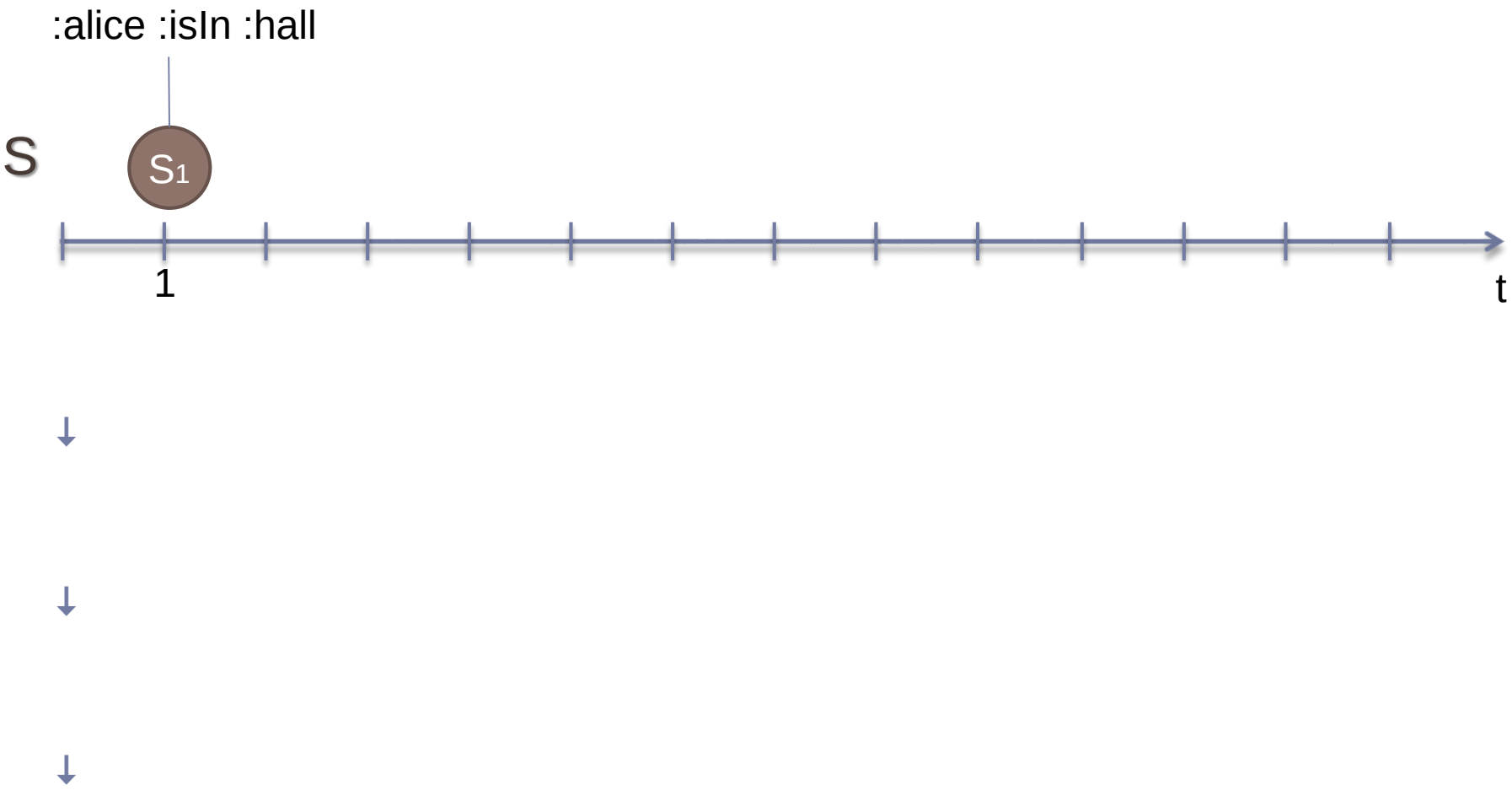
On correctness in RDF stream processor benchmarking

Daniele Dell'Aglio, Jean-Paul Calbimonte, Marco Balduini, Oscar Corcho and Emanuele Della Valle

The correctness problem (1)



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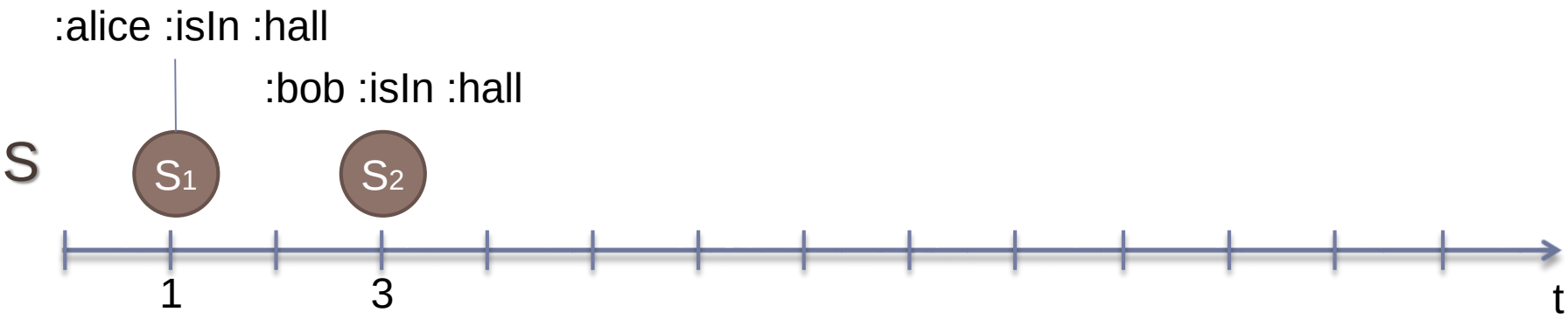

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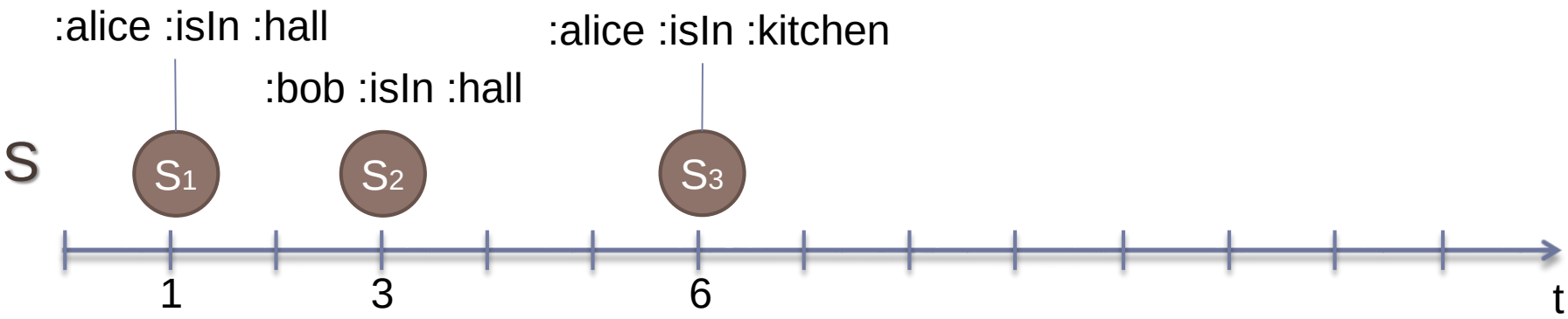

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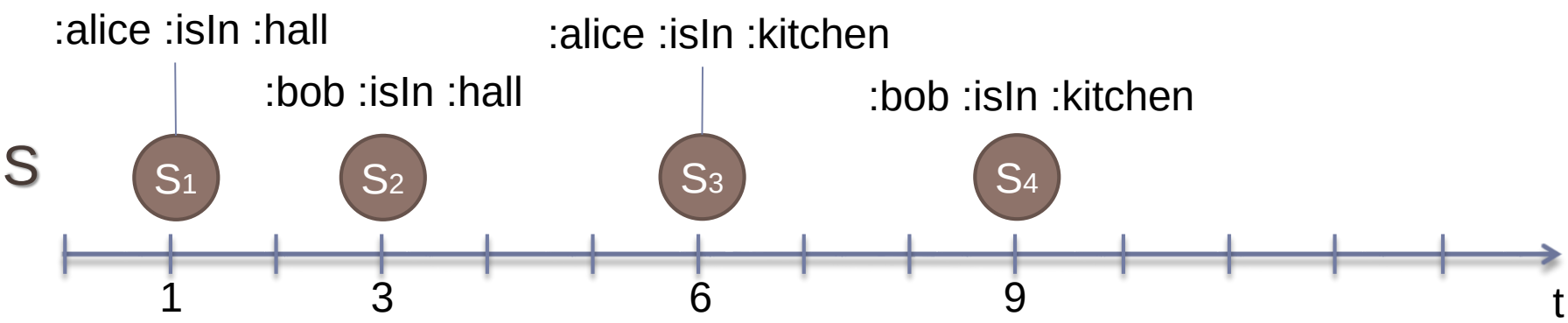

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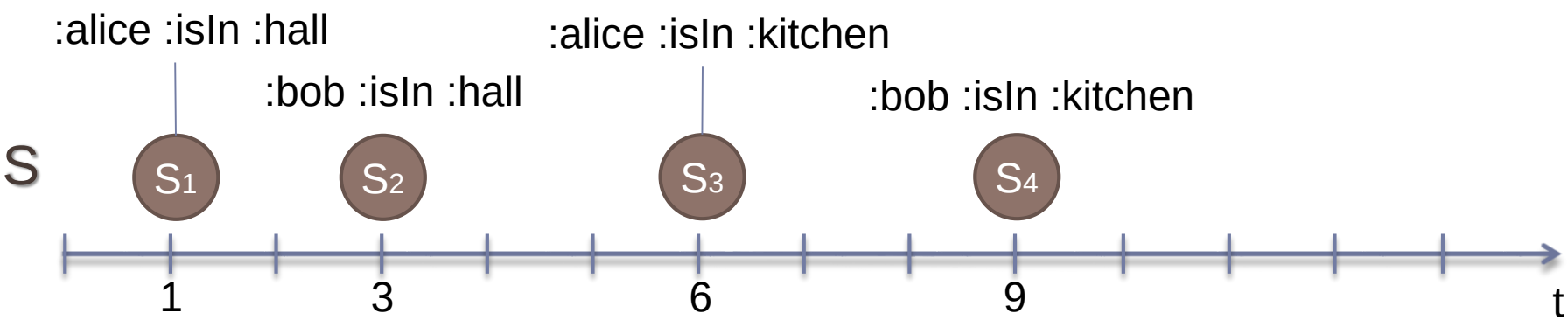

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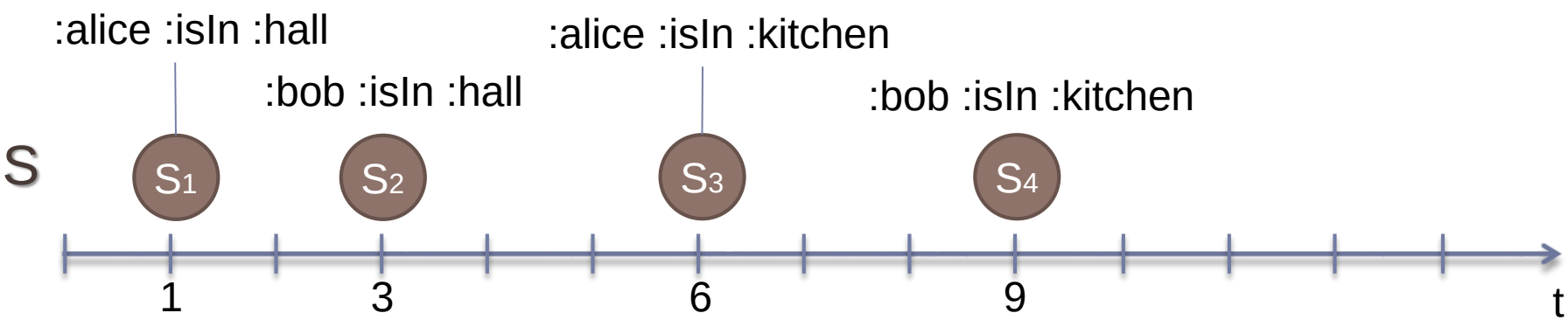

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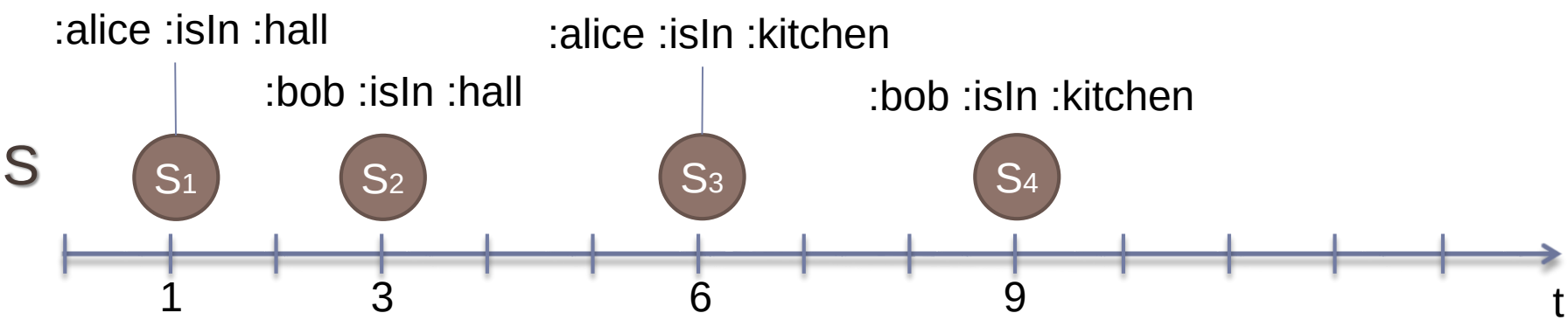

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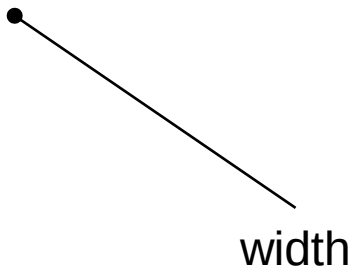

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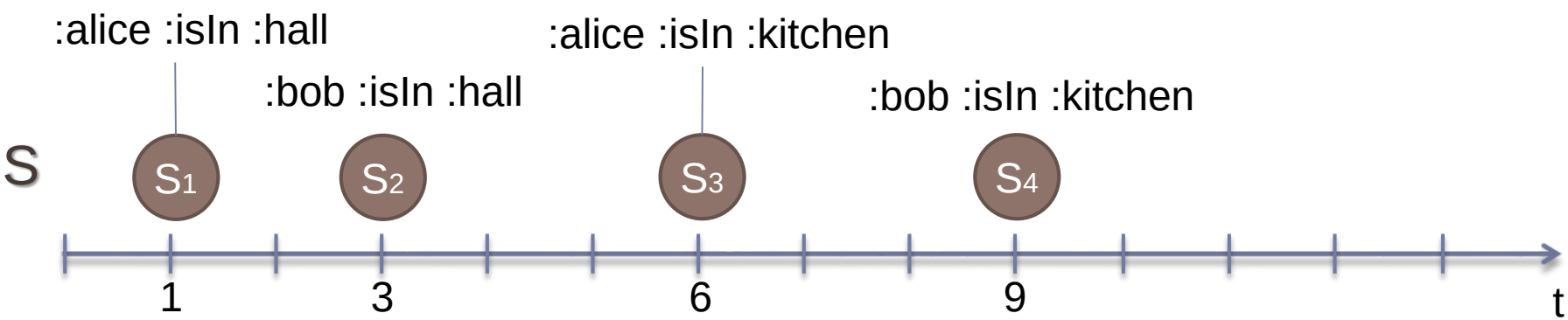

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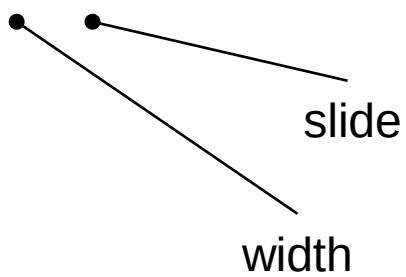

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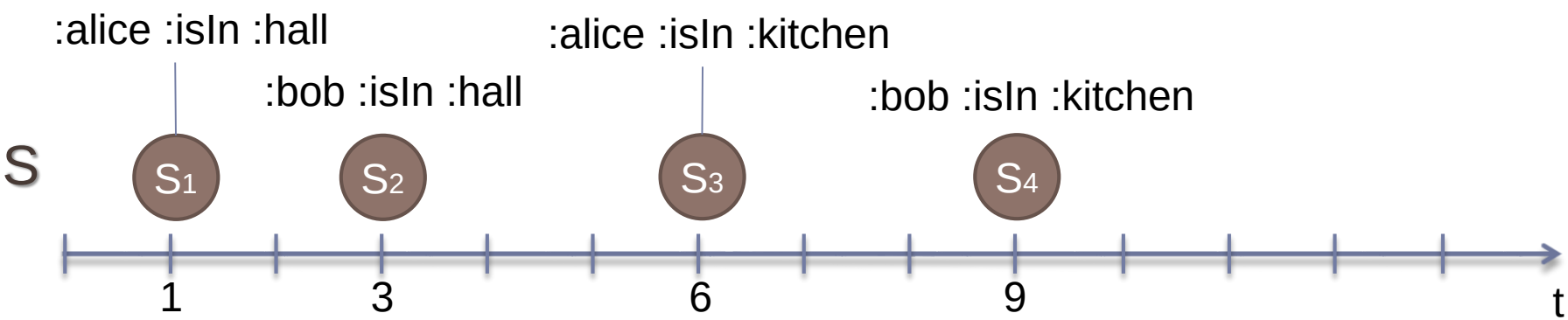

