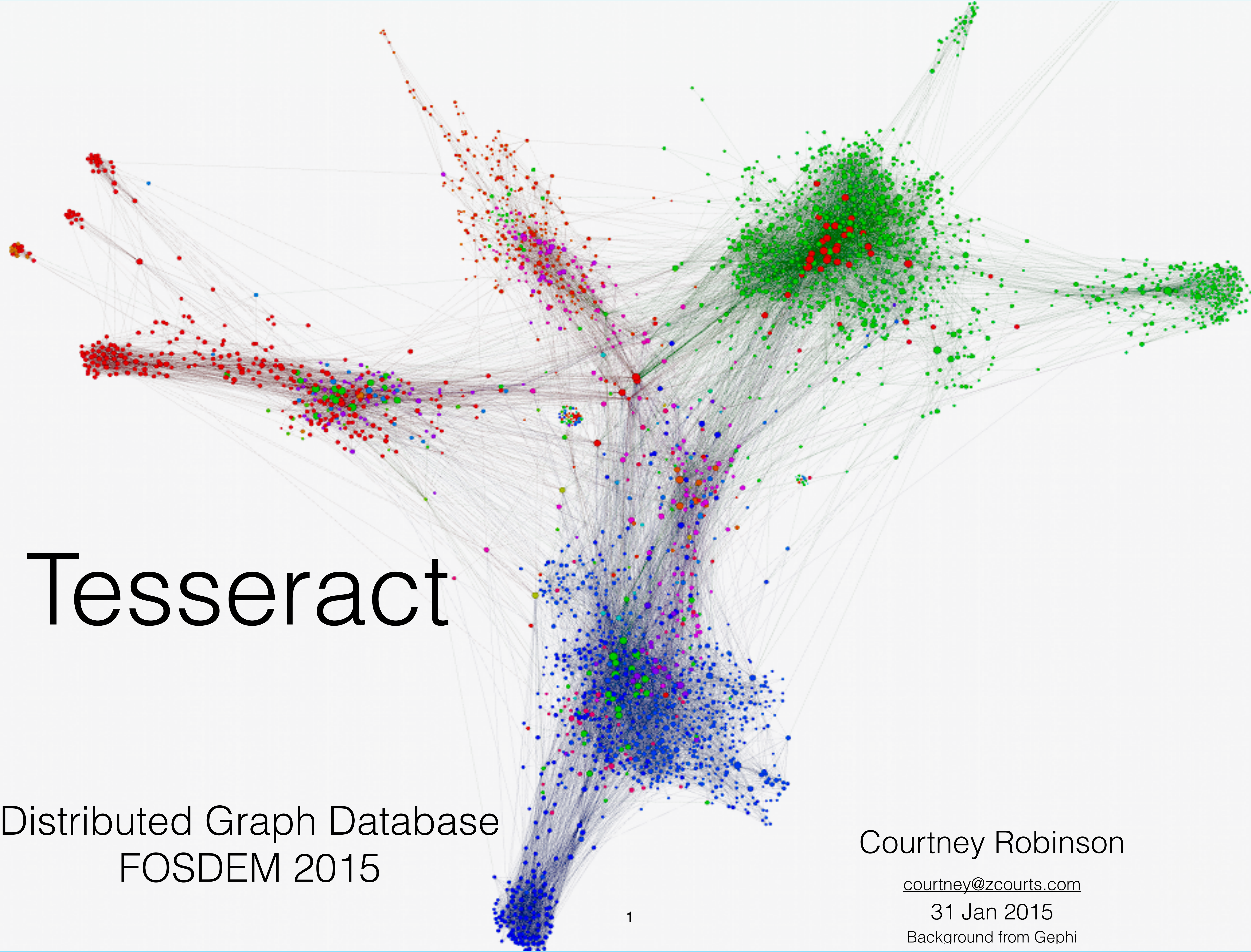


Tesseract

Distributed Graph Database
FOSDEM 2015

Courtney Robinson
courtney@zcourts.com

31 Jan 2015

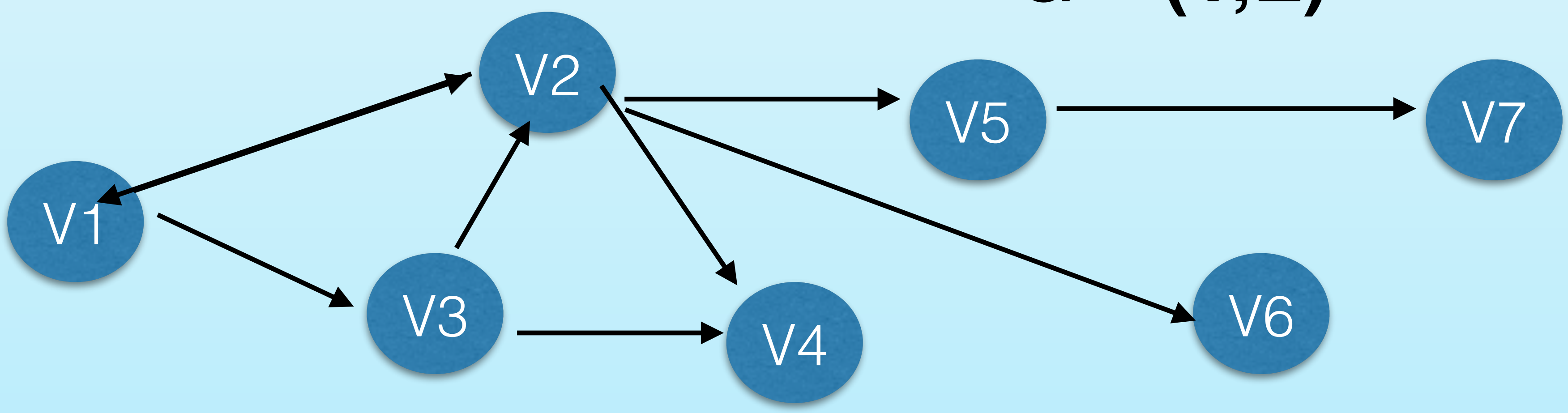
Background from Gephi

- I can be found around the web as “zcourts”, Google it…
- The web is one very prominent example of a graph
- Too big for a single machine
- So we must split or “partition” it over multiple
- Partitioning is hard…in fact, it has been shown to be np-complete
- All we can do is edge closer to more “optimal” solutions
- The Tesseract is an ongoing research project
- Its focus is on distributed graph partitioning
- The rest of this presentation is a series of solutions, which together, takes one step closer to faster distributed graph processing

Terminology

Graph - A graph G is made up of a set of vertices and edges,

G = (V,E)



Vertex - Smallest unit of user accessible datum

Edge - Connects two vertices, may have a direction

Property - Key value pair available on an Edge or Vertex

Aims of the Tesseract

1. Implement distributed eventually consistent graph database

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i.e provably eventually consistent (Shapiro et al) replicated & distributed data structures.

