Stream Reasoning For Linked Data

M. Balduini, J-P Calbimonte, O. Corcho,
D. Dell'Aglio, E. Della Valle, and J.Z. Pan

http://streamreasoning.org/sr4ld2013

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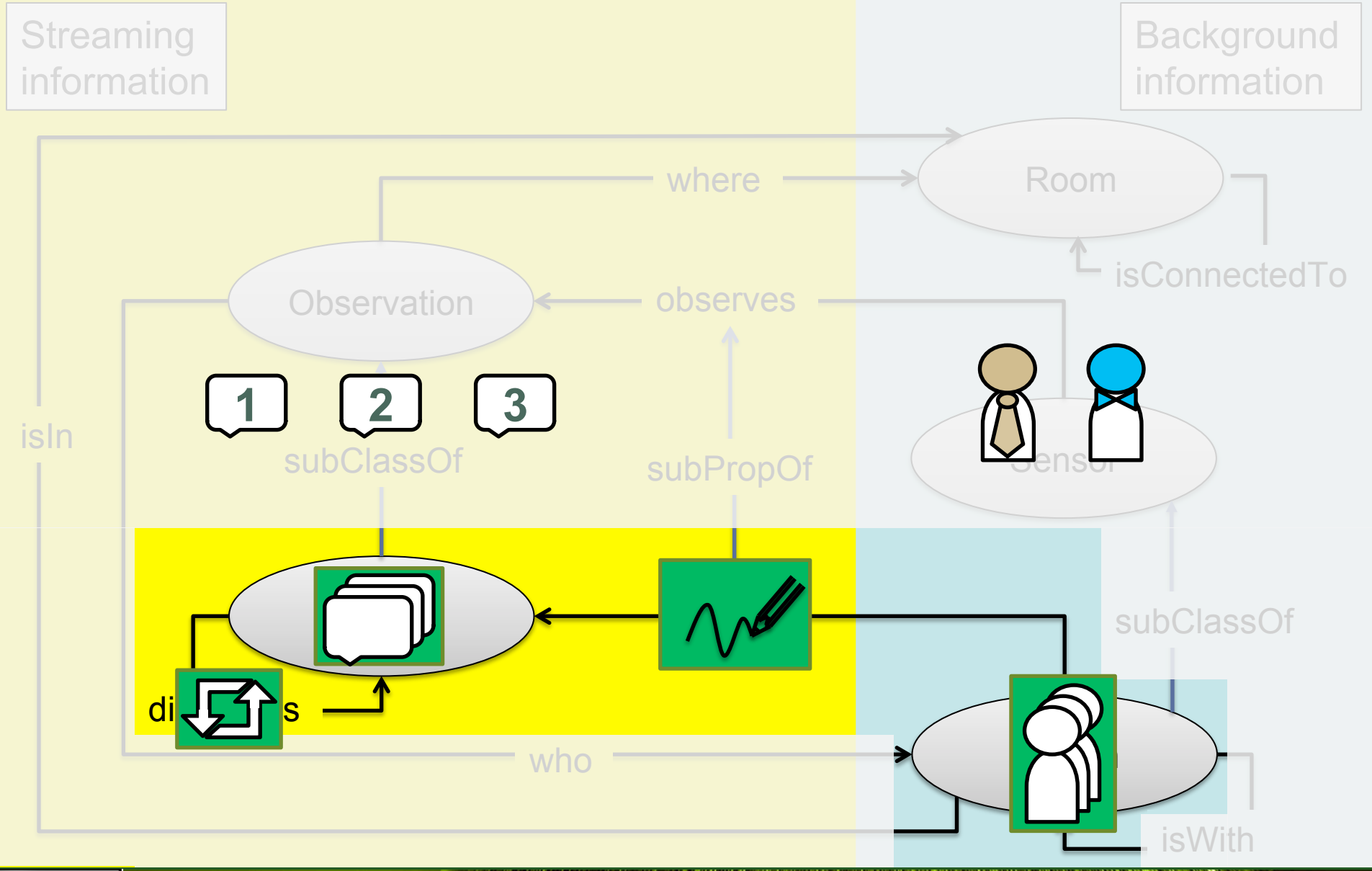
IMaRS: Incremental Materialization for RDF Streams