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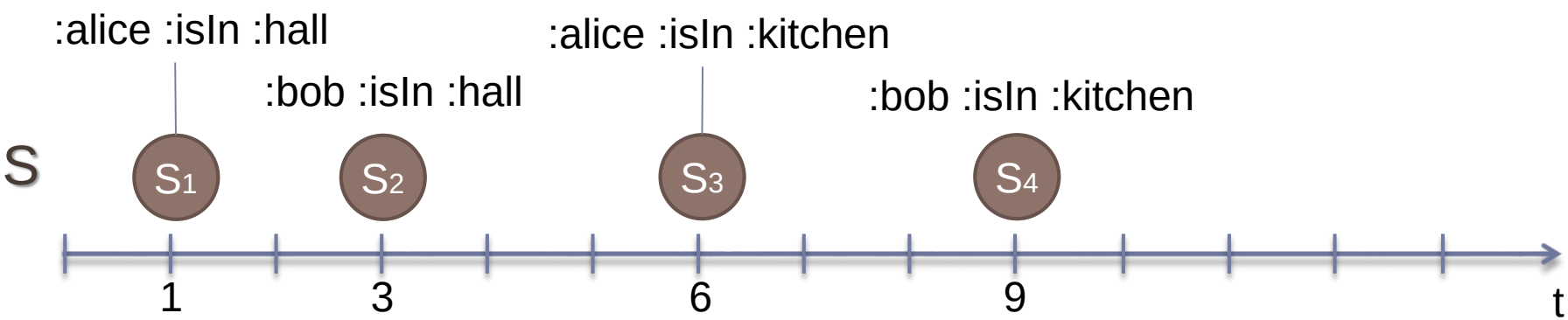

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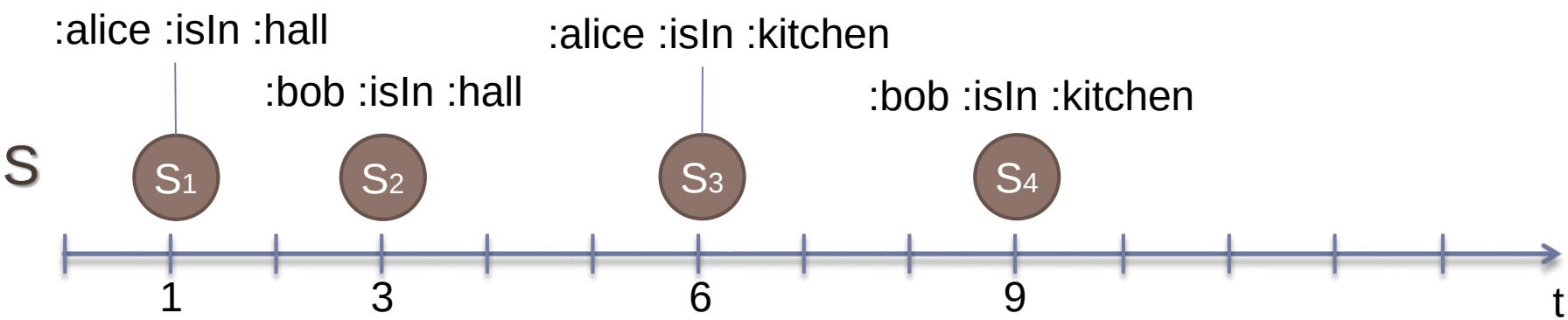

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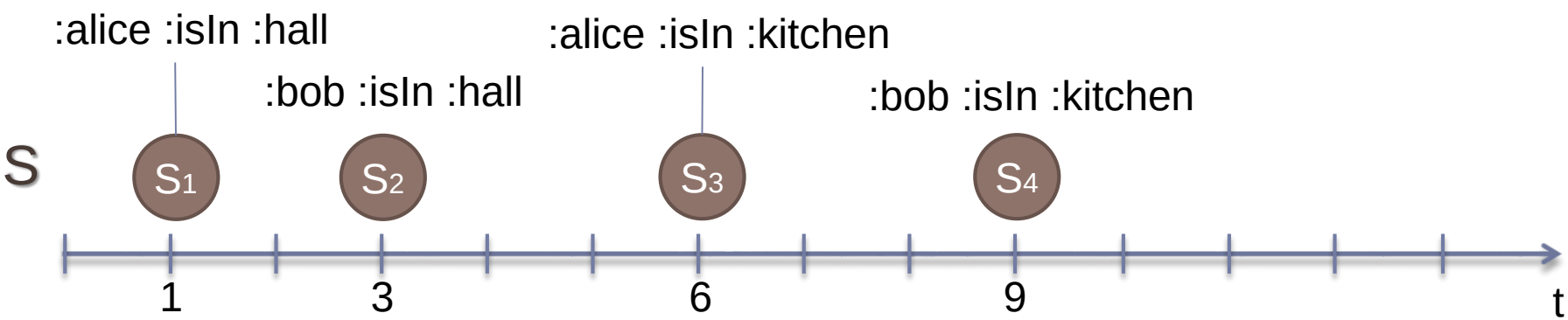

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Which is the correct answer?

All of them!

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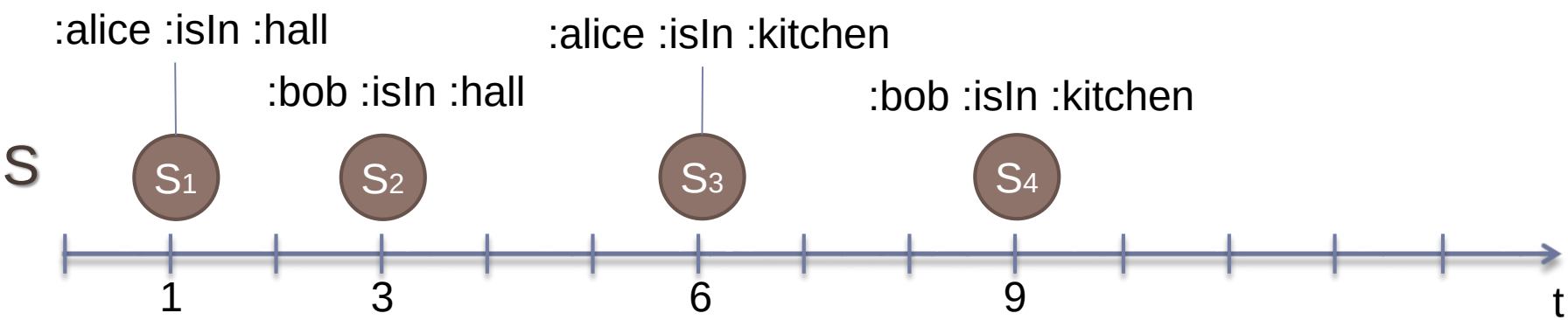

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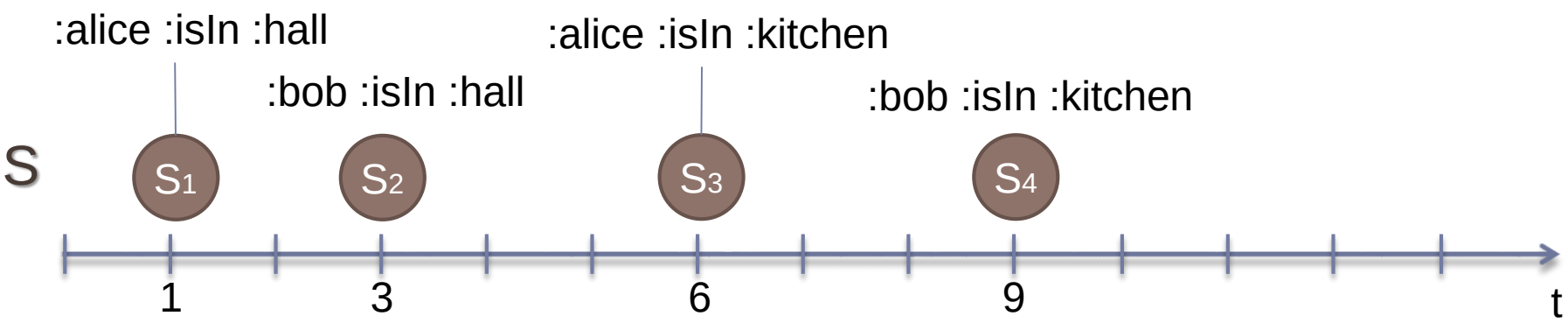

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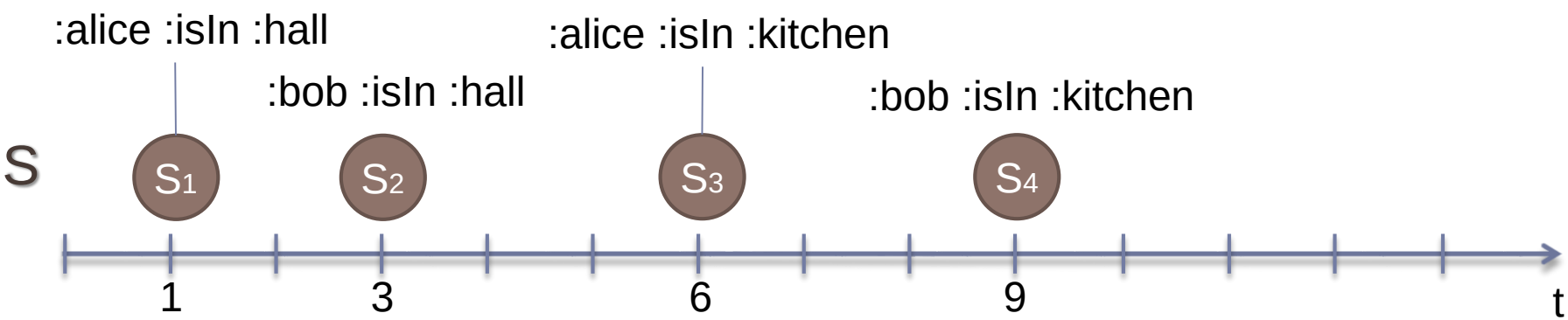

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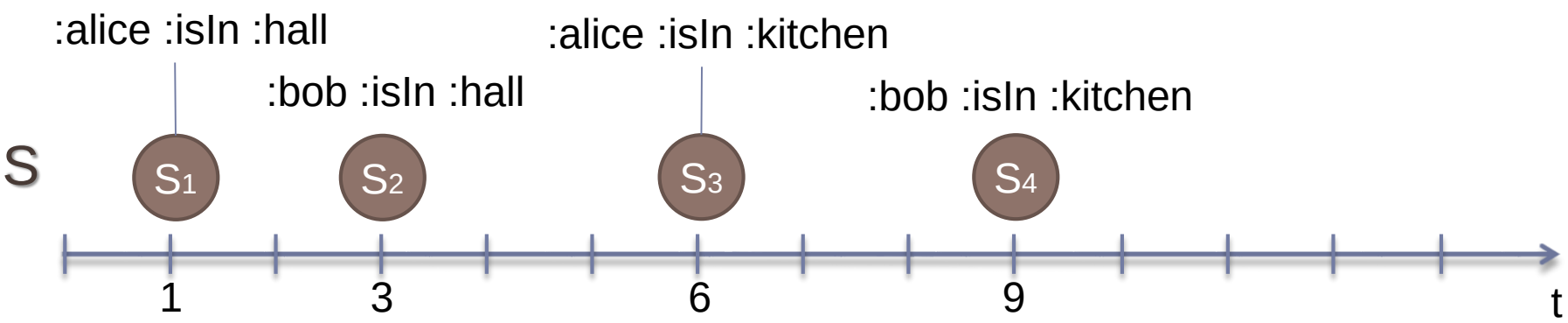

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- **Two systems** can provide **different correct answers**
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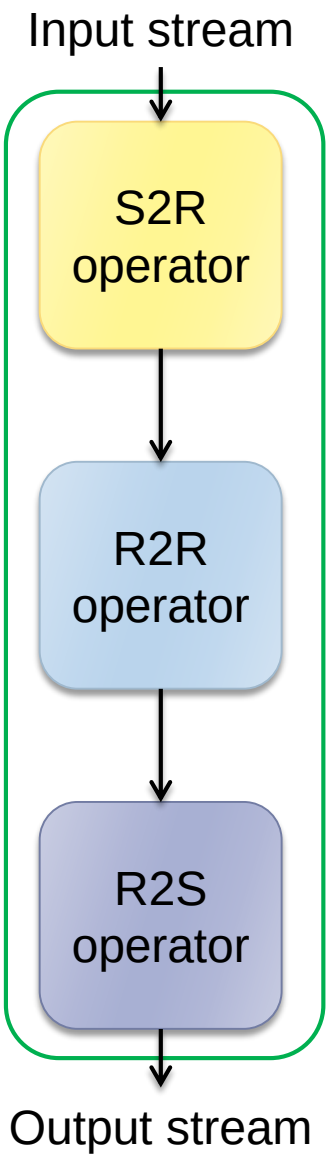
- Why is it important to understand those behaviours?
  - To assess the correct implementation of the systems
  - To improve the comprehension of the benchmarking

Our contribution

- A common **model** for the RDF stream processor operational semantics
- We propose **CSR-bench**, an extension of the SRbench benchmark that focuses on correctness
  - An **oracle** (an automatic correctness validator)
  - A **test** suite
- We considered the window-based RDF stream processors
  - CQELS
  - C-SPARQL
  - $\text{SPARQL}_{\text{stream}}$

The CSR Model (by CQL)



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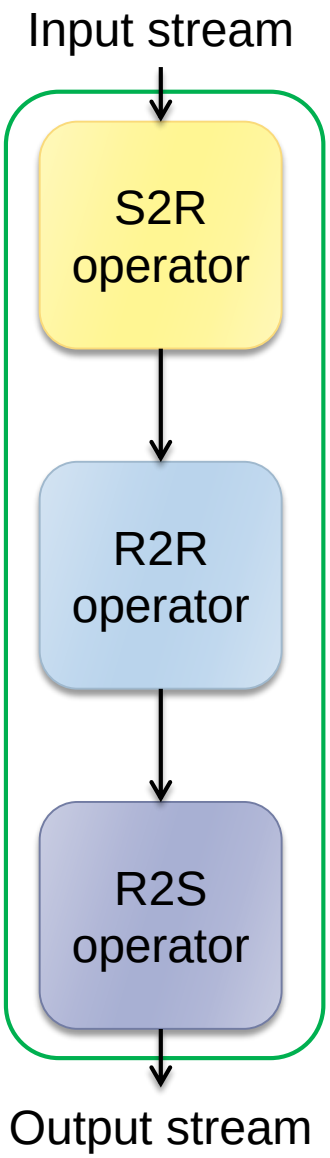

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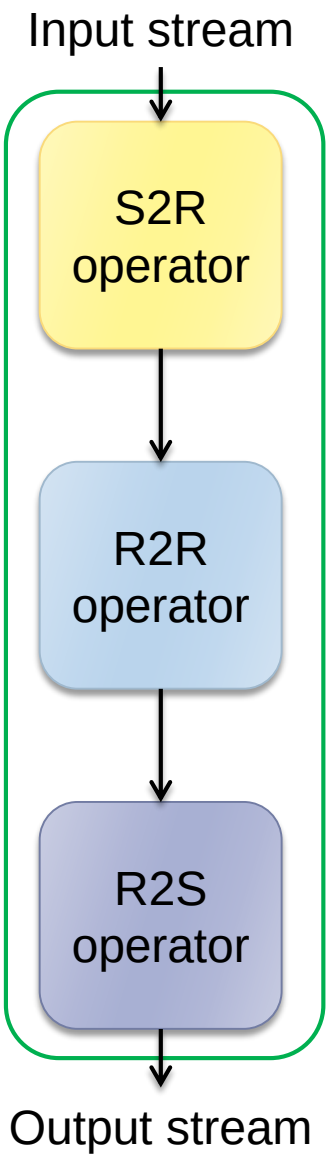

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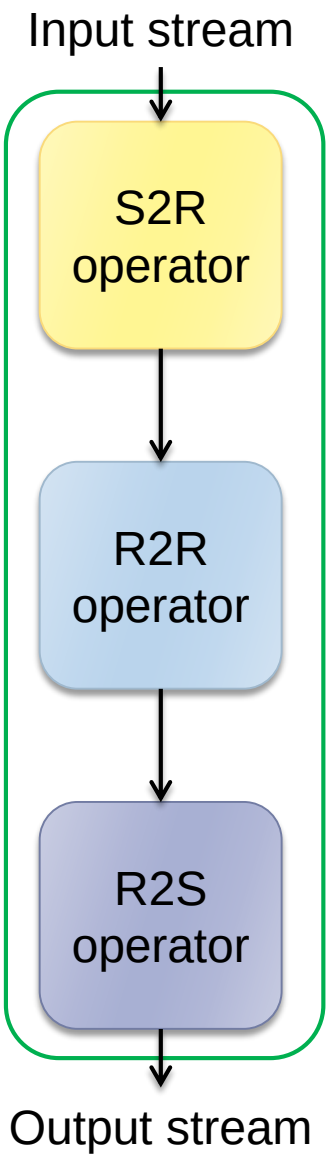

