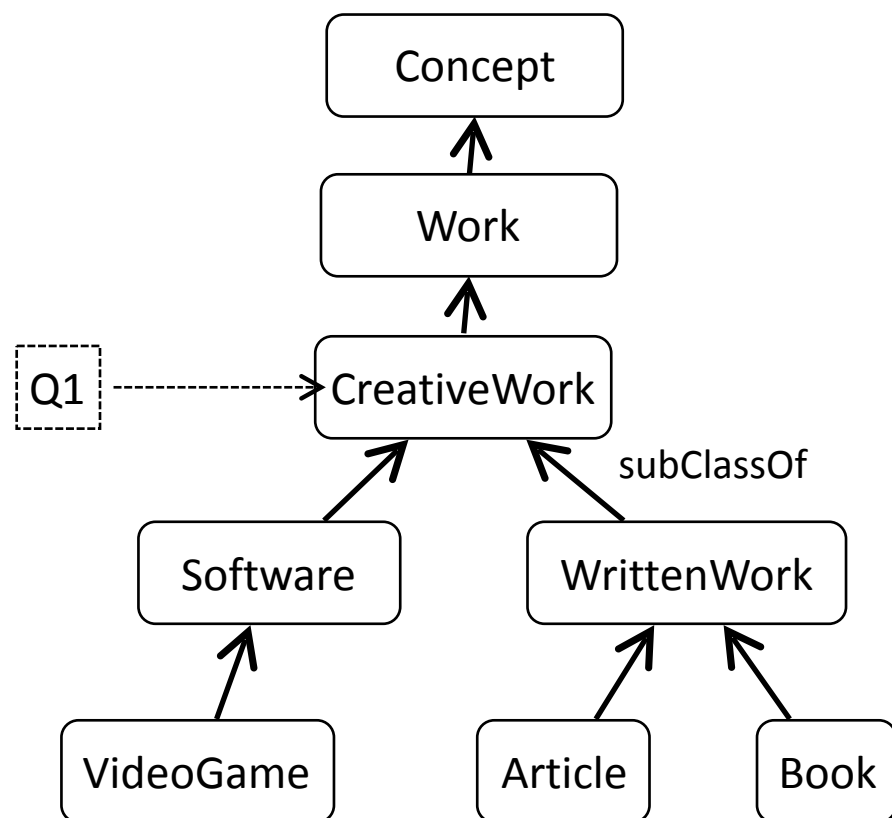
Article: [Article, WrittenWork, CreativeWork, Work, Concept]

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~~

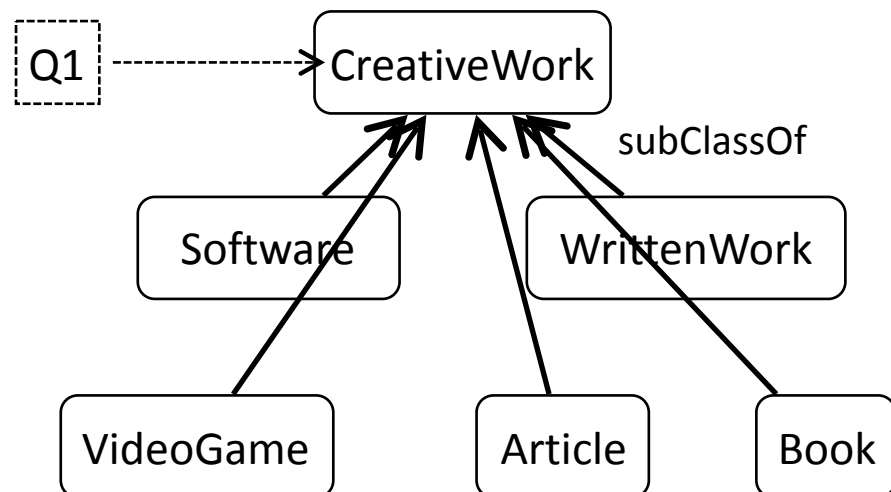
Article: ~~Article, WrittenWork, CreativeWork, Work, Concept~~

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~~

WrittenWork: ~~WrittenWork, CreativeWork, Work, Concept~~

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

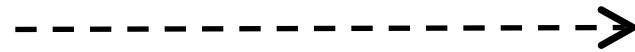
Book: ~~Book, WrittenWork, CreativeWork, Work, Concept~~