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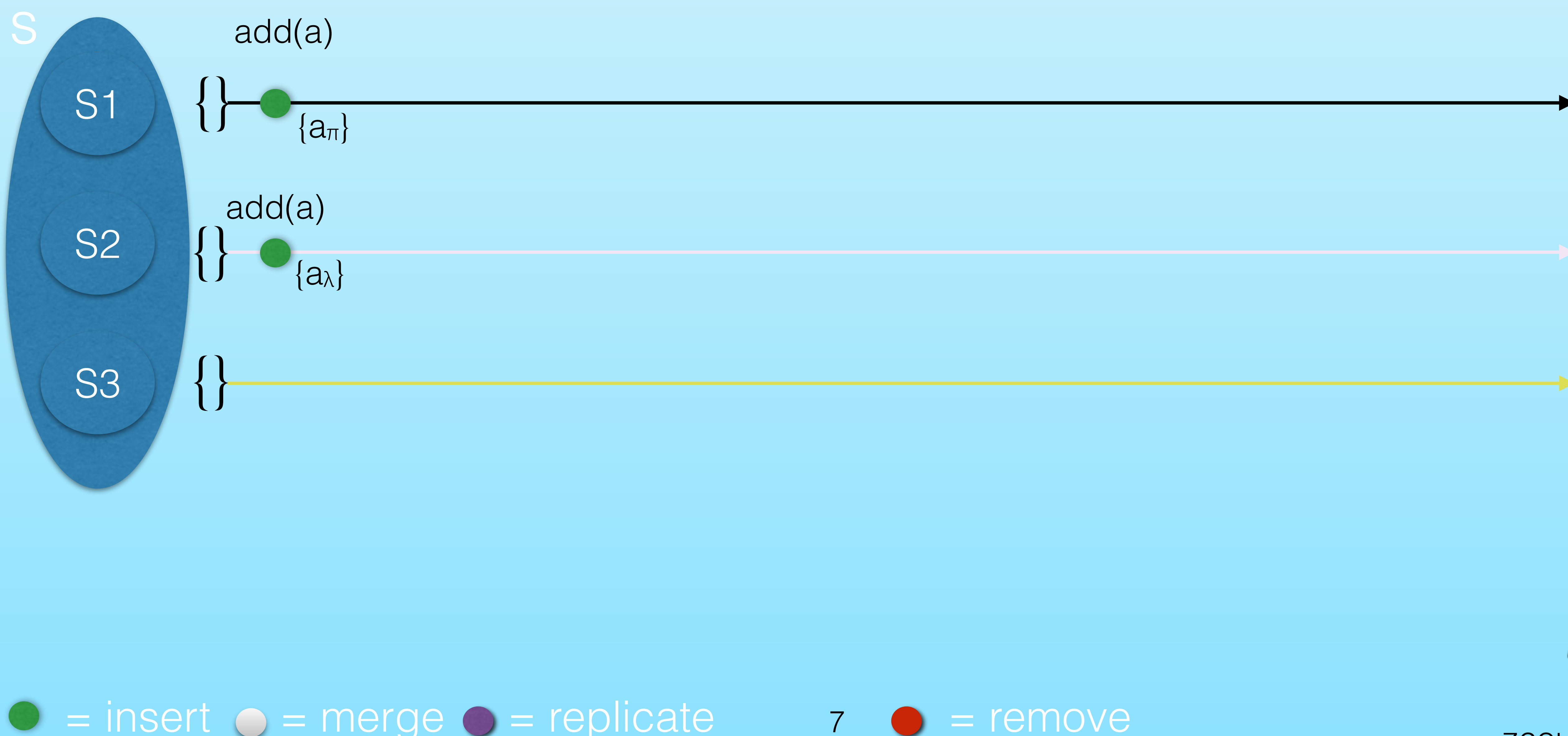

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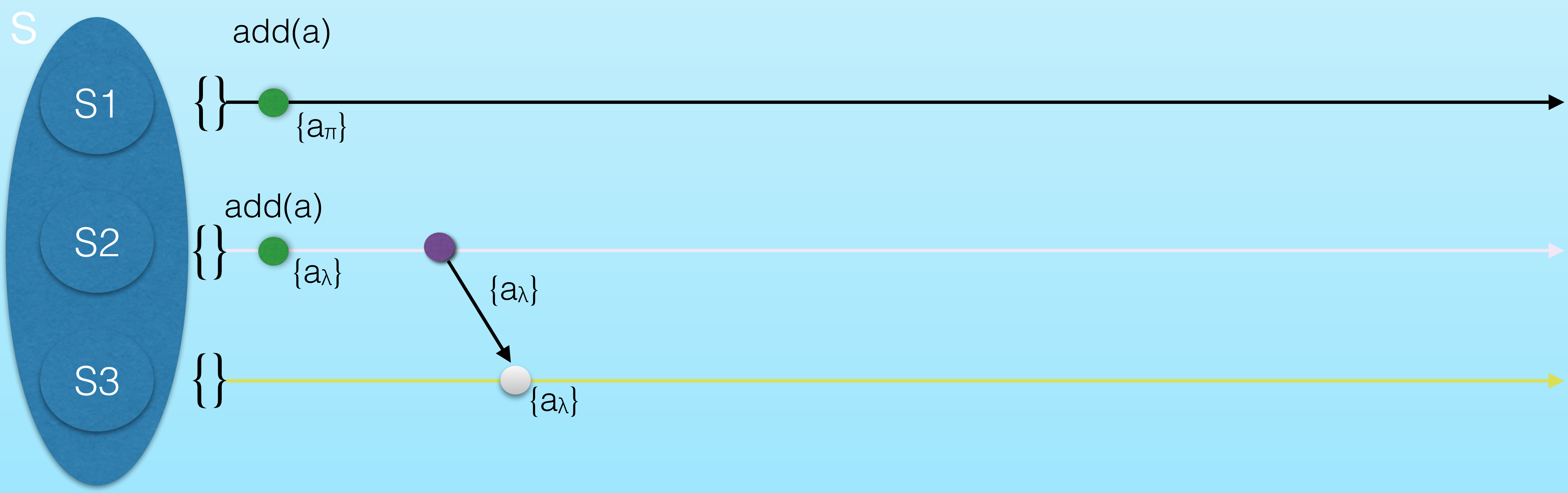