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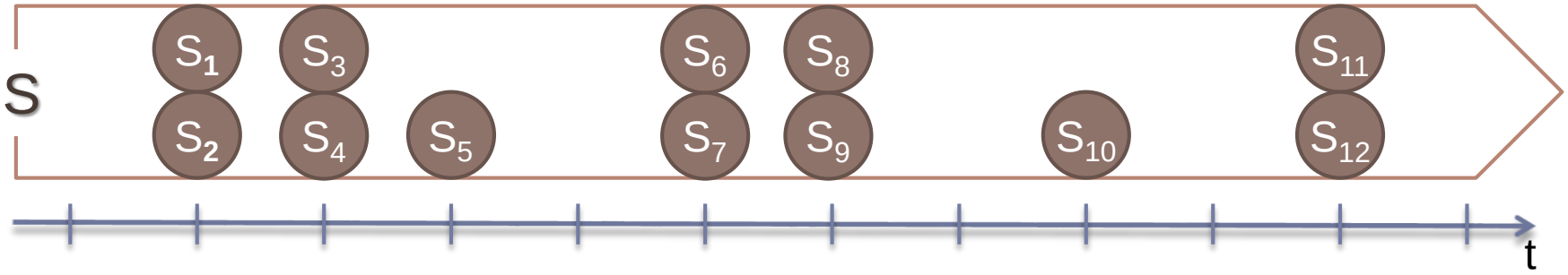
- Transform a set of mappings in another set of mappings
- **SPARQL** 1.0/1.1 queries

- Each set of mapping produced by the R2R operator is **transformed and appended** to the output stream
- Operators: RStream, DStream, IStream

The window operator (through SECRET)



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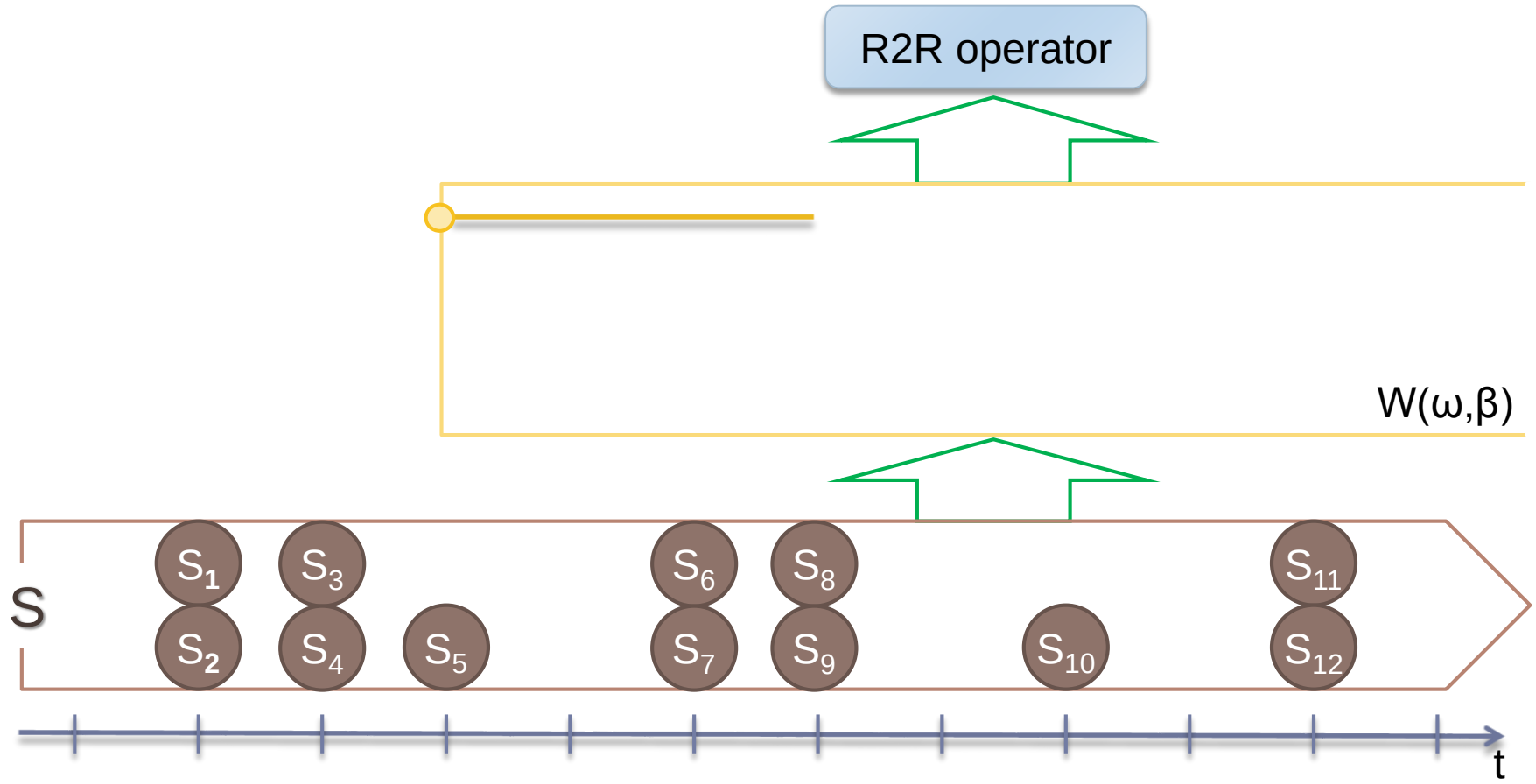

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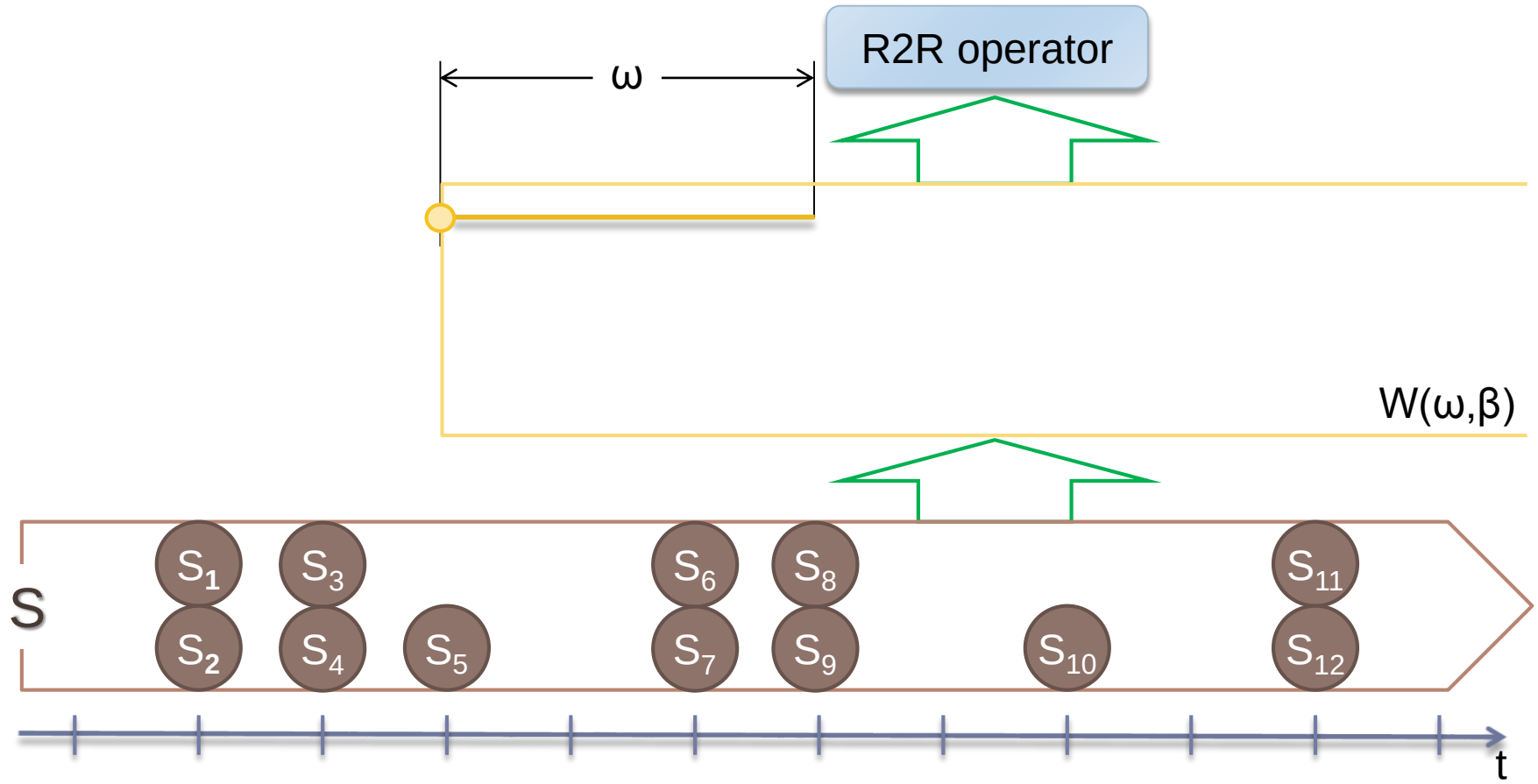

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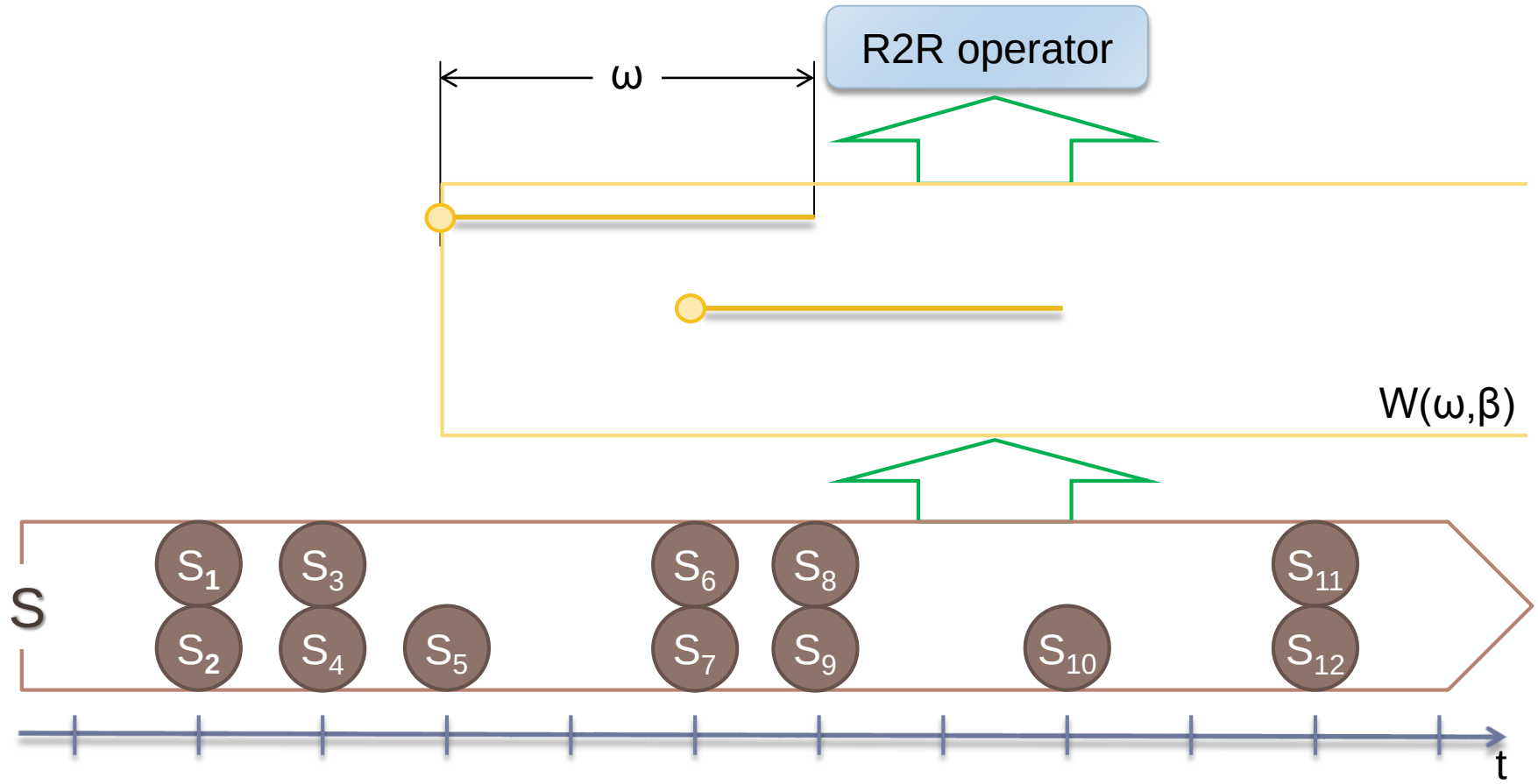

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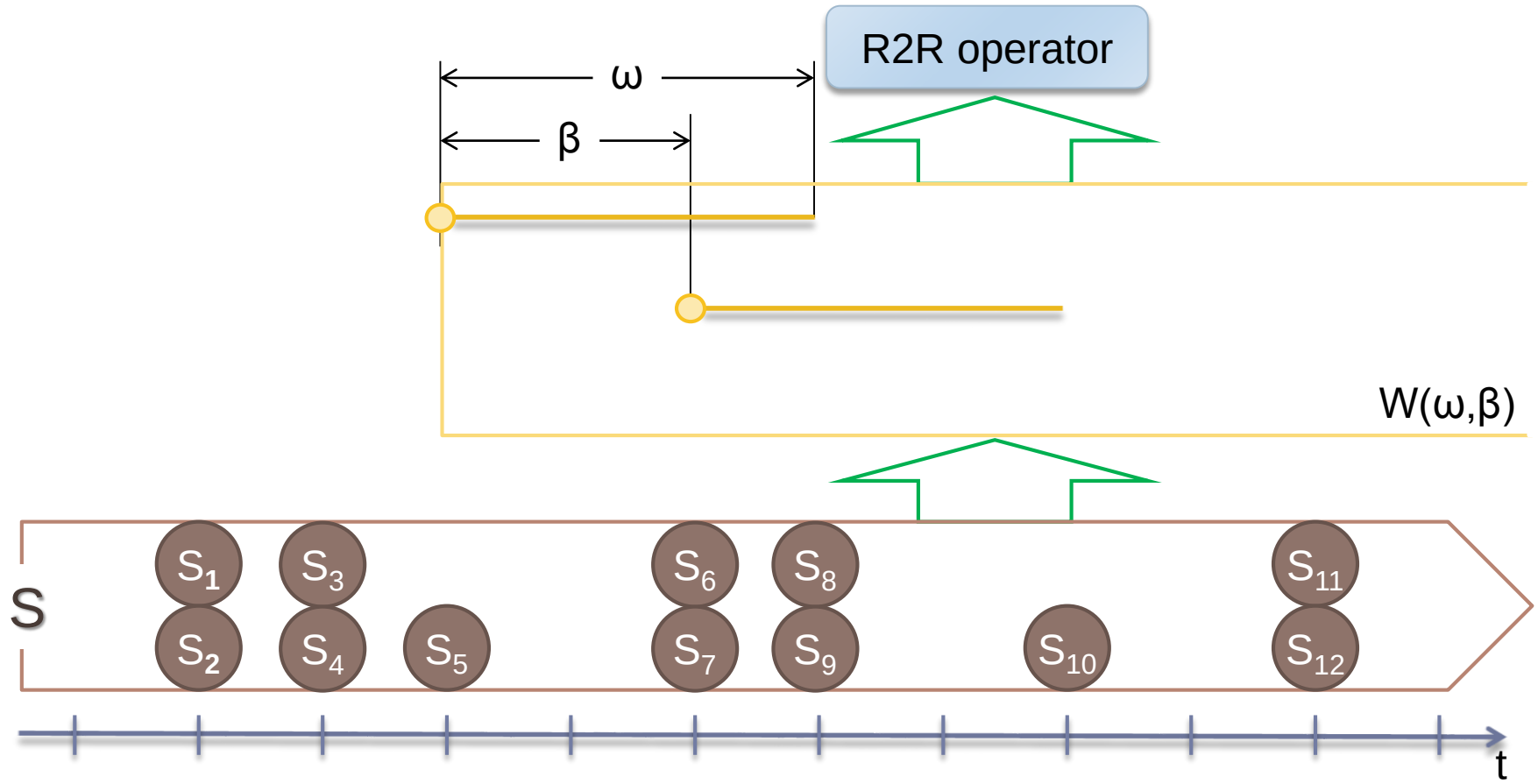