Software: ~~Software, CreativeWork, Work, Concept~~

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

Evaluation

Change stream

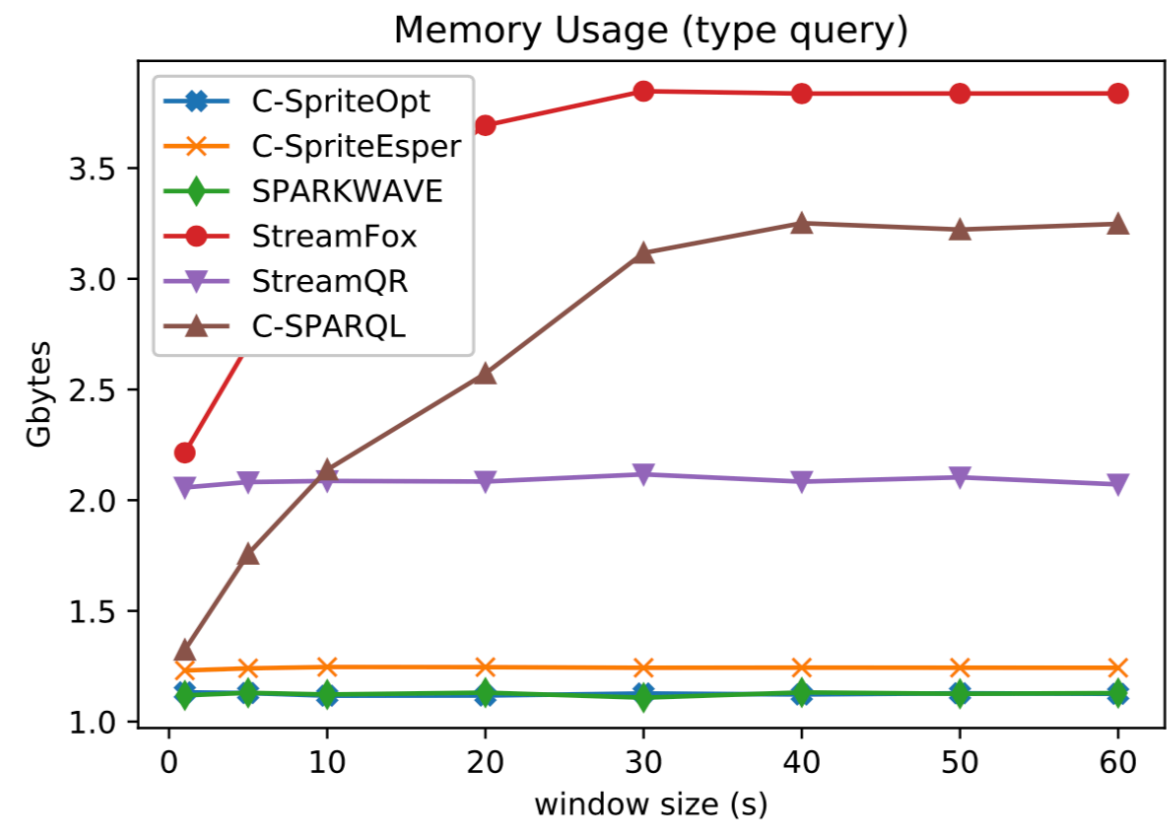
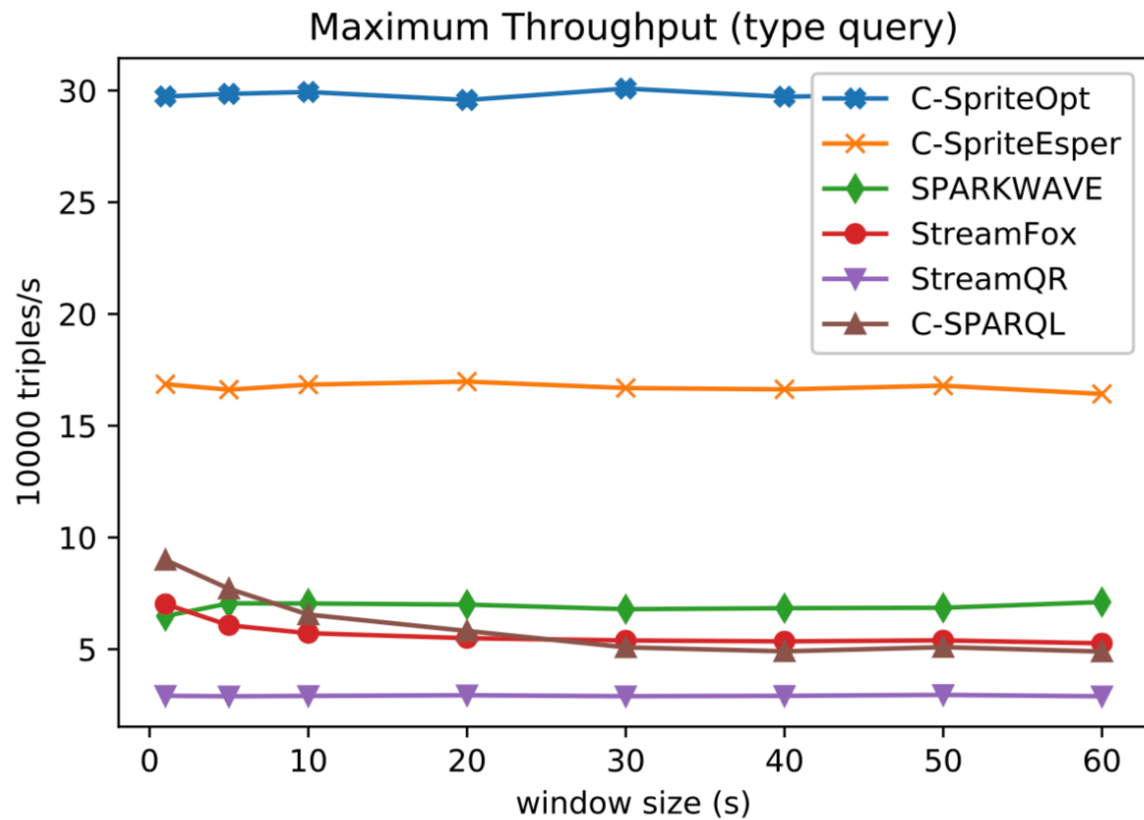