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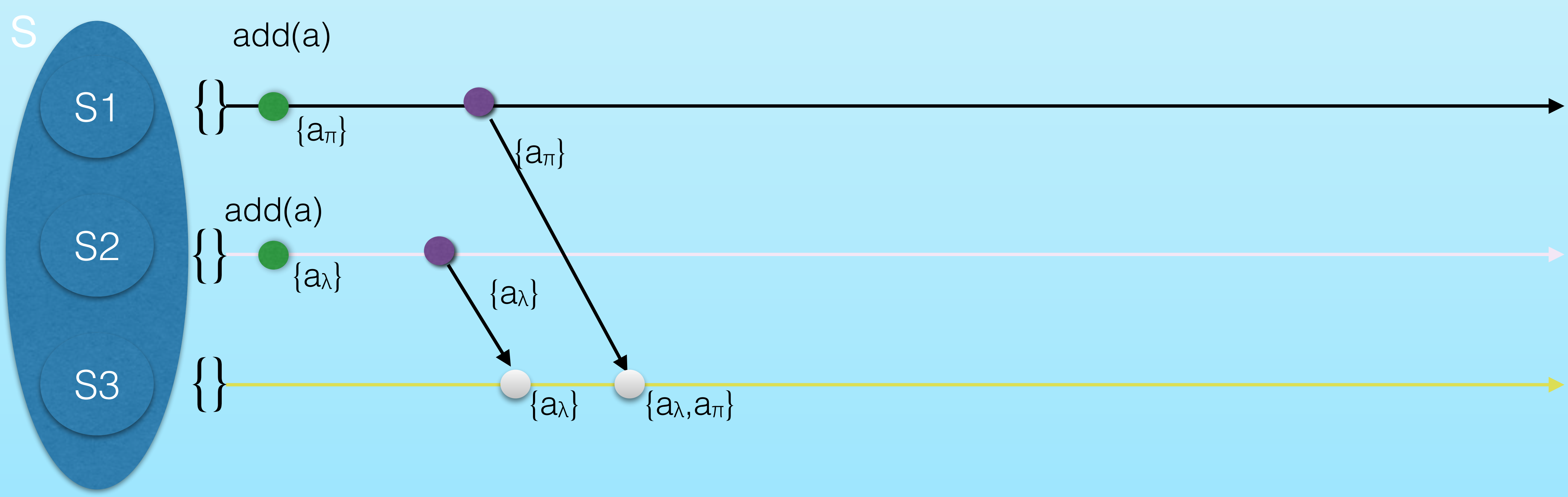