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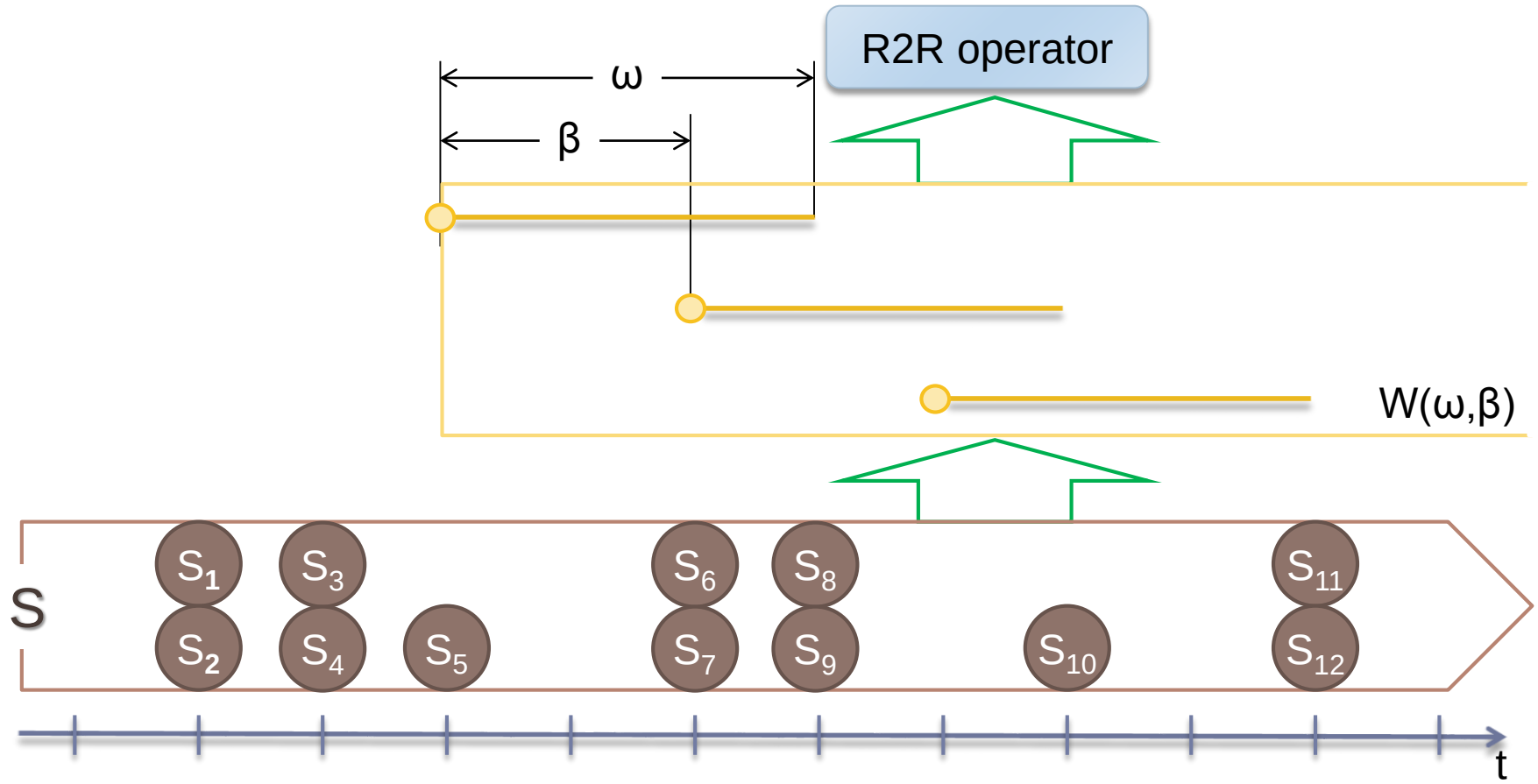

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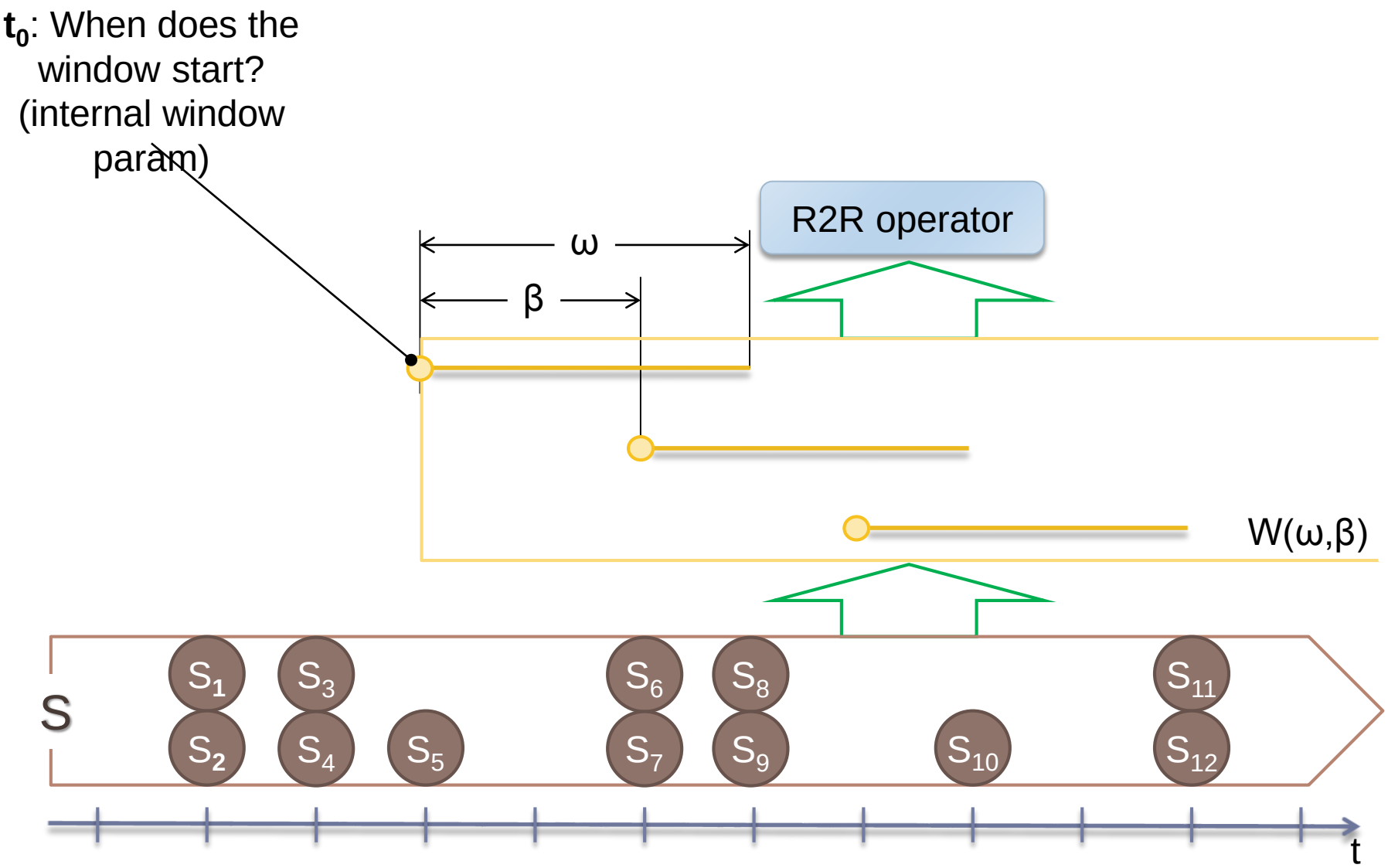

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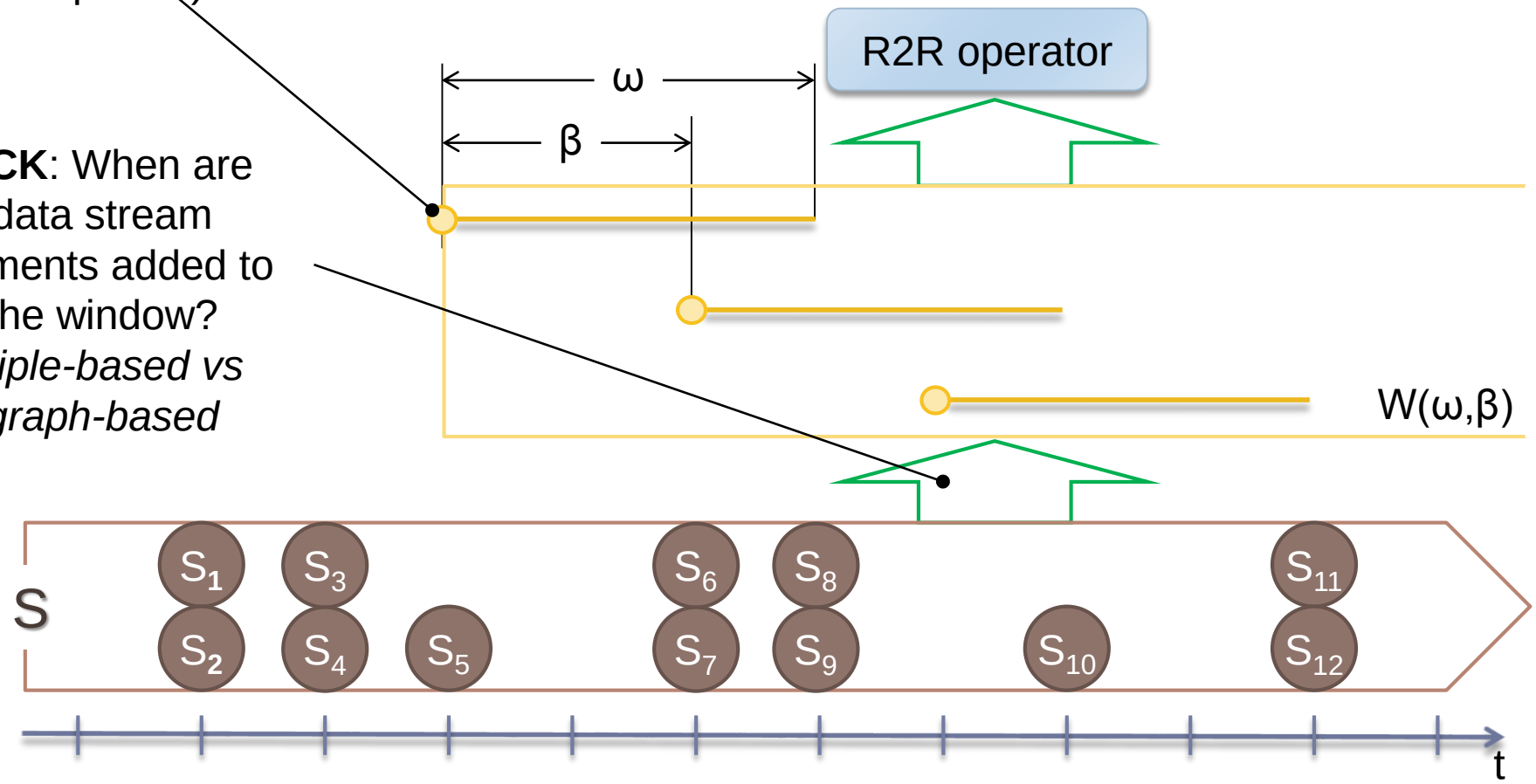
TICK: When are data stream elements added to the window? *Triple-based vs graph-based*



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REPORT: When is the window content made available to the R2R operator? *Non-empty content, Content-change, Window-close, Periodic*

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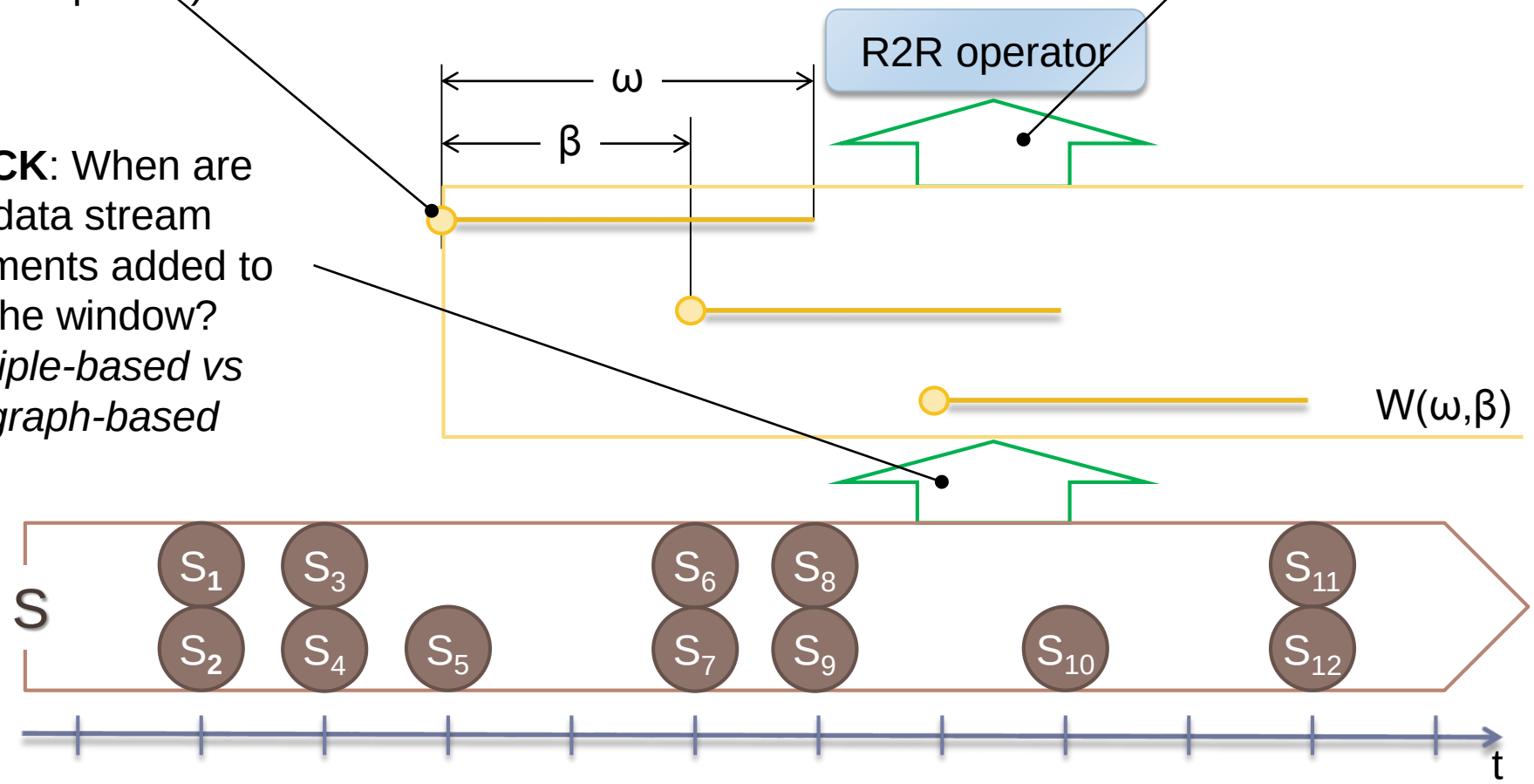
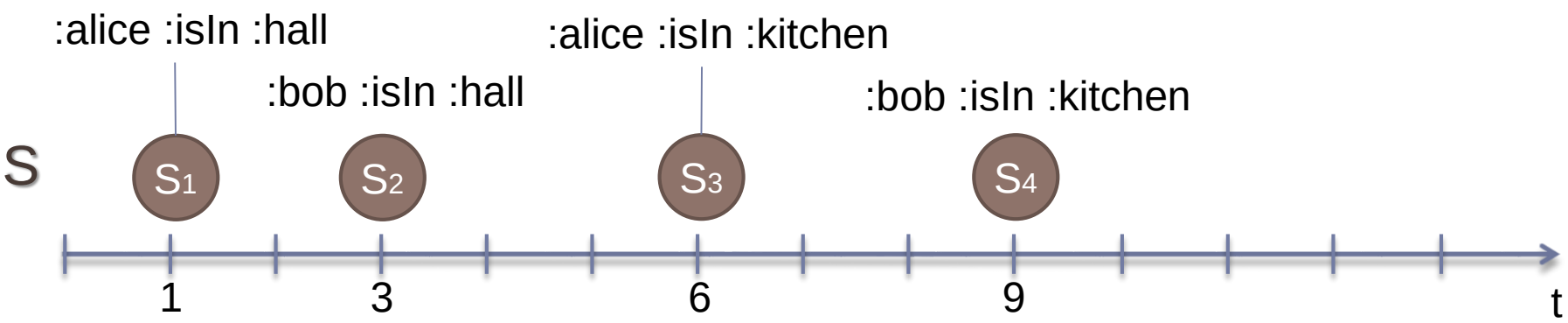


Classification of existing systems

- The report and the tick policies are related to the RSPs implementation and on how they implement the window operators
- Analysing the RSPs and their related documentation (papers, technical reports, etc.), we classified the systems:

	CQELS	C-SPARQL	$SPARQL_{stream}$
Report	Content-change	Window-close Non-empty content	Window-close Non-empty content
Tick	Tuple-driven	Tuple-driven	Tuple-driven
Empty relation notification	No	Yes	No