Q1: ?w a CreativeWork

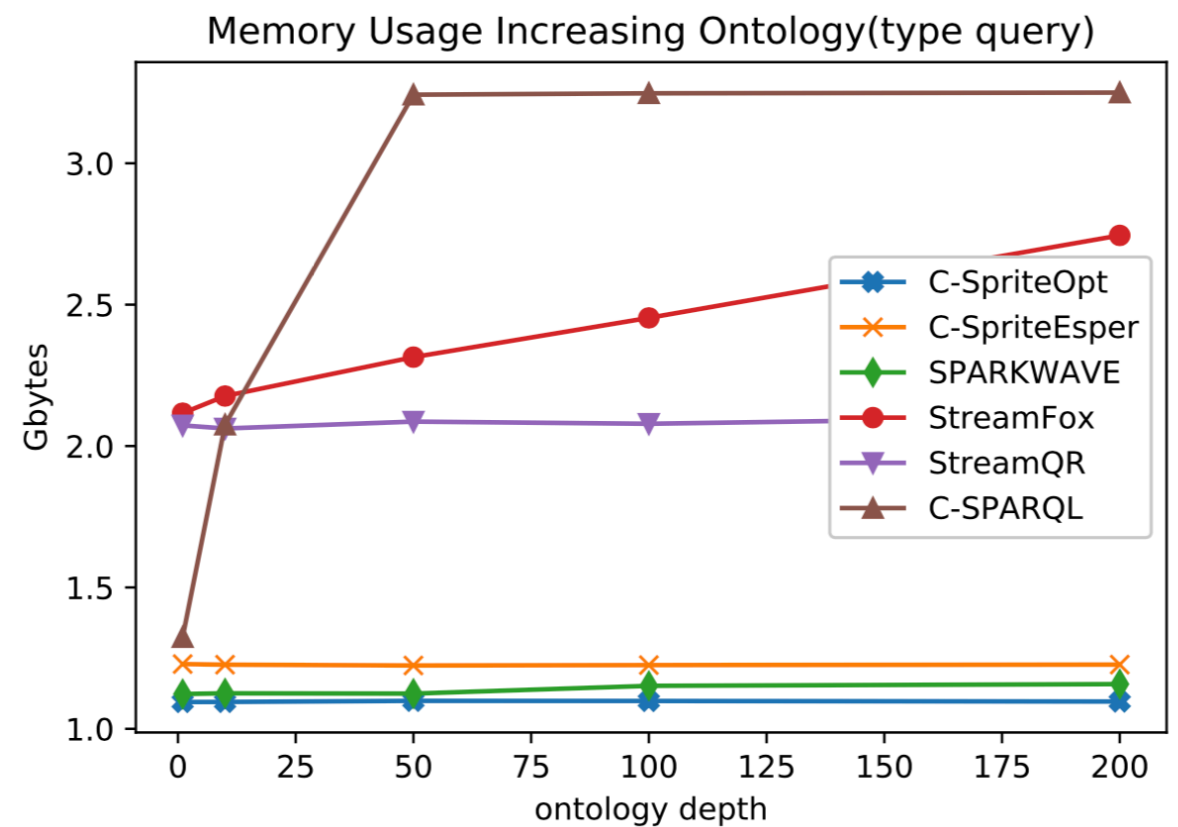
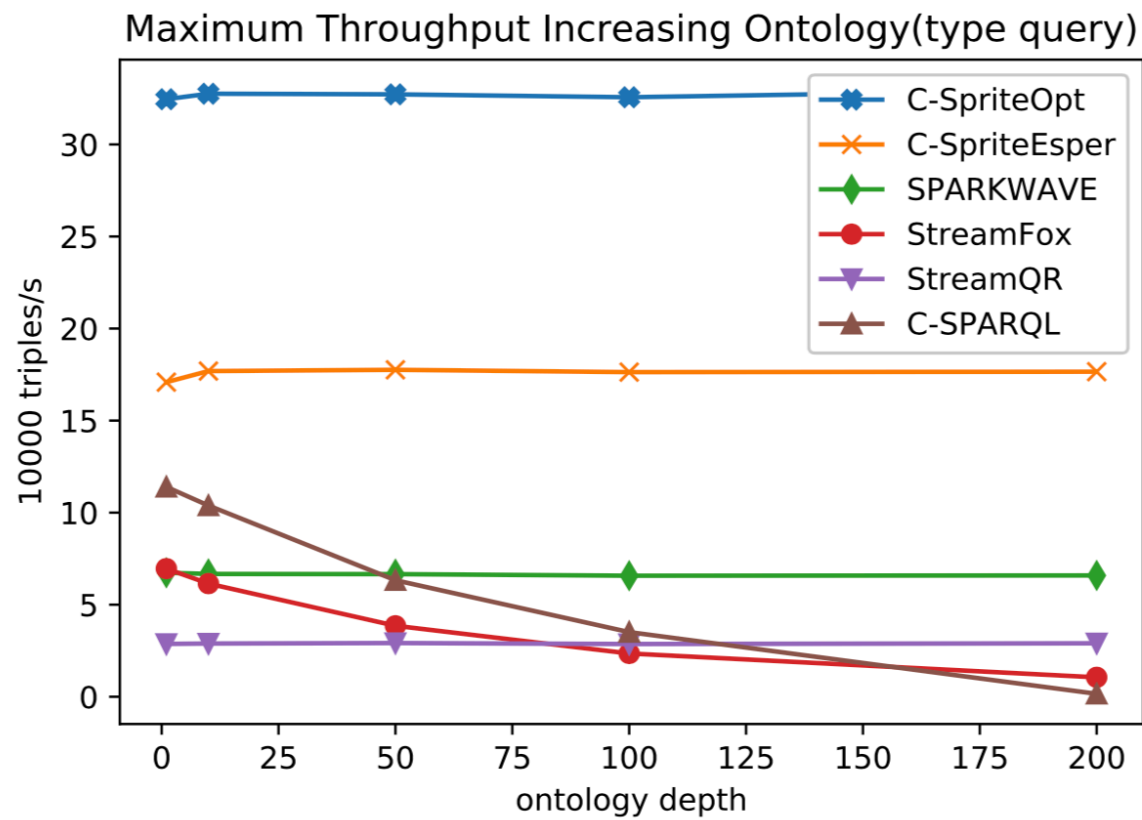


	Absolute Number	Relative Number
all triples	3.511.629	100%
Creative Works	56.581	1,61%
Top 5 Creative Works:		
MusicalWork	21.438	0,61%
Film	13.890	0,40%
WrittenWork	6.814	0,19%
TelevisionShow	4.579	0,13%
Software	4.493	0,13%

Evaluation: Increasing window size

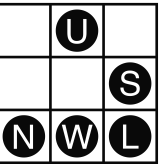


Evaluation: Increasing ontology depth



Future Work

- TRA @ Apache Spark
- Query Containment



Questions?

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- **Web2:** streamreasoning.org
- **Web3:** streaminglang.io