Daniele Dell'Aglio and Emanuele Della Valle

Running Example – Data Model



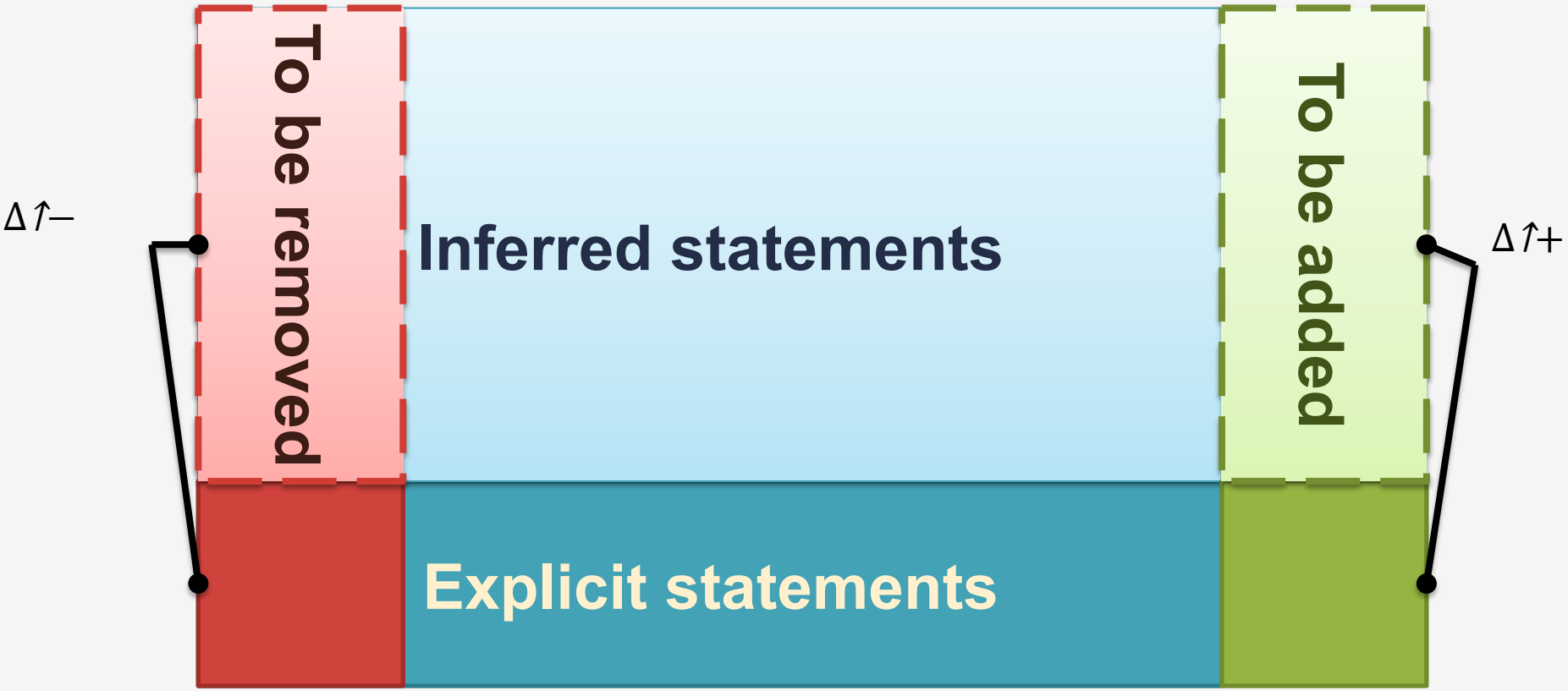
What

- Add reasoning in window-based RSPs
- Naïve solution: materialize everything, every time
- But windows slide:
  - The materialisation is executed every time the window updates
  - Only part of data changes at each window update
  - Materialisation is (usually) an expensive task