RSP output correctness



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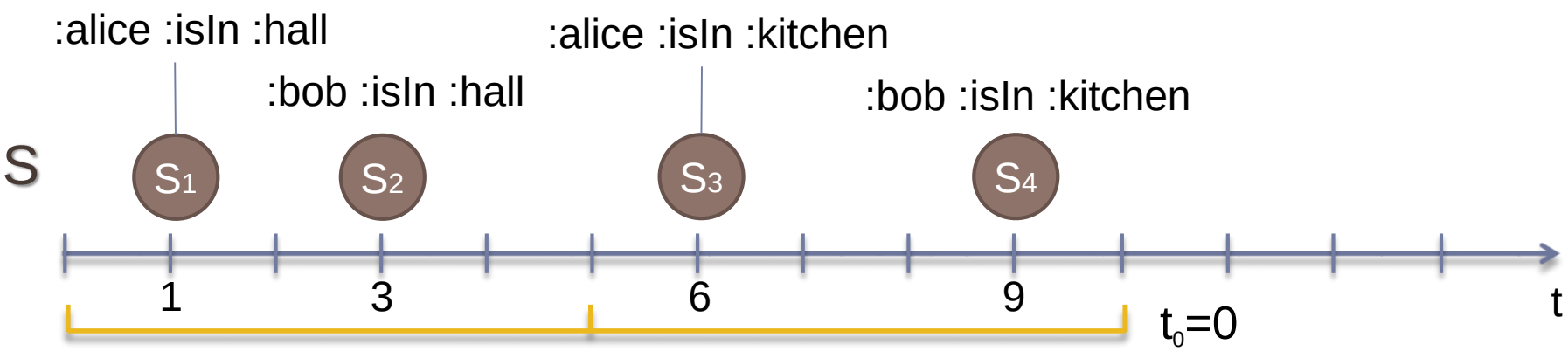

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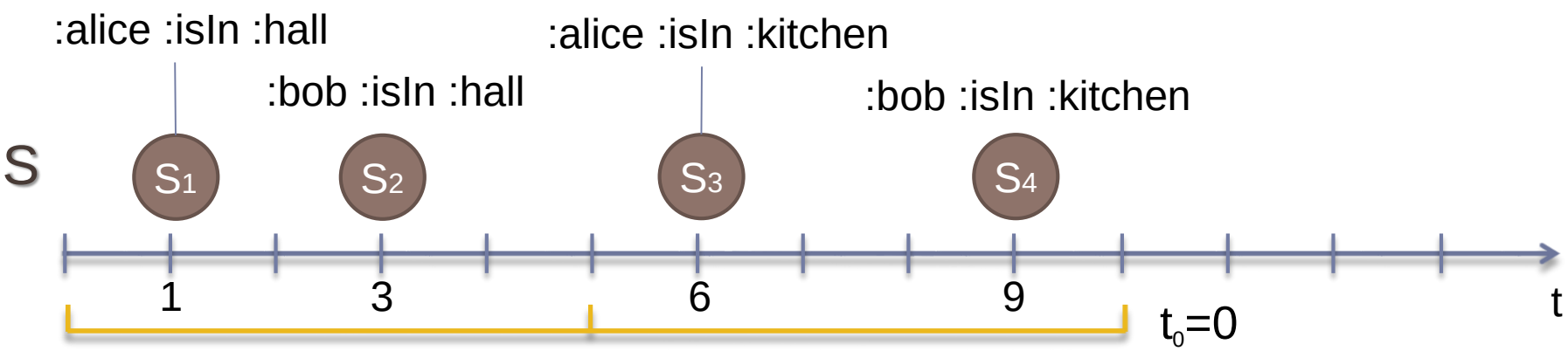

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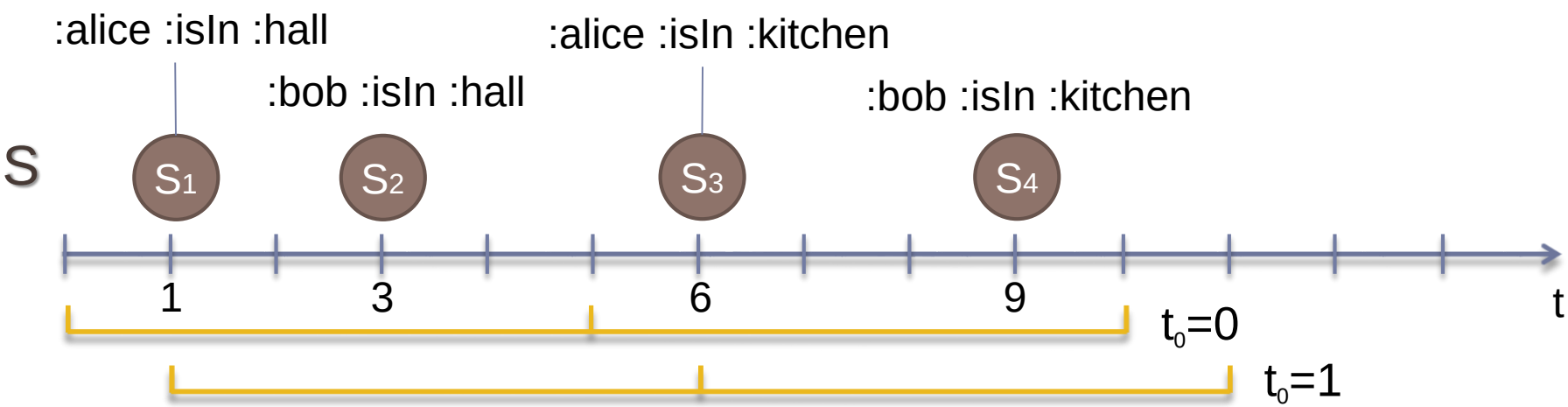

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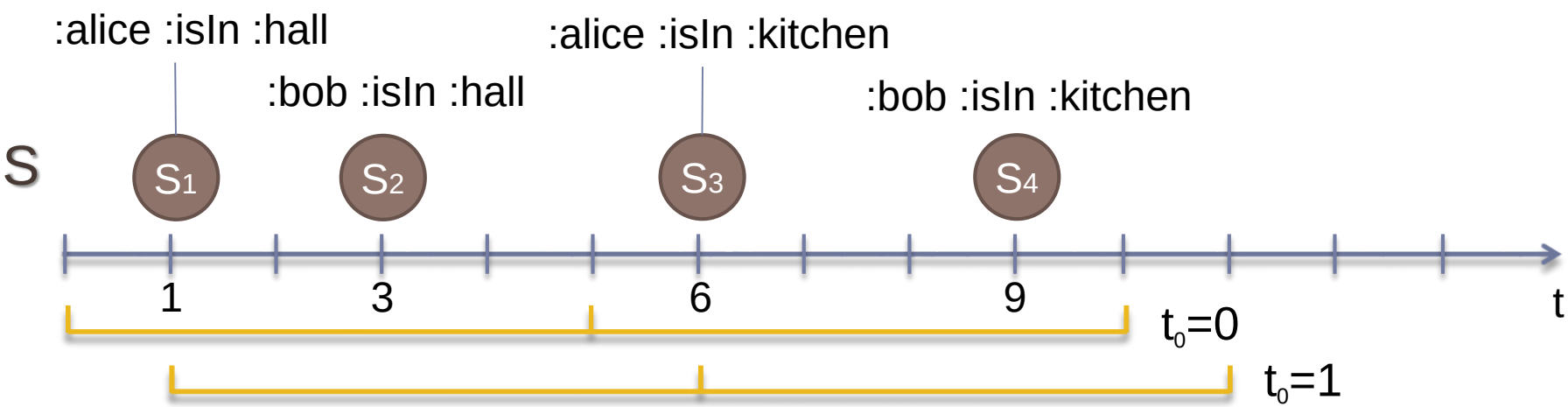

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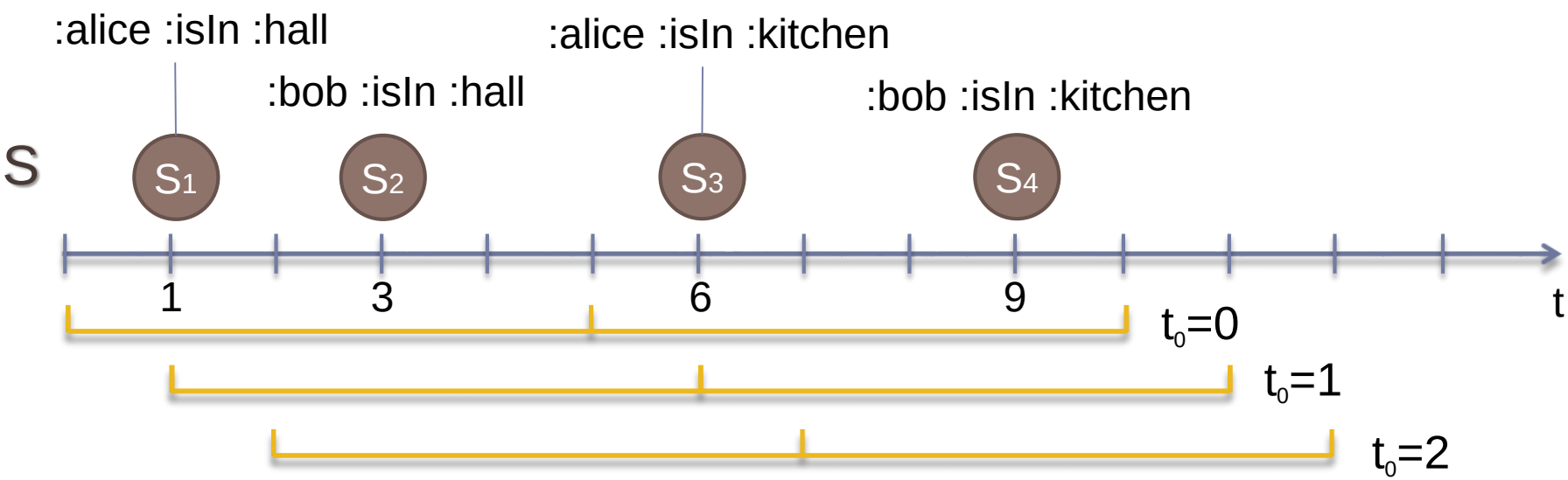

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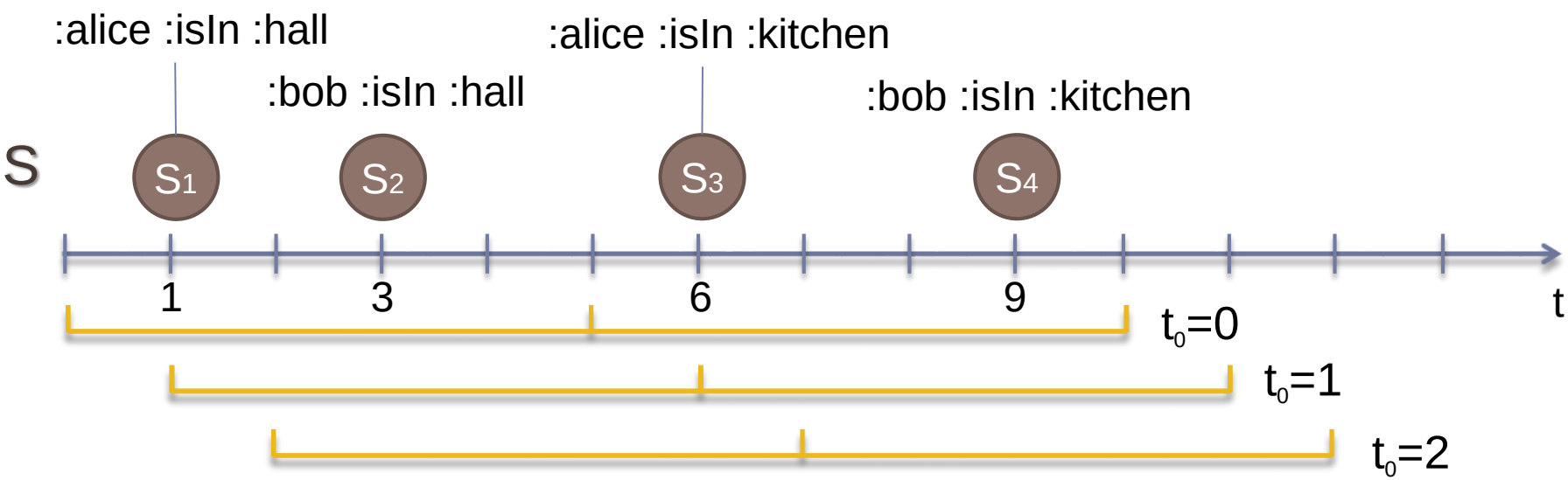
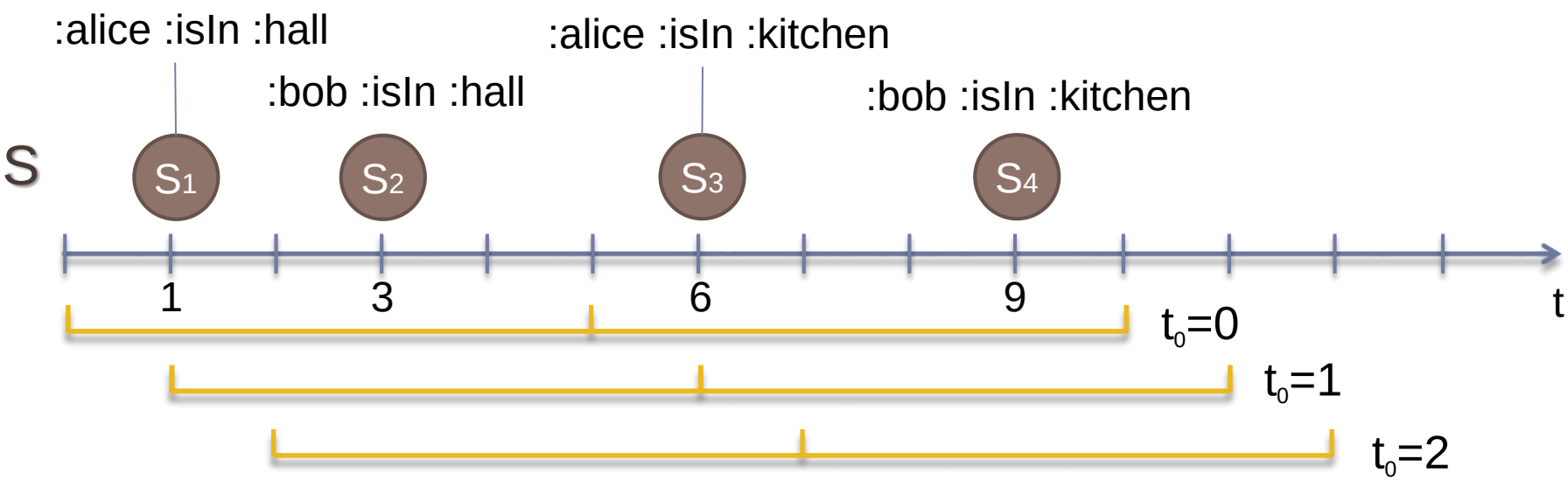
RSP output correctness



Execution	1° answer	2° answer
1	:hall [6]	:kitchen [11]
2	:hall [5]	:kitchen [10]
3	:hall [6]	:kitchen [11]
4	- [7]	- [12]

Window	1° answer	2° answer
t_0=0	:hall [5]	:kitchen [10]
t_0=1	:hall [6]	:kitchen [11]
t_0=2	- [7]	- [12]

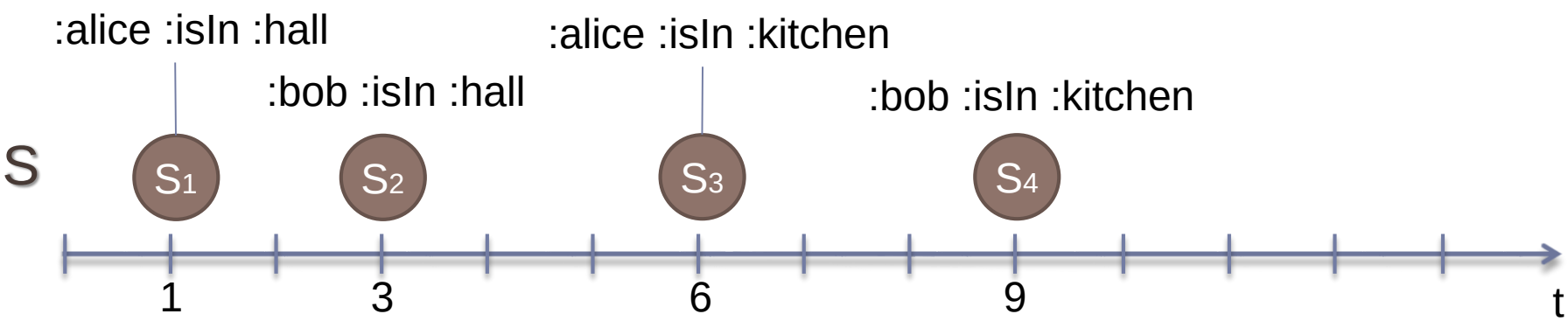
RSP output correctness



Execution	1° answer	2° answer
1	:hall [6]	:kitchen [11]
2	:hall [5]	:kitchen [10]
3	:hall [6]	:kitchen [11]
4	- [7]	- [12]

Window	1° answer	2° answer
t_0=0	:hall [5]	:kitchen [10]
t_0=1	:hall [6]	:kitchen [11]
t_0=2	- [7]	- [12]