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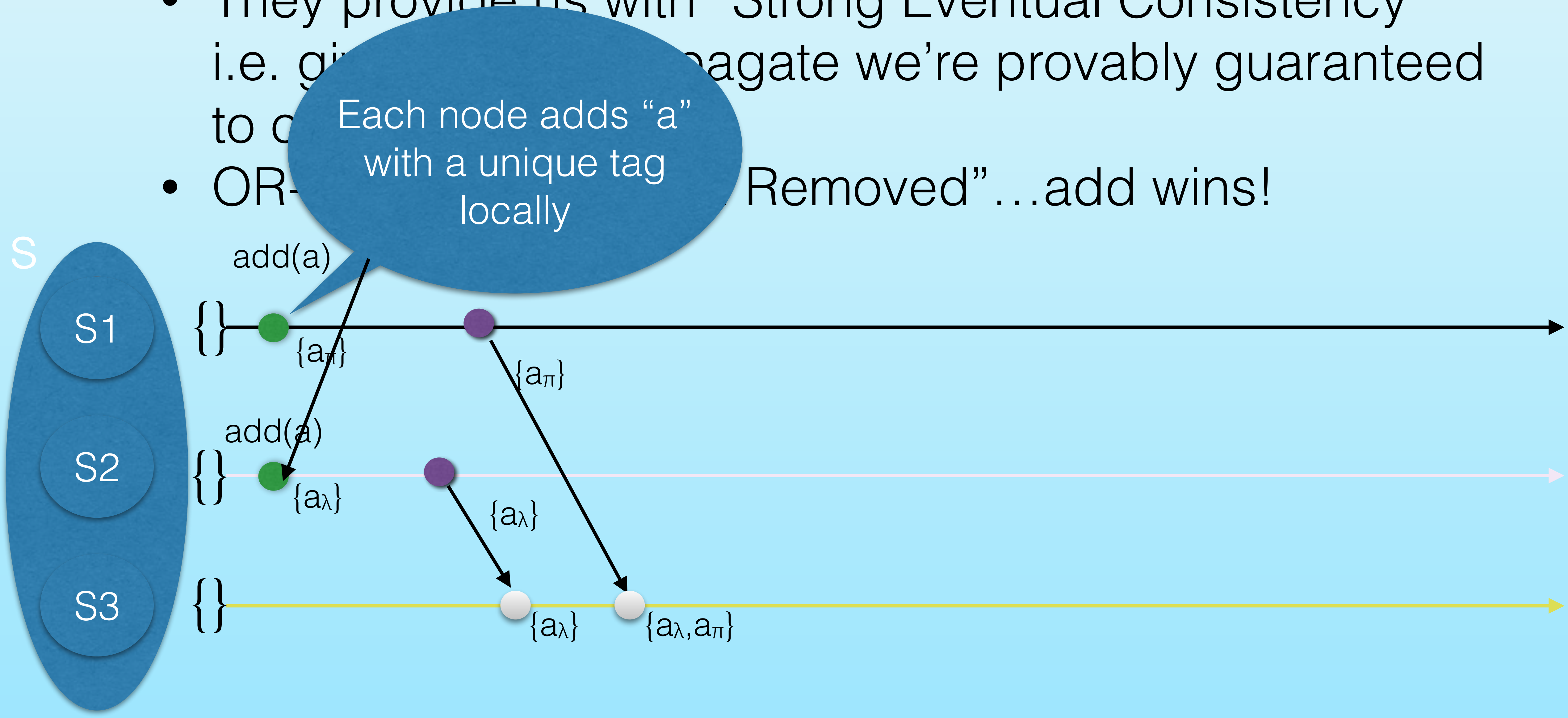