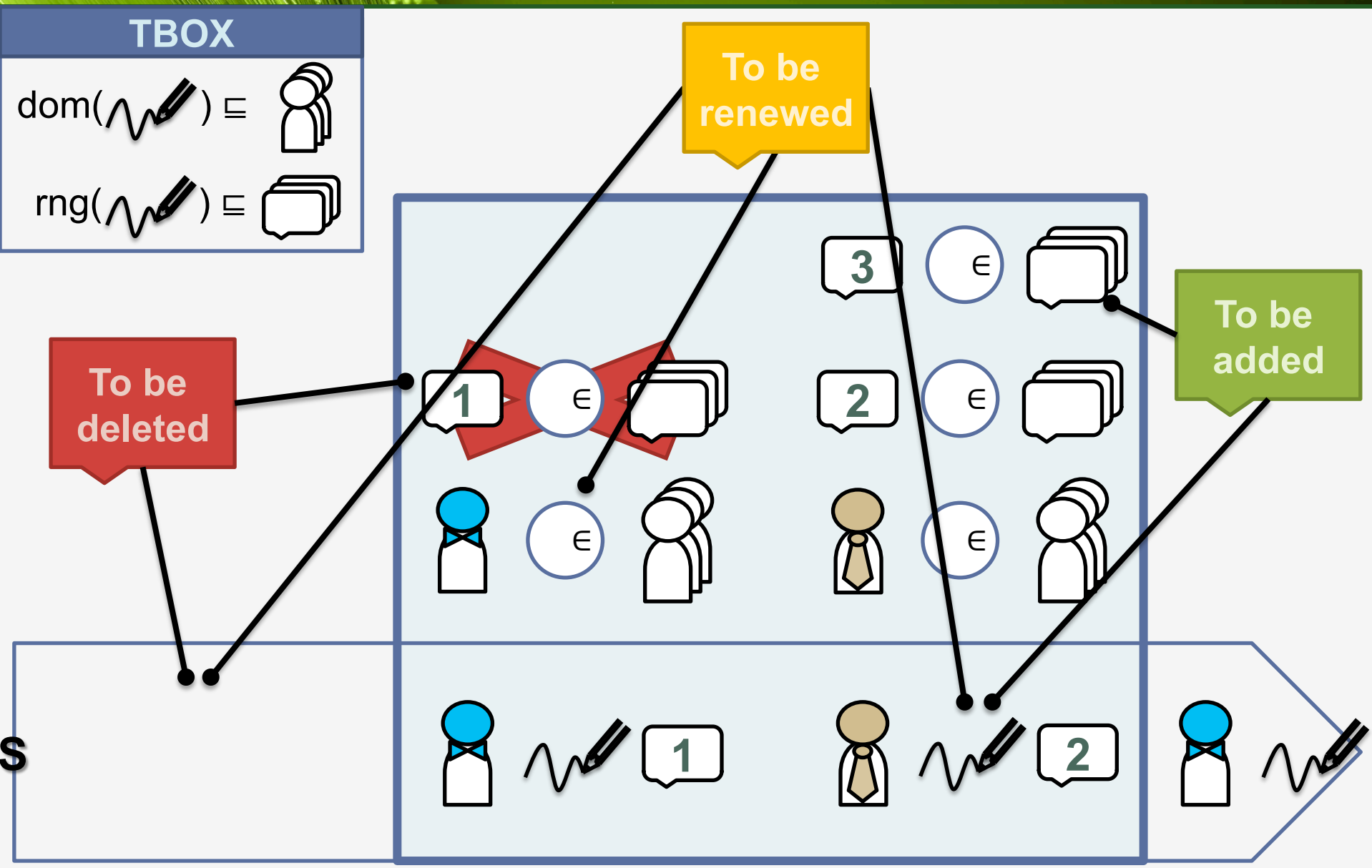
Naïve solution: an example

Incremental maintenance

- Adopt an incremental approach
- Compute only the differences that should be removed and added from the materialization



Incremental maintenance: an example



Which technique?