RSP output correctness



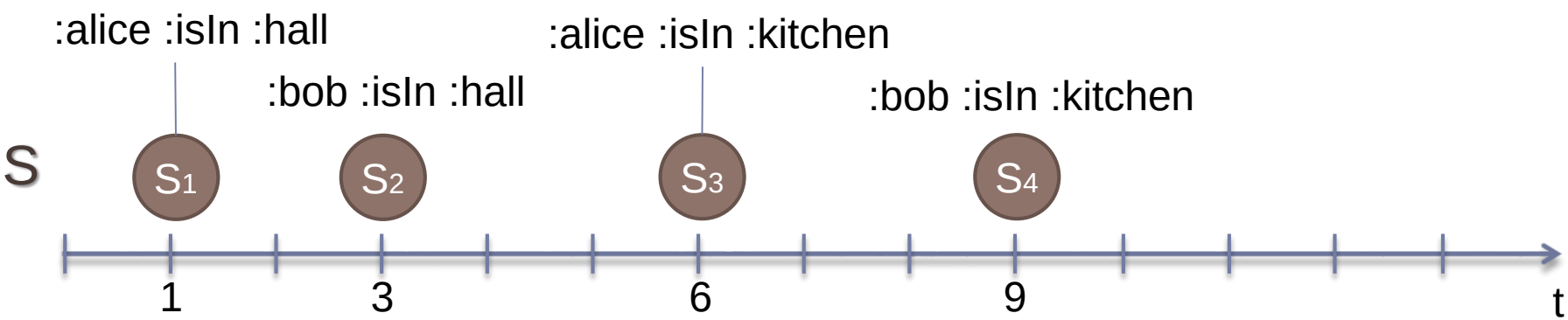
System 1

Execution	1° answer	2° answer
1	:hall [6]	:kitchen [11]
2	:hall [5]	:kitchen [10]
3	:hall [6]	:kitchen [11]
4	- [7]	- [12]

System 2

Execution	1° answer	2° answer
1	:hall [3]	:kitchen [9]
2	No answers	
3	:hall [3]	:kitchen [9]
4	No answers	

RSP output correctness



System 1

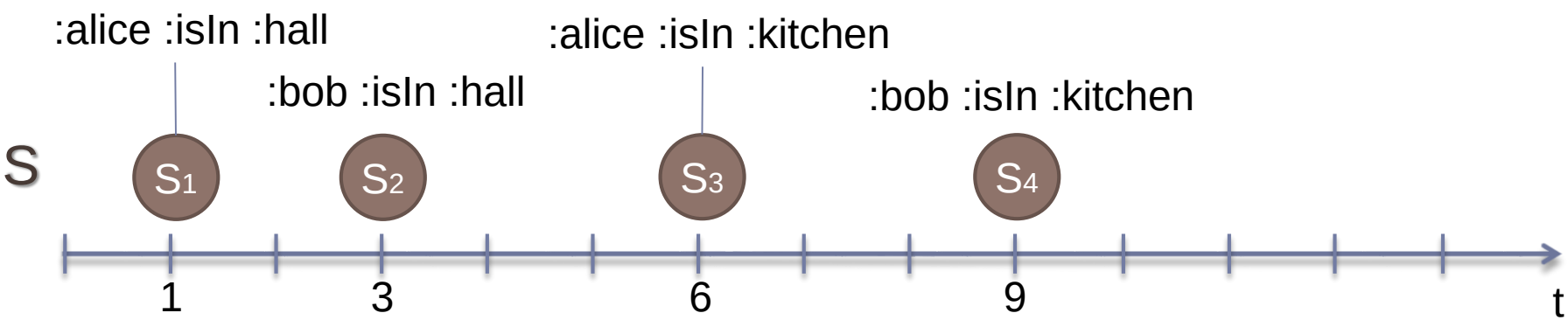
Execution	1° answer	2° answer
1	:hall [6]	:kitchen [11]
2	:hall [5]	:kitchen [10]
3	:hall [6]	:kitchen [11]
4	- [7]	- [12]

System 2

Execution	1° answer	2° answer
1	:hall [3]	:kitchen [9]
2	No answers	
3	:hall [3]	:kitchen [9]
4	No answers	

Window-close vs content-change report policy

RSP output correctness



System 1

Execution	1° answer	2° answer
1	:hall [6]	:kitchen [11]
2	:hall [5]	:kitchen [10]
3	:hall [6]	:kitchen [11]
4	- [7]	- [12]

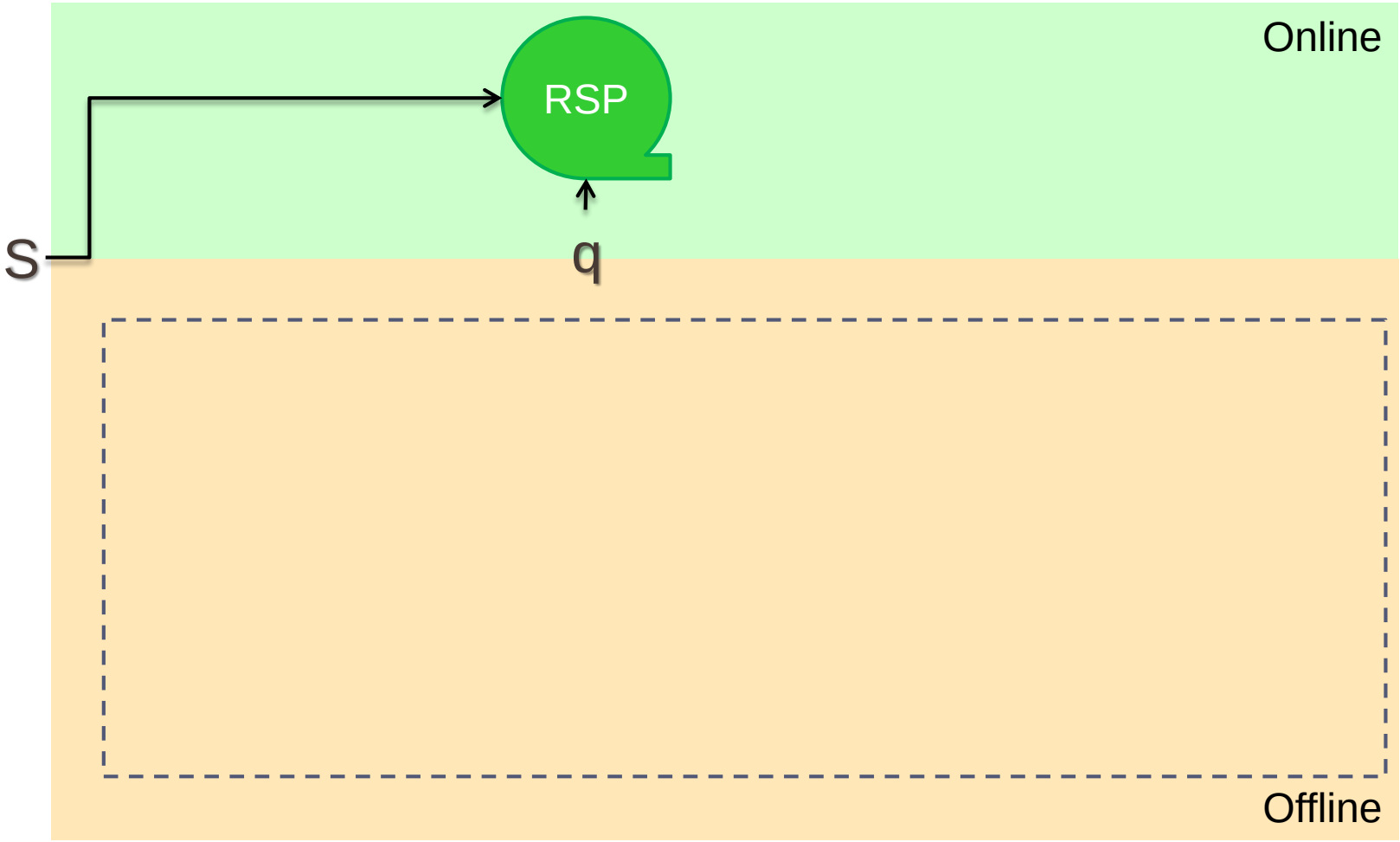
System 2

Execution	1° answer	2° answer
1	:hall [3]	:kitchen [9]
2	No answers	
3	:hall [3]	:kitchen [9]
4	No answers	

Window-close vs content-change report policy

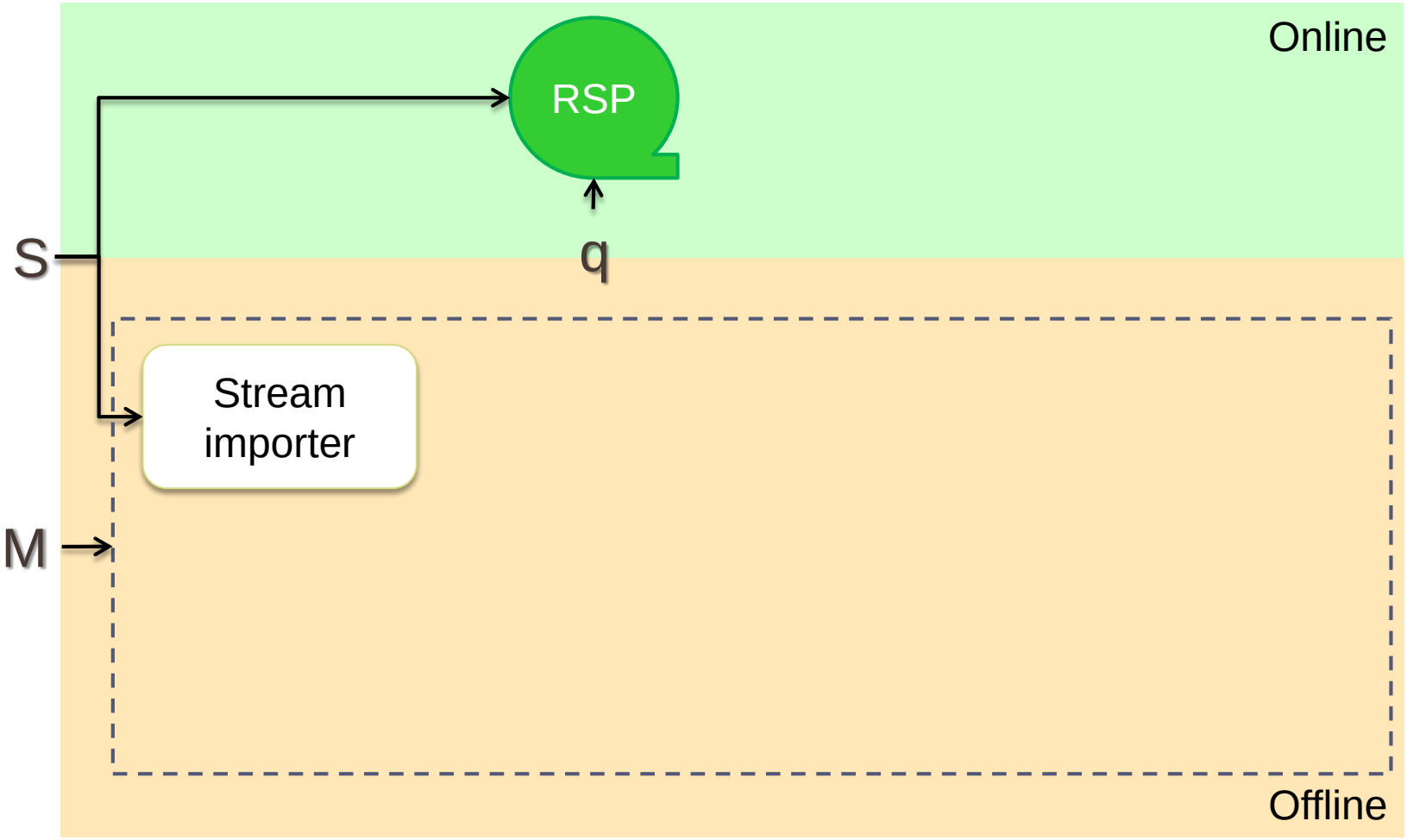
Empty relation notification (yes|no)

The oracle



Available at: https://github.com/dellaglio/csrbench-ora
(Apache 2.0 licence)

The oracle



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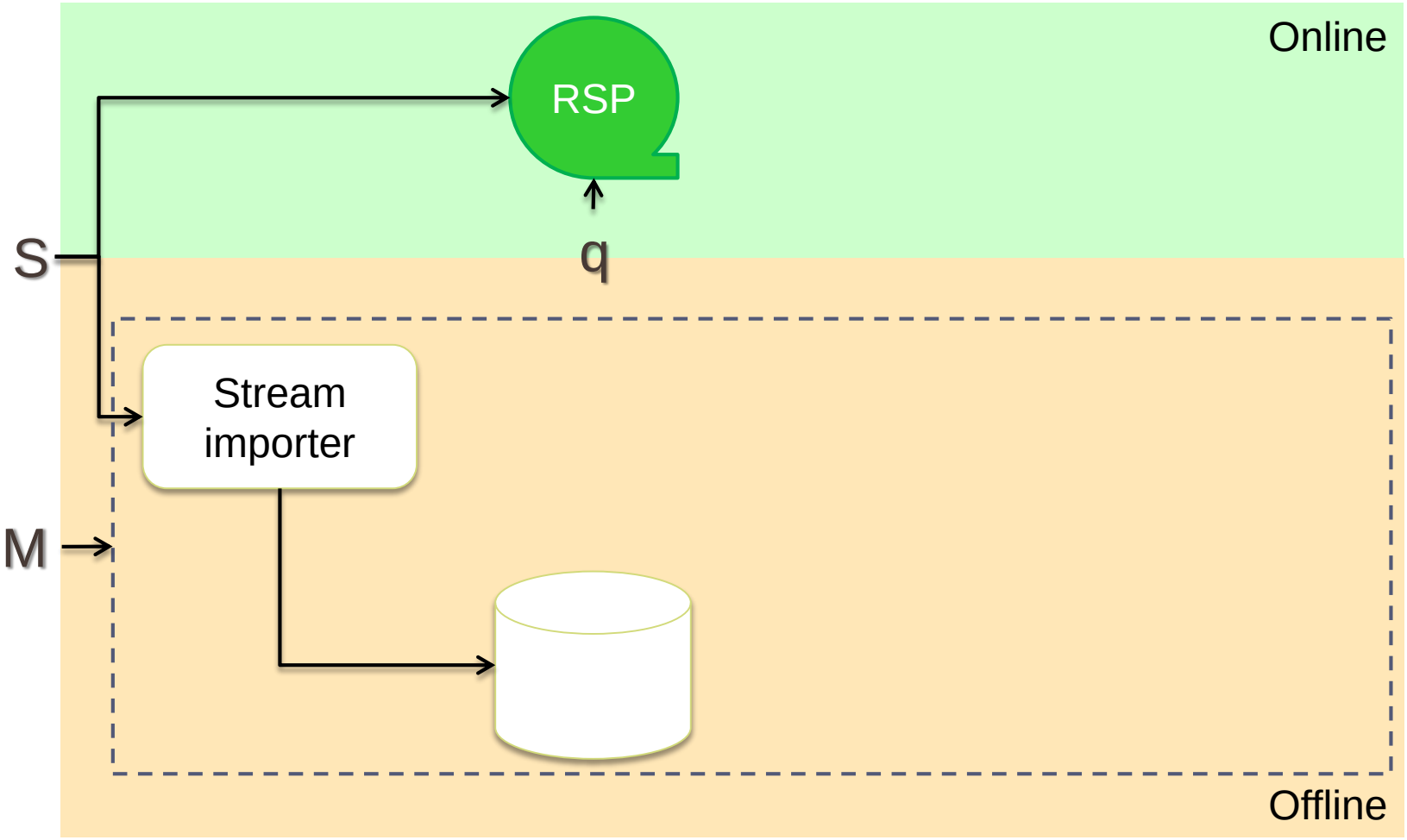
The oracle



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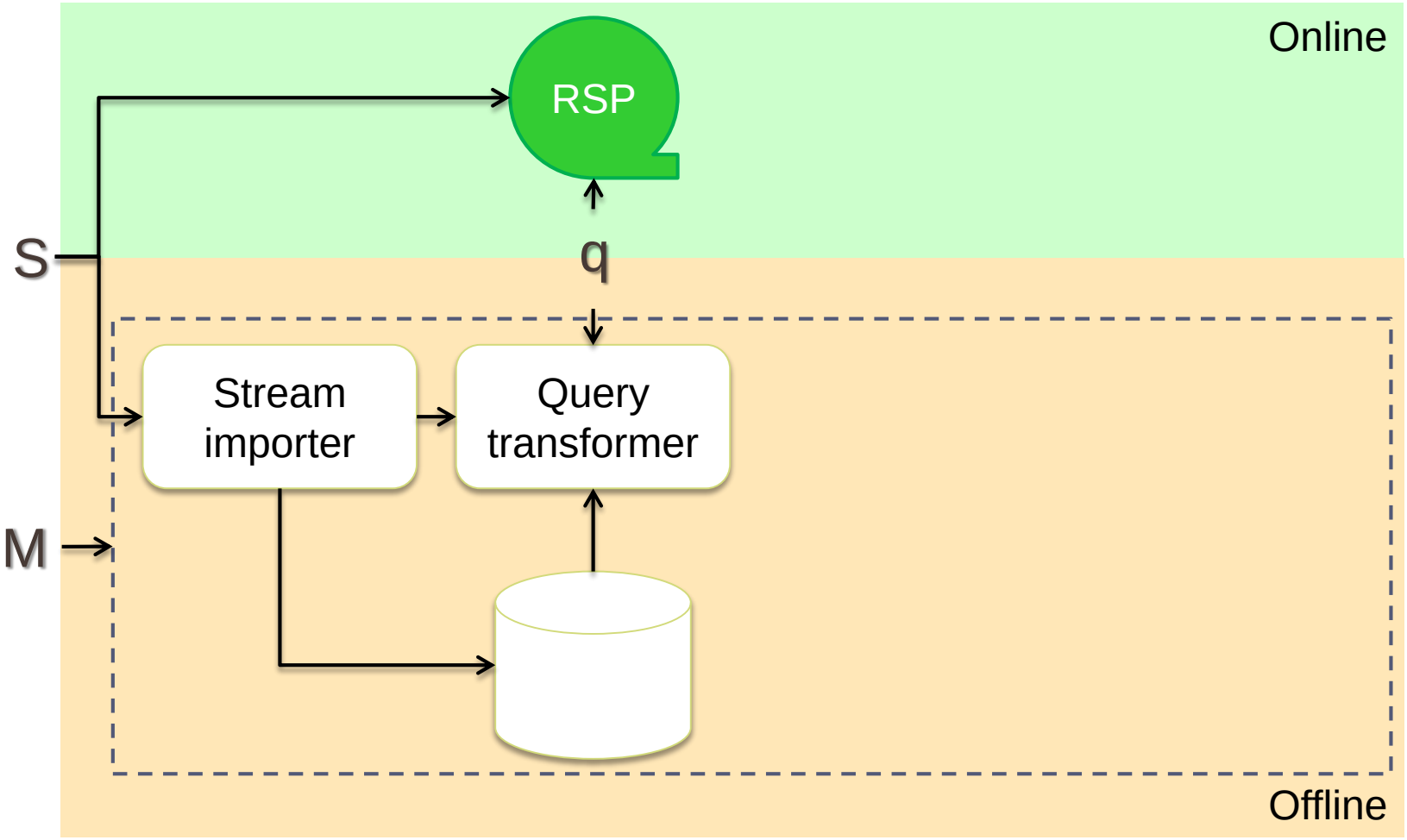
The oracle