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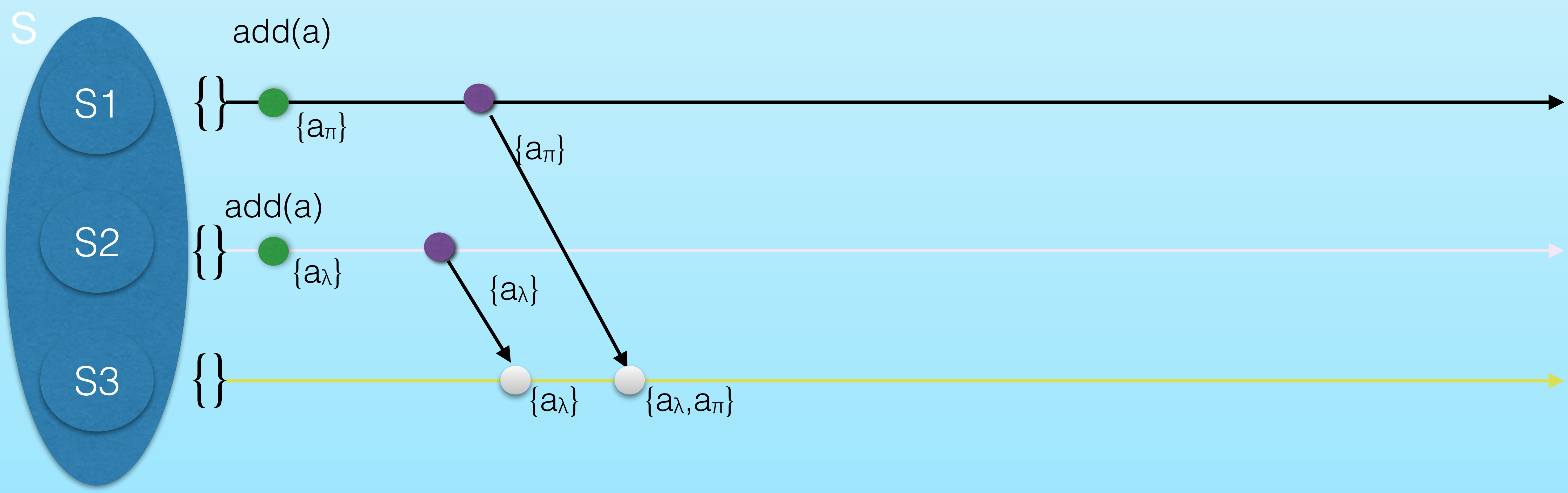

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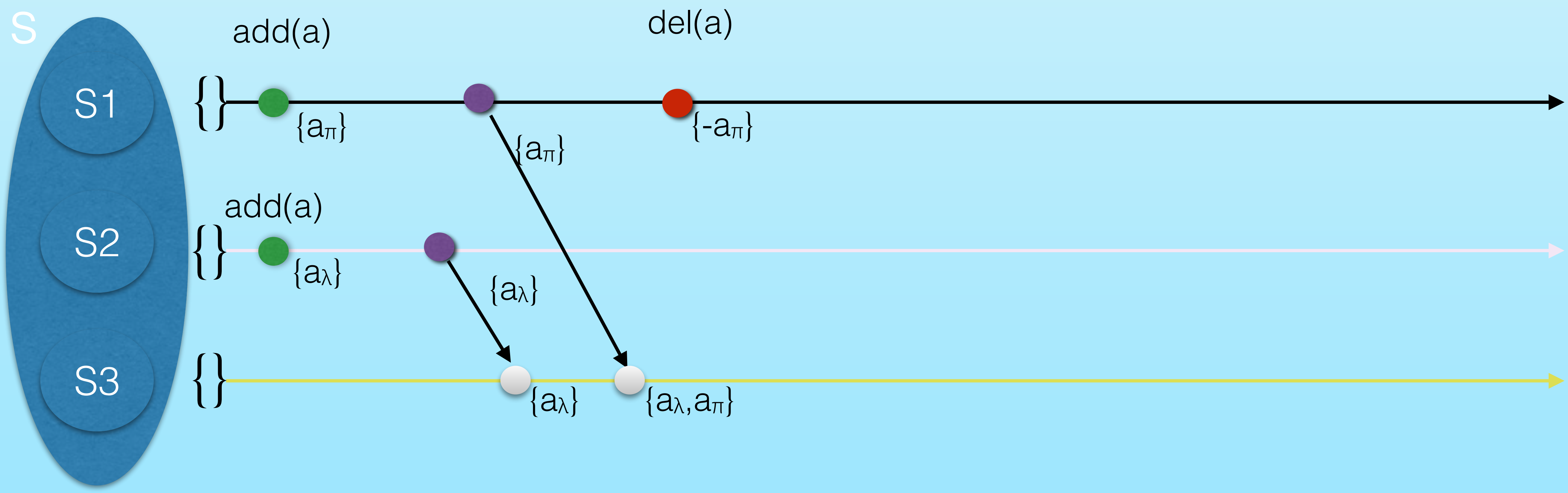