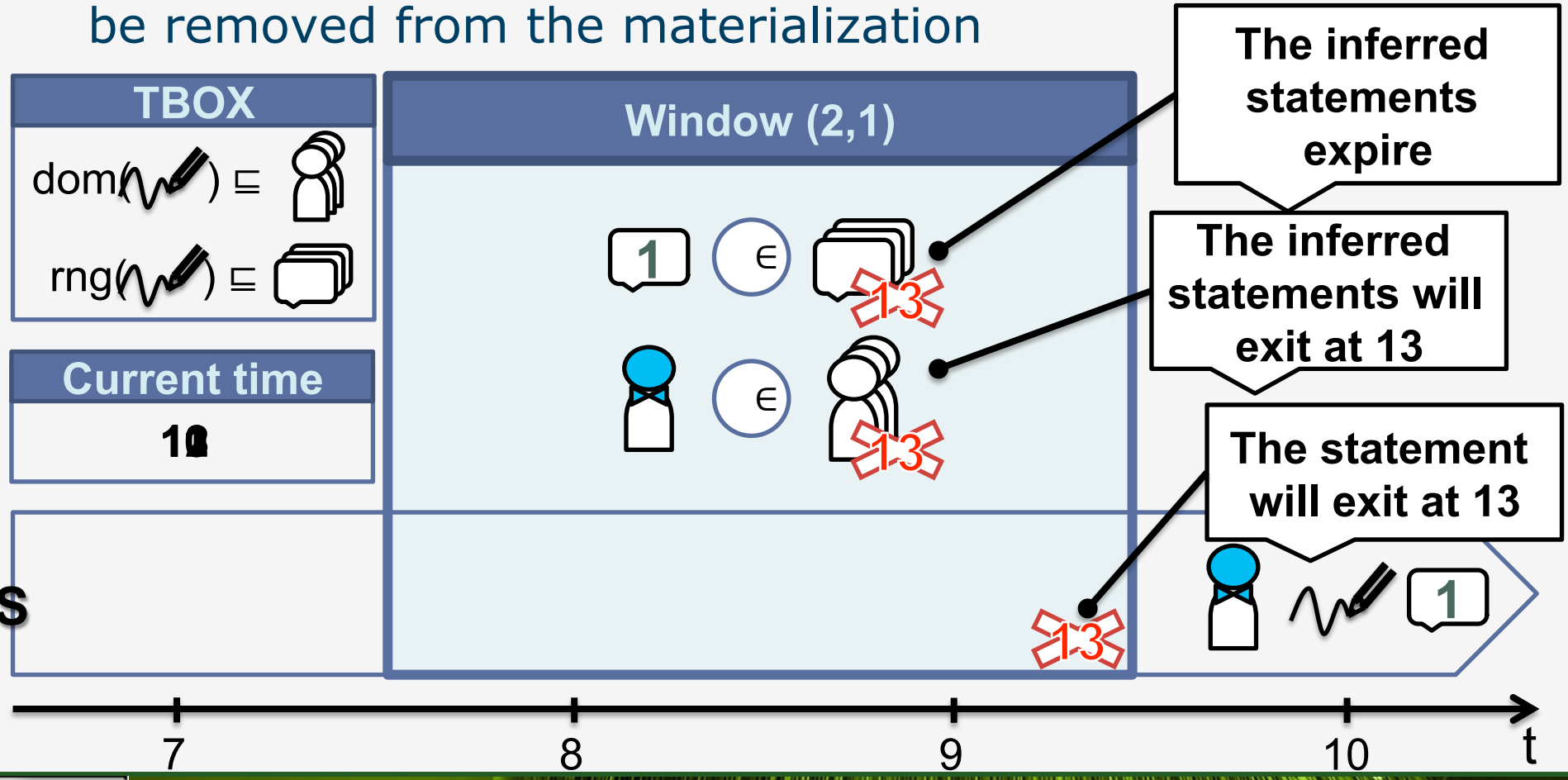
- The common problem in designing incremental maintenance techniques is in the management of **deletions**
- In general it is not possible to foresee the statement deletions
  - DRed works with random insertions and deletions
- In our setting it is possible
  - The window operator allow us to determine when statements will be removed

IMaRS

- Variation of DRed for RDF streams
- It pushes the maintenance algorithm in the window operator
- An IMaRS window is a sliding window with four parameters:
  - ω: the size of the window
  - β: the slide of the window
  - T: the TBox that describes the data model
  - M: the mantinance program
- One of the central IMaRS concepts is the **expiration time**