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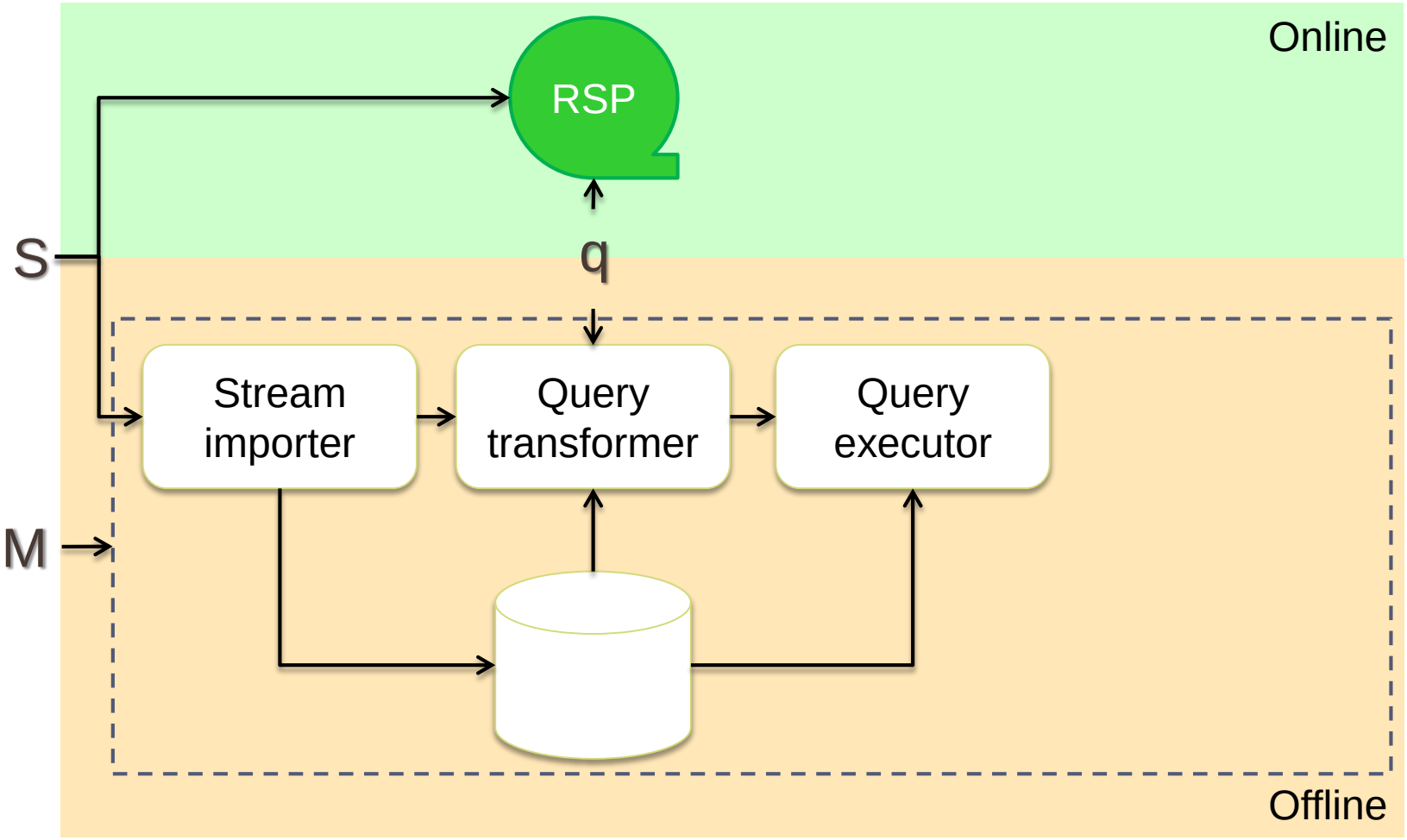
The oracle



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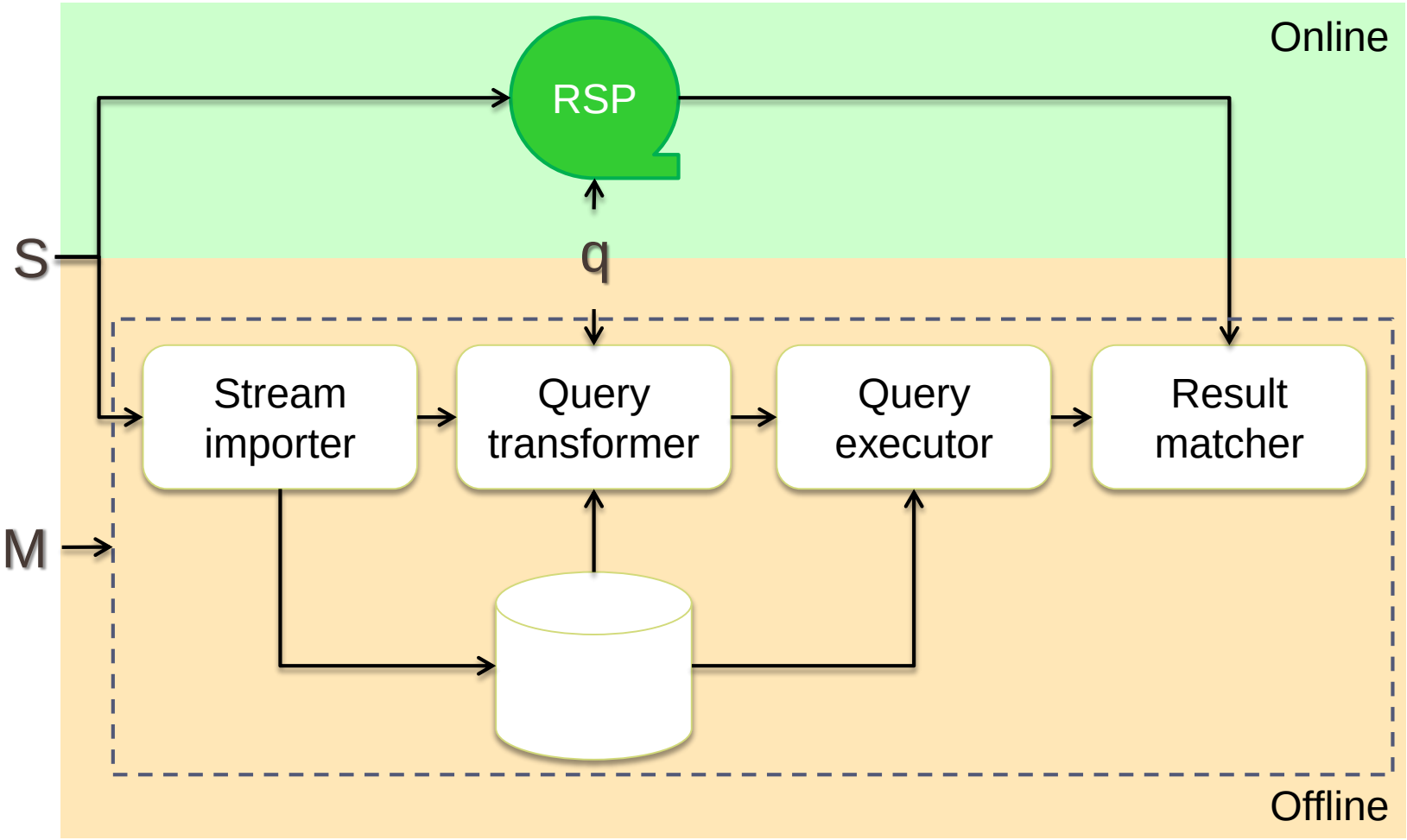
The oracle



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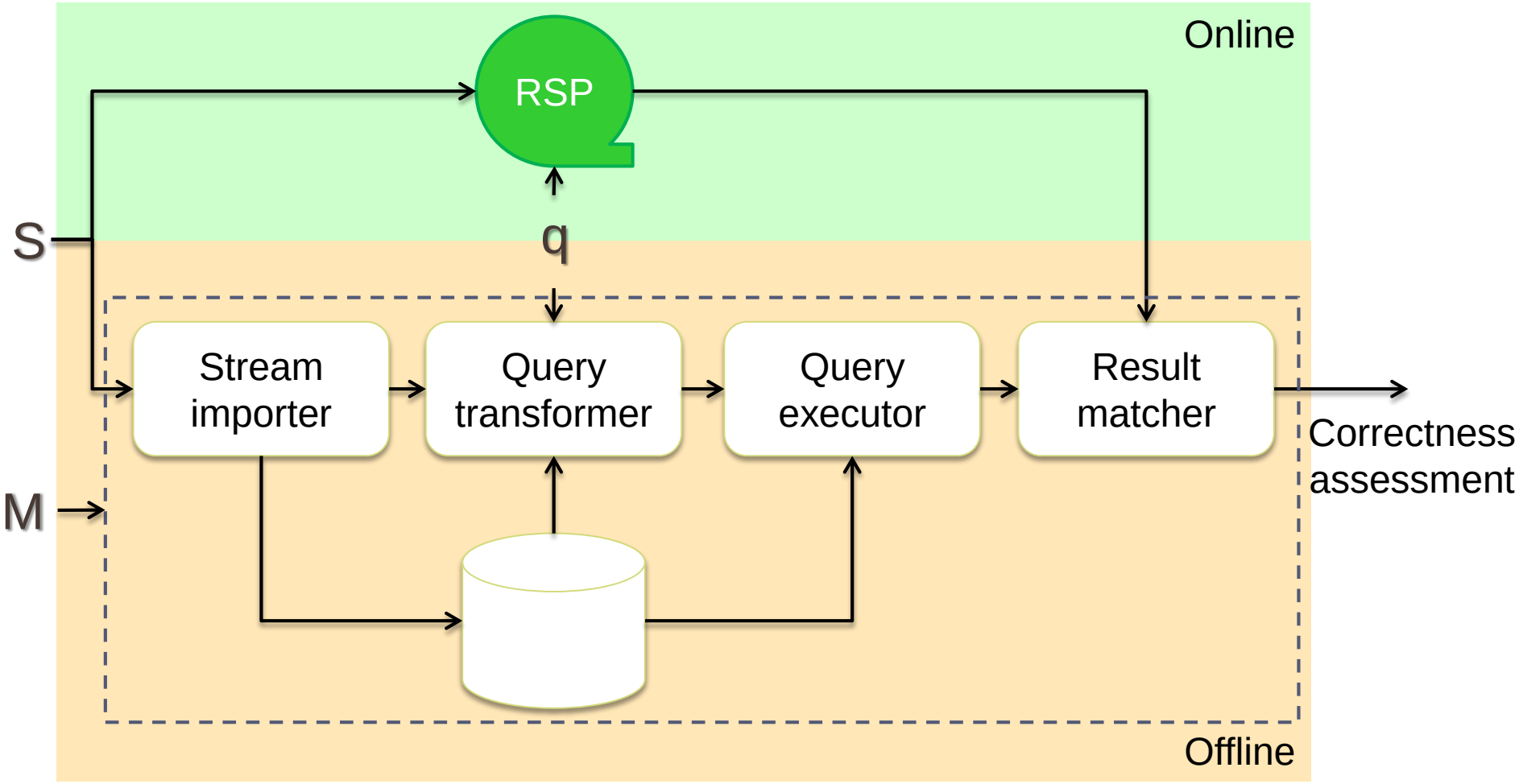
The oracle



Available at: https://github.com/dellaglio/csrbench-ora
(Apache 2.0 licence)

Design of the tests

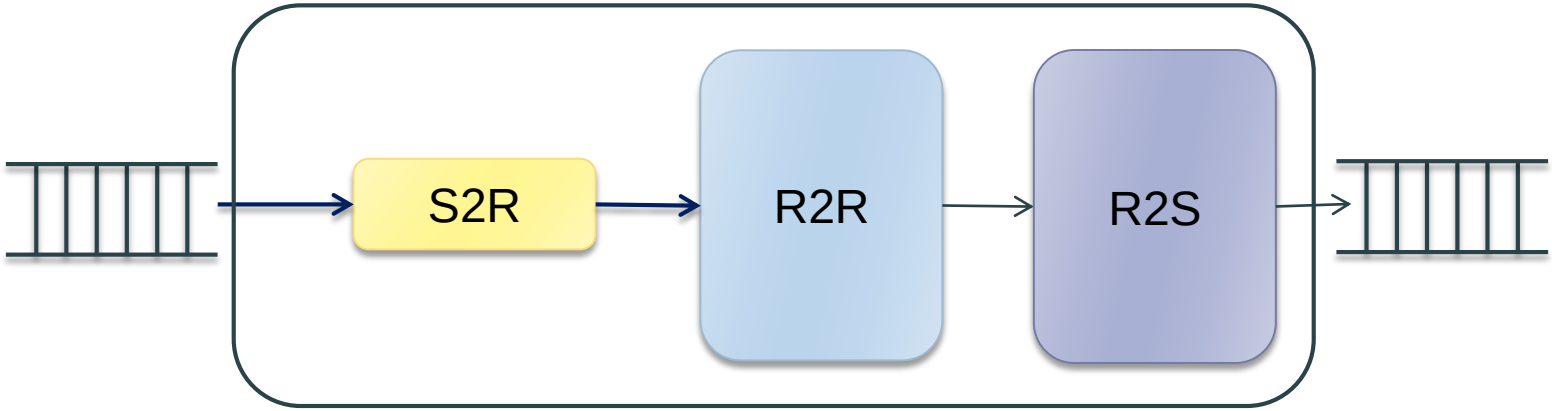
- As data set, we consider the LinkedSensorData data set
  - Data stream describing blizzards and hurricanes in the US
- We designed the query set taking into account
  - Window size and slide parameters
  - Presence of aggregation operators
  - Joins of timestamped triples
- We collected a set of seven parametrized queries
- The list of the queries and their explanation is available at: http://www.w3.org/wiki/CSRBench

Results

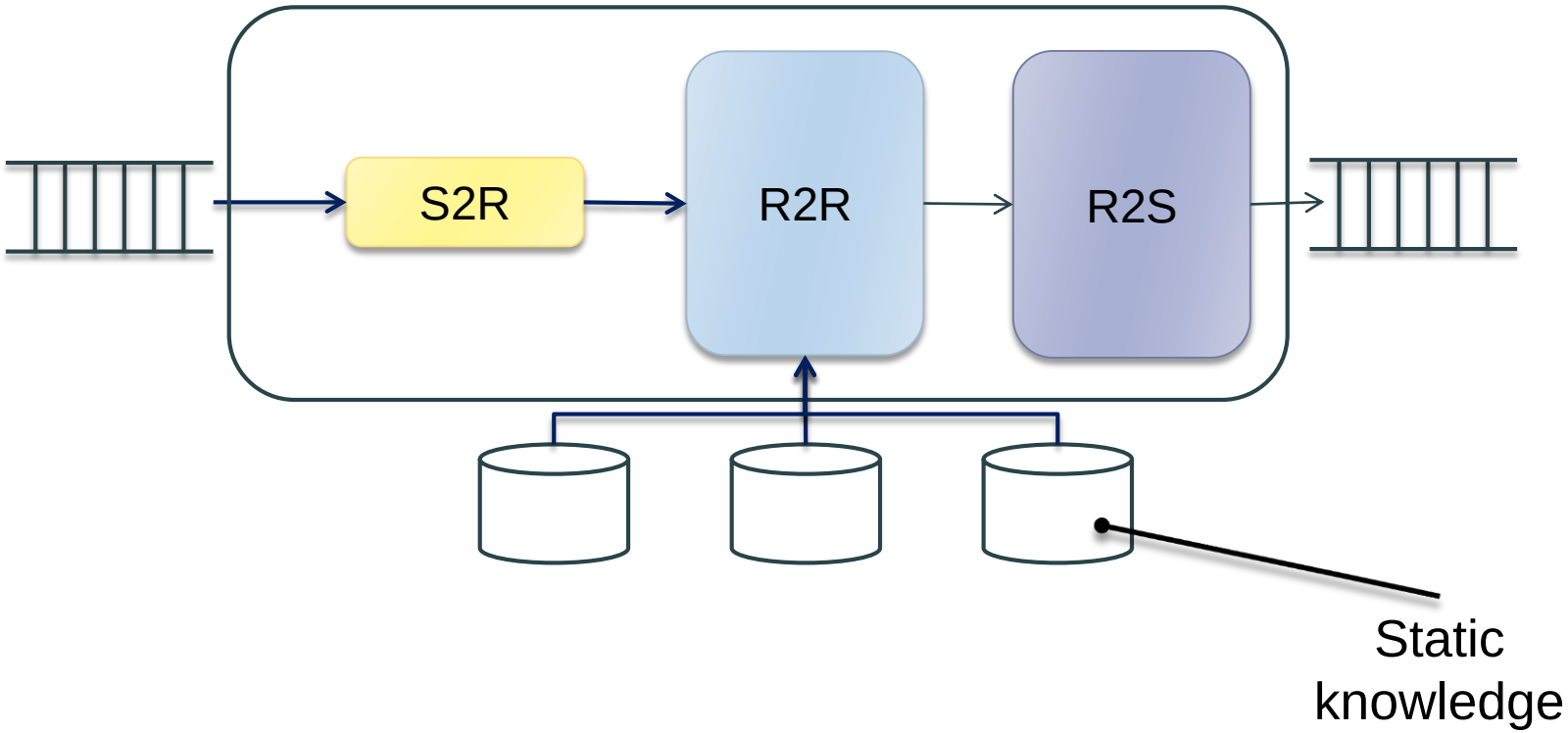
- All the three systems that we considered in our experiments showed wrong behaviours
- The defects we identified are related to:
  - the window operator
    - Initialization
    - Slide parameter
    - Window contents
  - timestamps of the triples
    - Internal timestamp management