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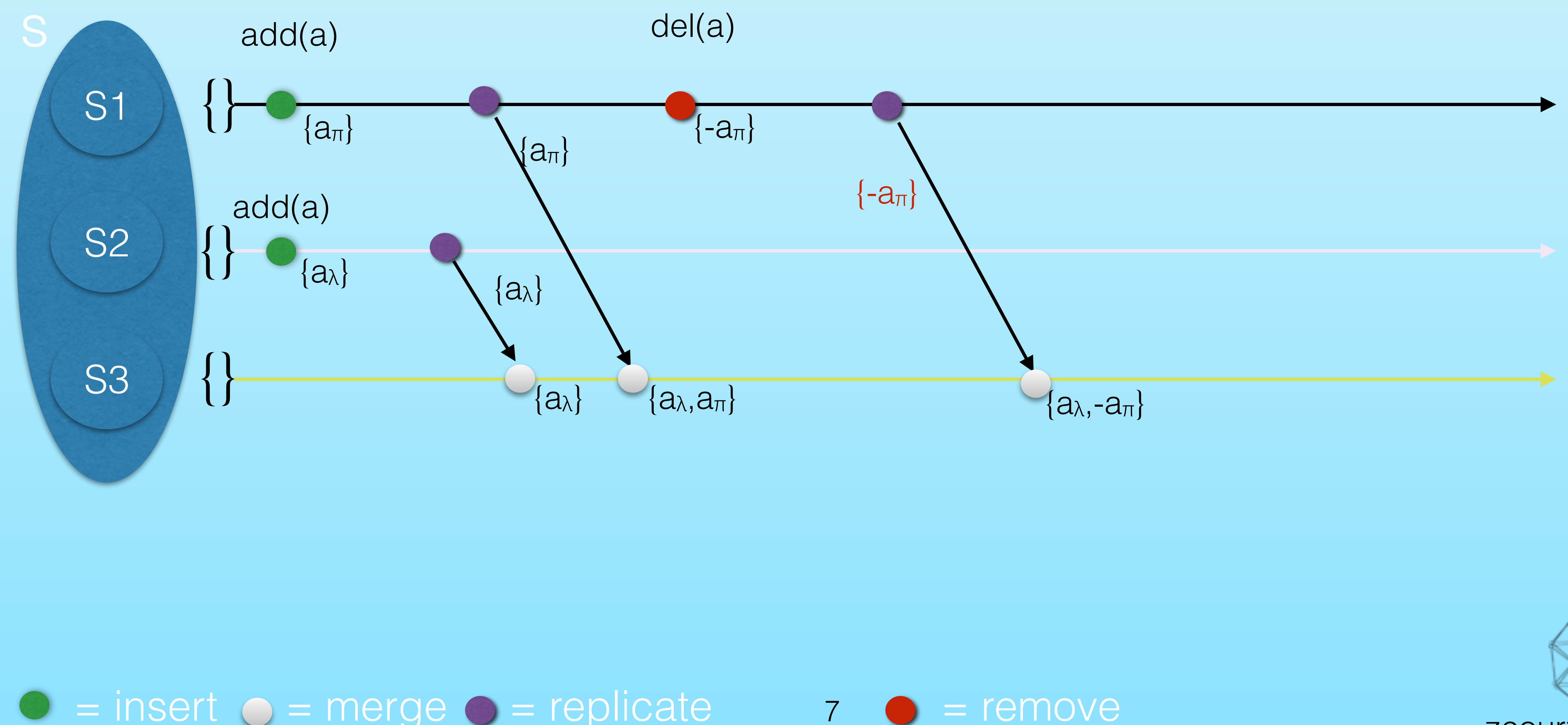