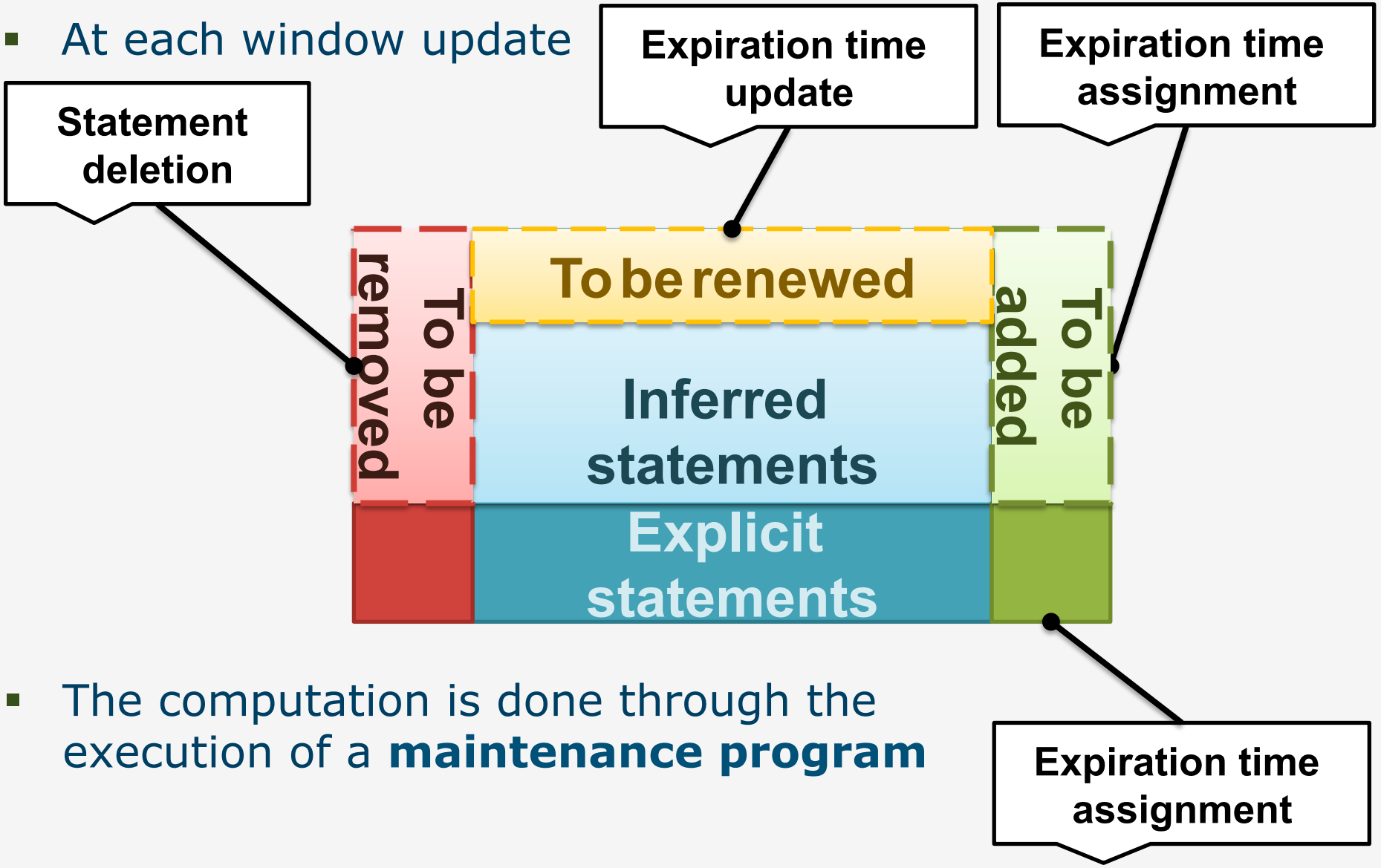
Expiration time

- Every time a statement is added to the window, it is annotated with an **expiration time**
- The expiration time indicates when the statement should be removed from the materialization