	CQELS	C-SPARQL	SPARQL$_{stream}$
Q1			
Q2			
Q3			
Q4			
Q5			
Q6			
Q7			

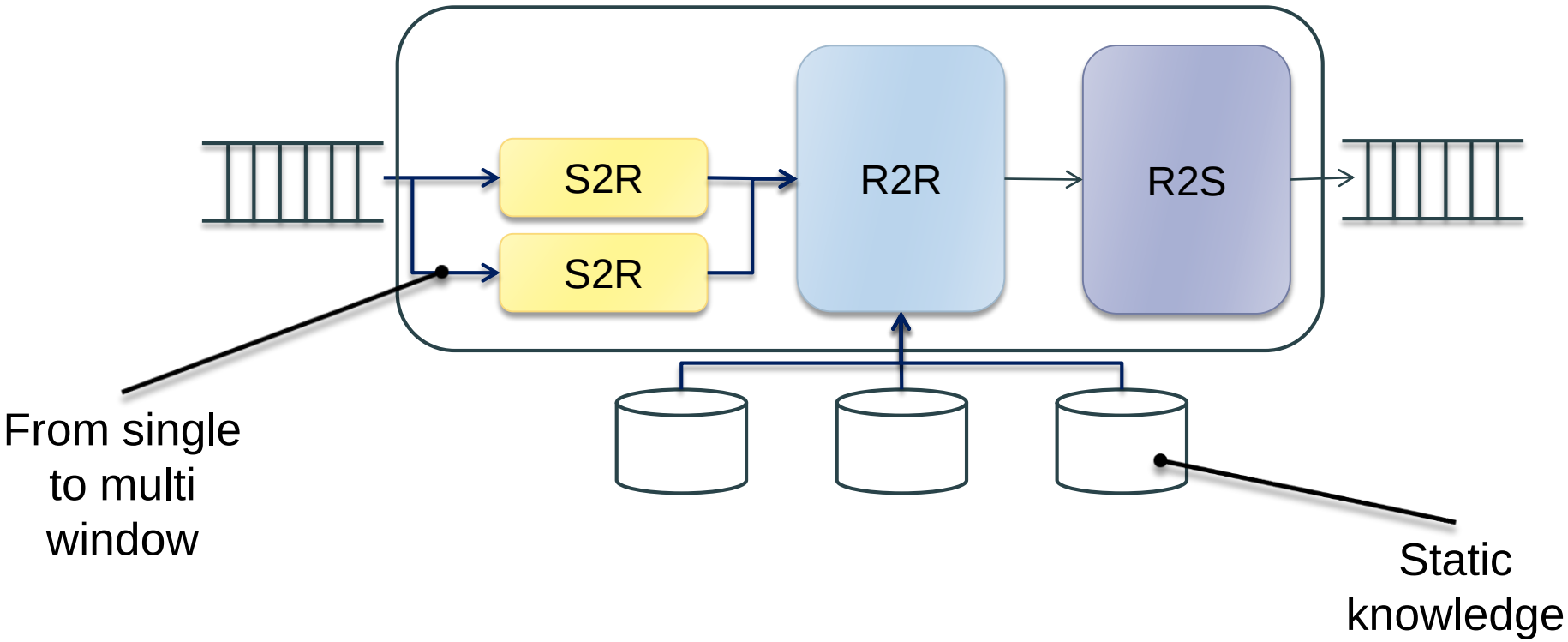
(Removable) constraints



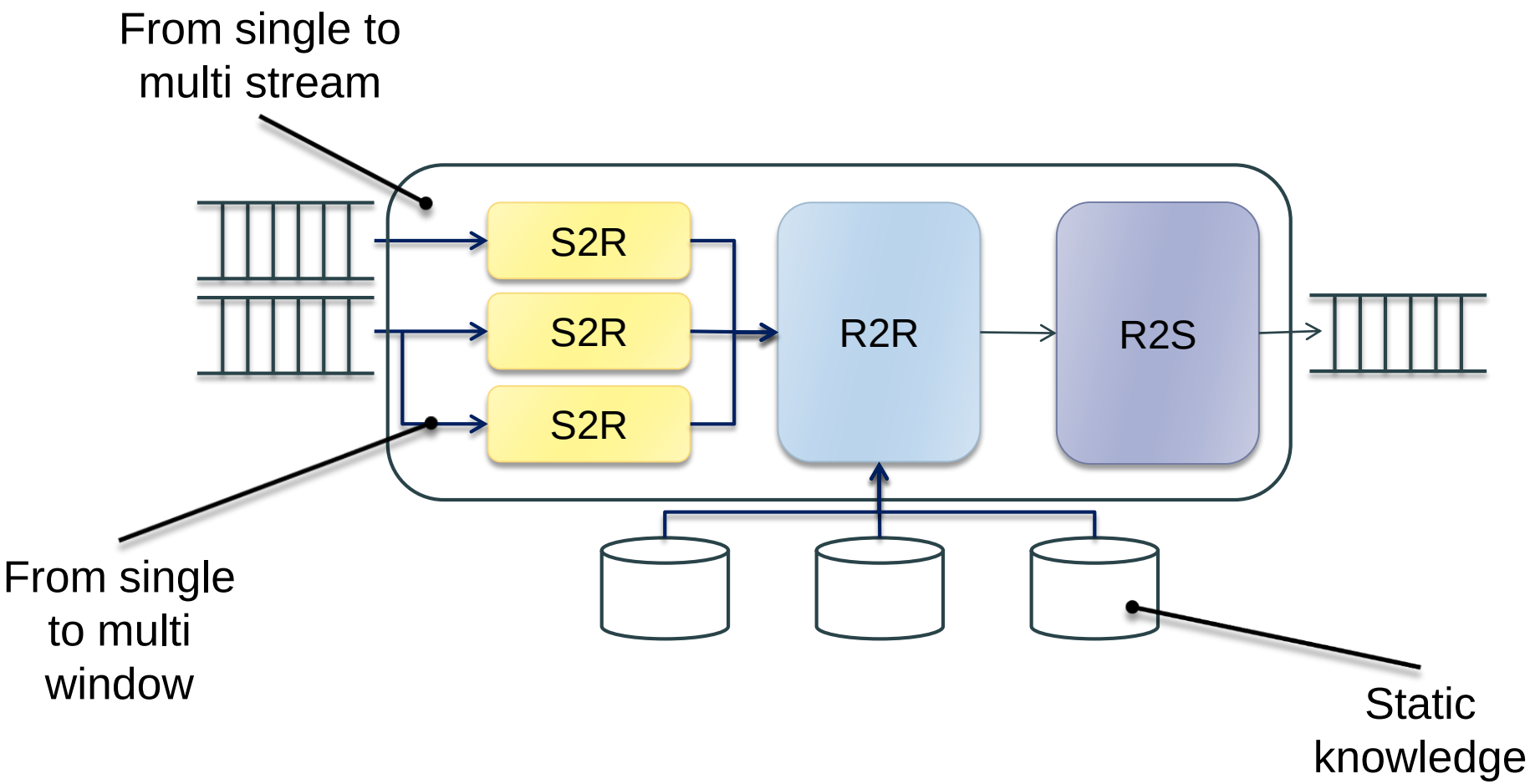
(Removable) constraints



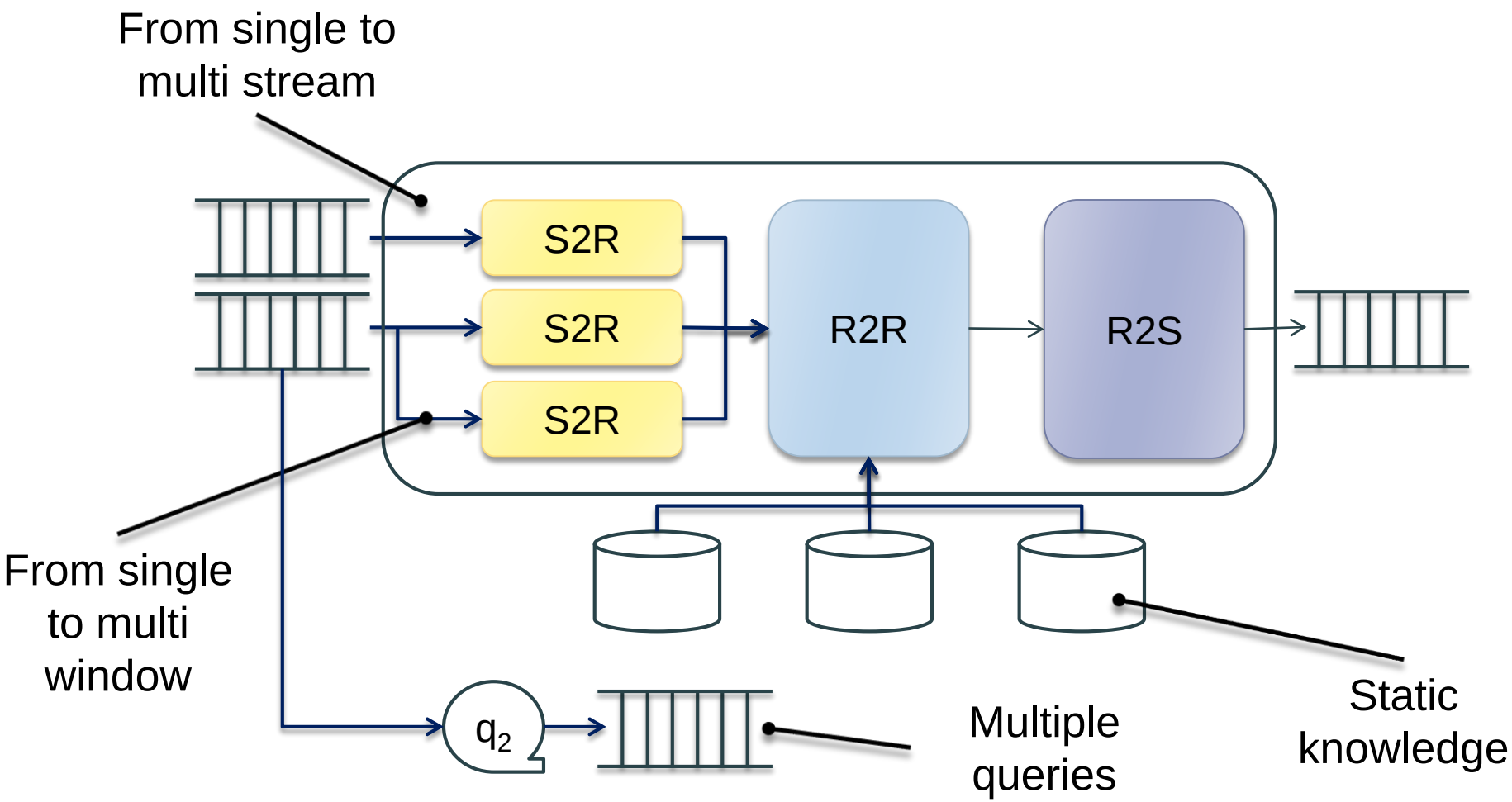
(Removable) constraints



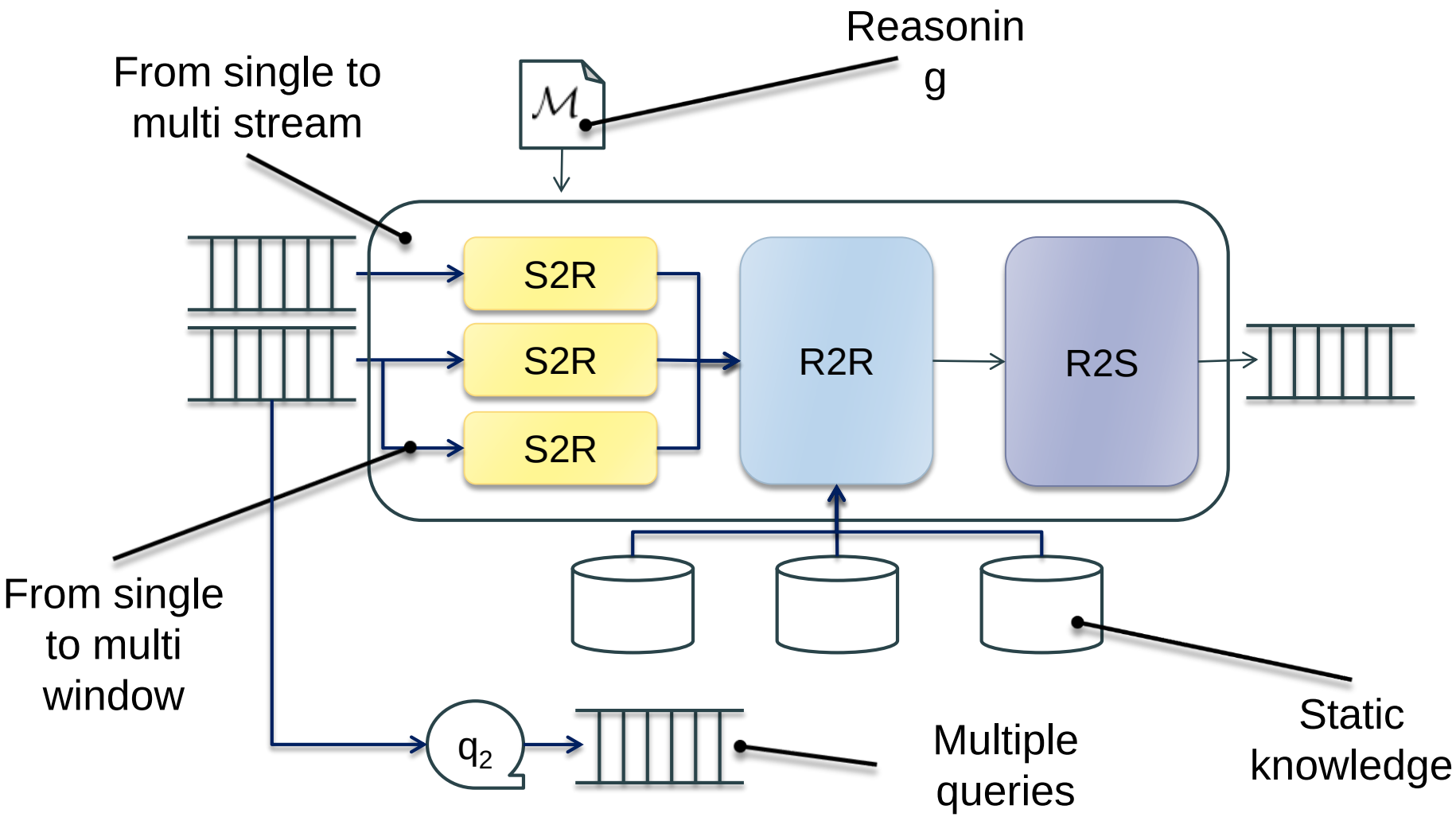
(Removable) constraints



(Removable) constraints



(Removable) constraints



Conclusions

- A **model** that describes in a **more accurate** way the RSPs' **operational semantics** helps their improvement:
  - Better design of the system
  - Prediction of the expected behaviours
- A **common and shared test environment** helps developers of both existing and upcoming RSPs
  - It becomes easier to set up experiments to detect defects and to correct them
- Possible **improvements** of the **existing benchmarks** (e.g., SRbench and LSBench)
  - Design of new tests
  - Better interpretation of the experiment results

Thank you! Questions?

On correctness in RDF stream processor benchmarking

Daniele Dell'Aglio (DEIB, Politecnico di Milano)

Jean-Paul Cabilmonte (OEG, Universidad Politécnica de Madrid)

Marco Balduini (DEIB, Politecnico di Milano)

Oscar Corcho (OEG, Universidad Politécnica de Madrid)

Emanuele Della Valle (DEIB, Politecnico di Milano)

wiki: http://www.w3.org/wiki/CSRBench

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