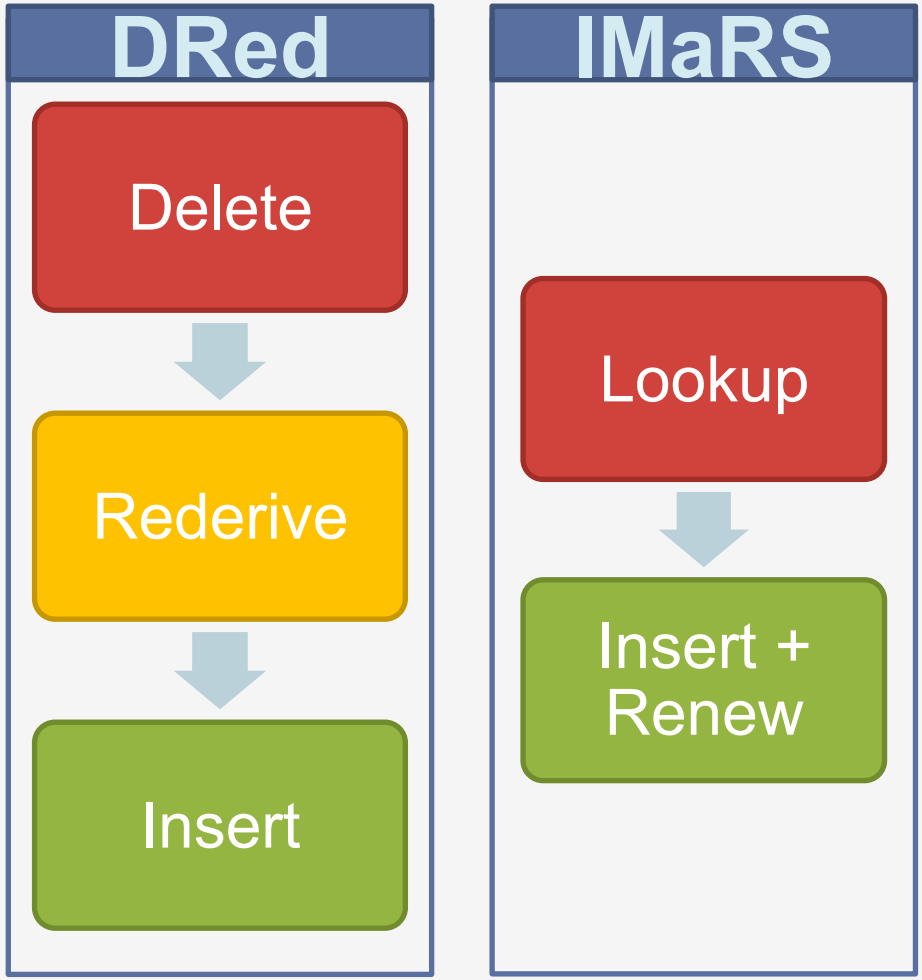
Expiration time generation

- At each window update



- The computation is done through the execution of a **maintenance program**

IMaRS at a glance



IMaRS maintenance program

- The maintenance program computes the delta sets $\Delta^{\uparrow}_{-}$ and $\Delta^{\uparrow}_{+}$
  - It is a **logic program**
- The program is executed every time the content changes
  - In our context, the program is executed every time the window slides
- The program is composed by **maintenance rules**
  - A maintenance rule adds a statement in a set (**context**) if the preconditions are satisfied

IMaRS contexts

- The maintenance program uses four contexts to build the delta sets $\Delta^{\uparrow}-$ and $\Delta^{\uparrow}+$
  - *Mat*: the current materialization
  - *Ins*: the input that enters the stream and the related inferred statements
- Additionally, two support sets are used:
  - *New*: statements to be added to the materialization
  - *Ren*: renewed statements
- The new materialization is computed as

$$Mat \cup \Delta^{\uparrow}+ \setminus \Delta^{\uparrow}-$$

IMaRS maintenance rules

- Two examples of maintenance rules:

Δ^{-}(?s,?p,?o)[e]← *Mat*(?s,?p,?o)[e] .
e < now

A triple is removed by the materialization when its expiration time expires

Ins(?x,?p,?z)[e]← *New*(?x,?p,?y)[e1].
Ins(?x,?p,?y)[e2] . *Ins*(?
p,isA,TransitiveProperty)[e3].
e=min{e1,e2,e3}

When a triple <*s,p,o*> enters the window, *p* is transitive and there is a triple <*o,p,k*> in the *Ins* context, then the triple <*s,p,k*> is a candidate for the addition in the materialization

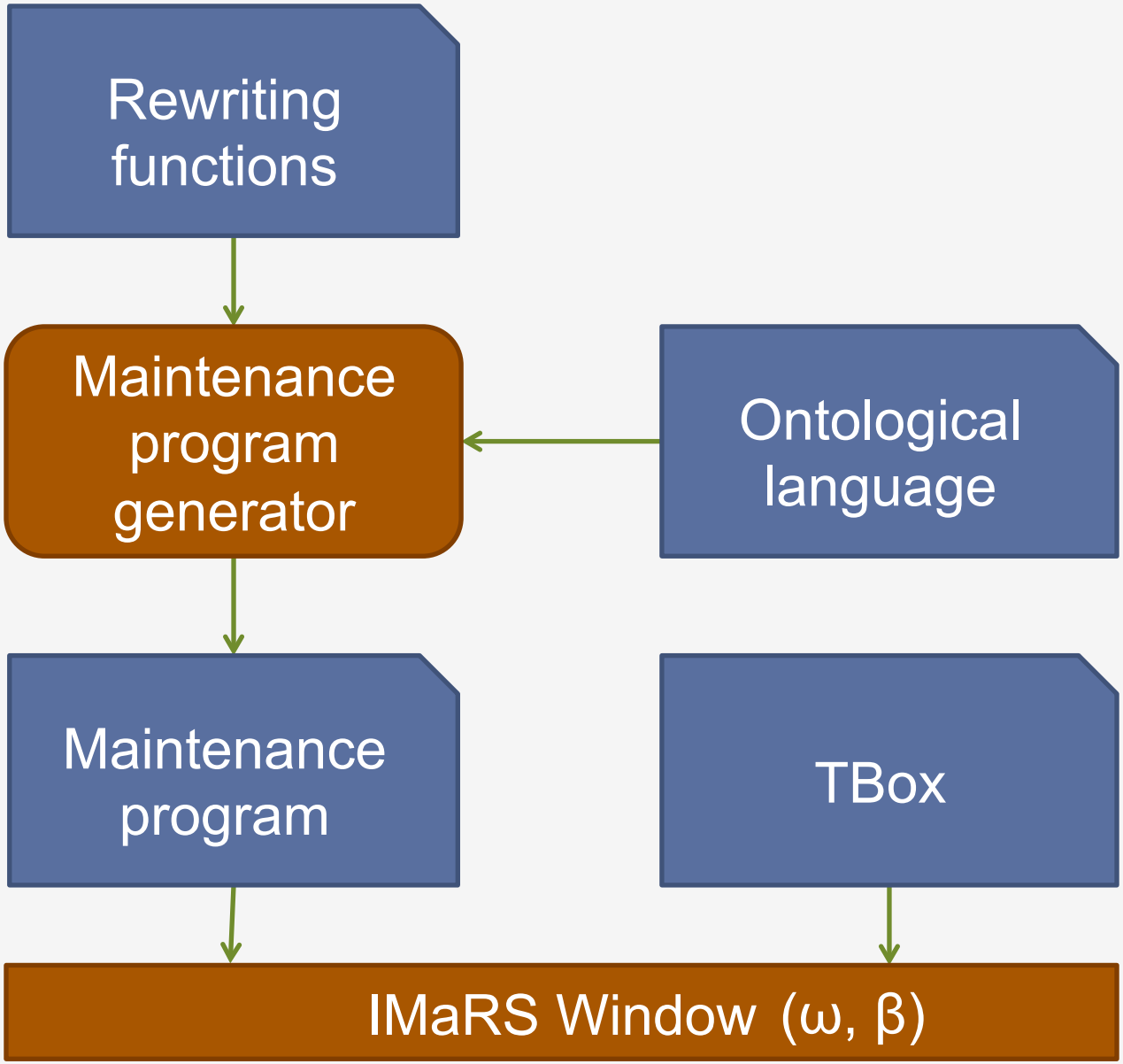
IMaRS maintenance program

- The maintenance program is composed by two sets of maintenance rules:
  - One set of fixed maintenance rules
  - One dependent on the ontological language
- The ontological language should be expressed as a set of inference rules, e.g.

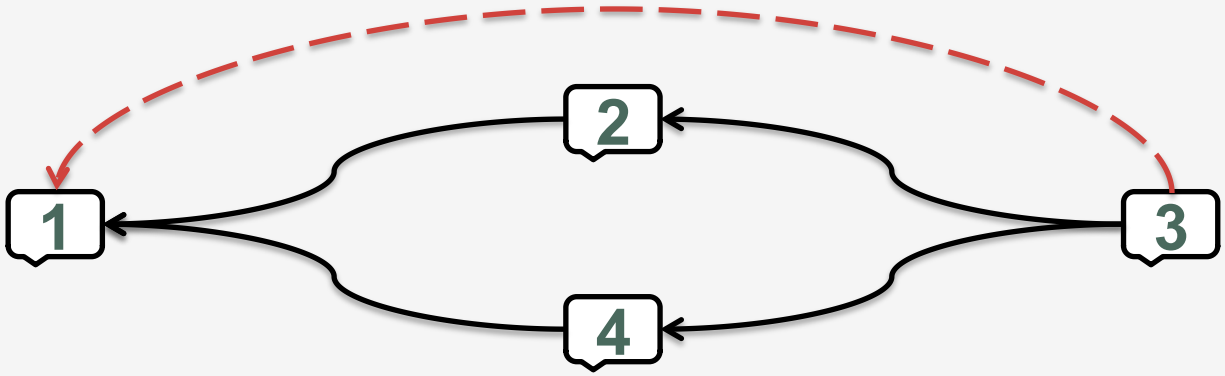
```
T(?x, ?p, ?z) :-
T(?p, rdf:type, owl:TransitiveProperty),
T(?x, ?p, ?y), T(?y, ?p, ?z)
```

- It does not depend on the TBox!

Generation of the maintenance program



Example: DRed



Delete

Rederive

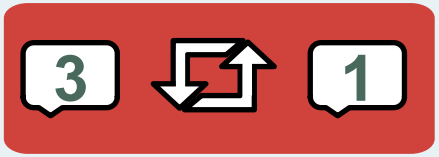
TBOX

tr()

Current time

1~~2~~

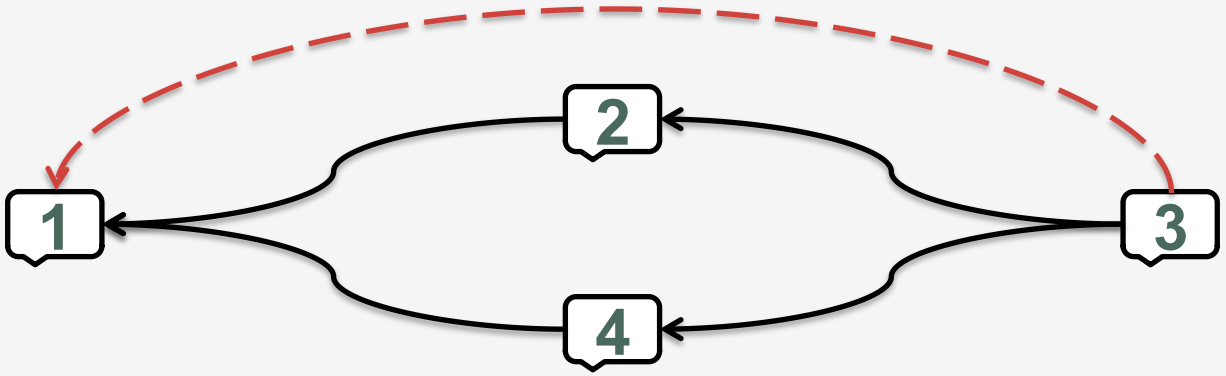
Window (3,1)

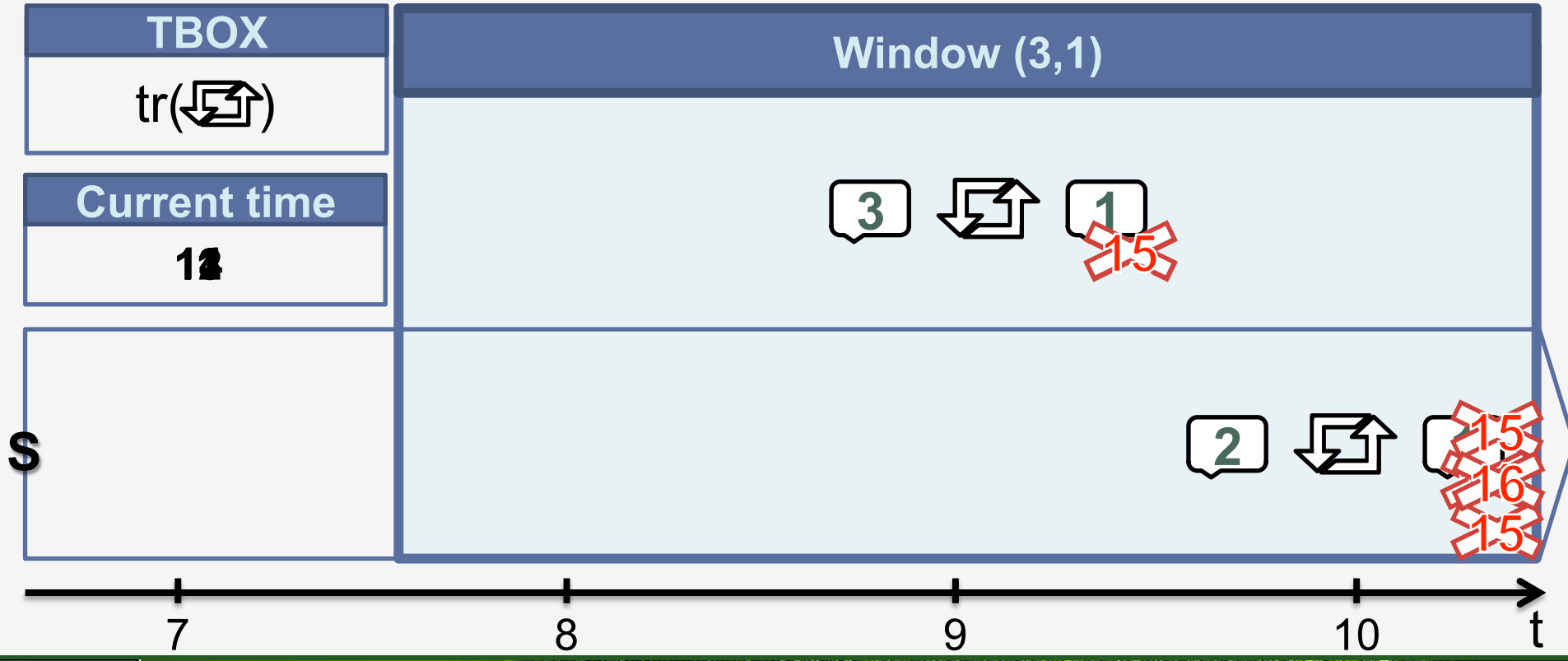


S

7 8 9 10 t

Example: IMaRS





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