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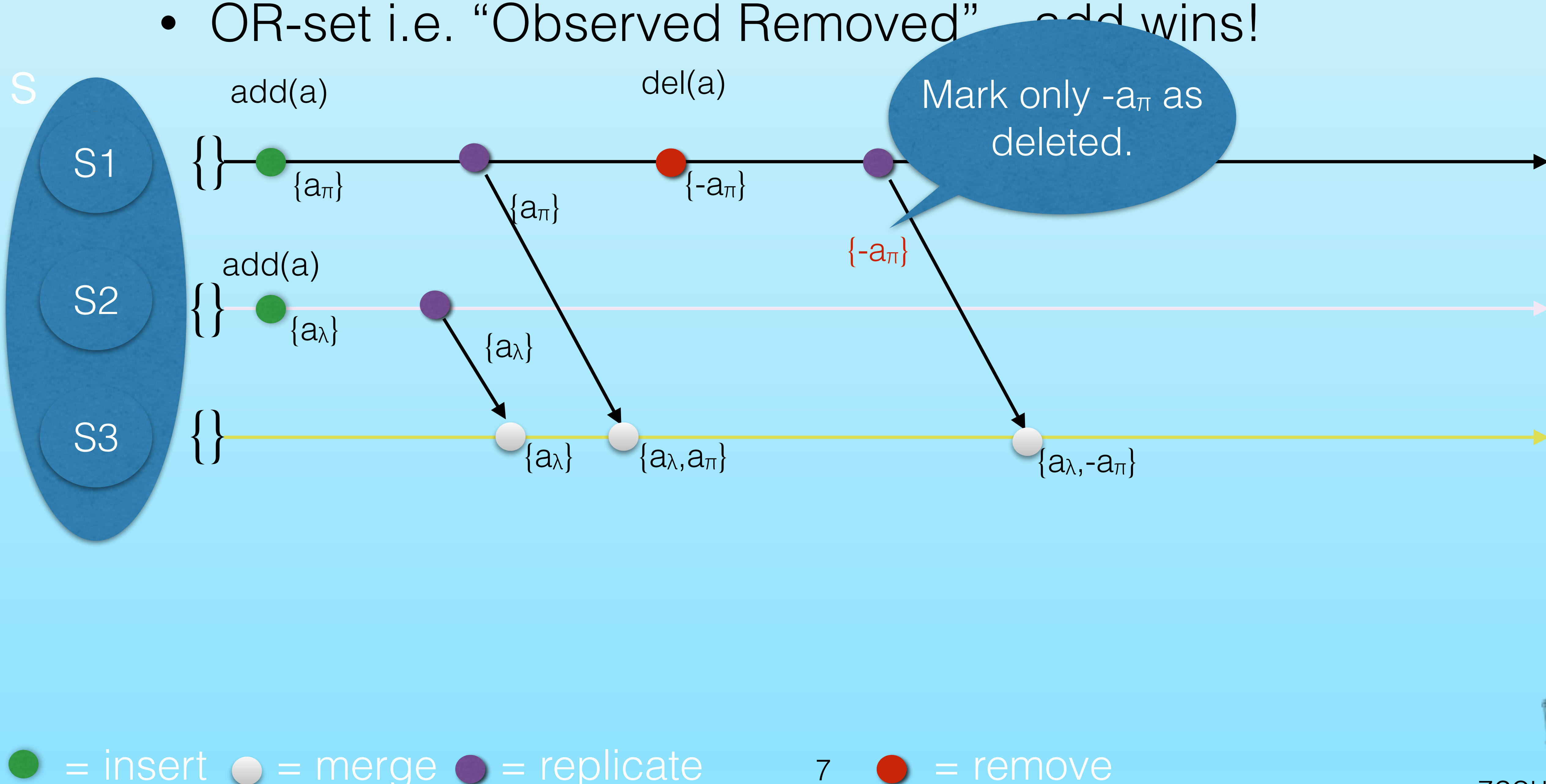

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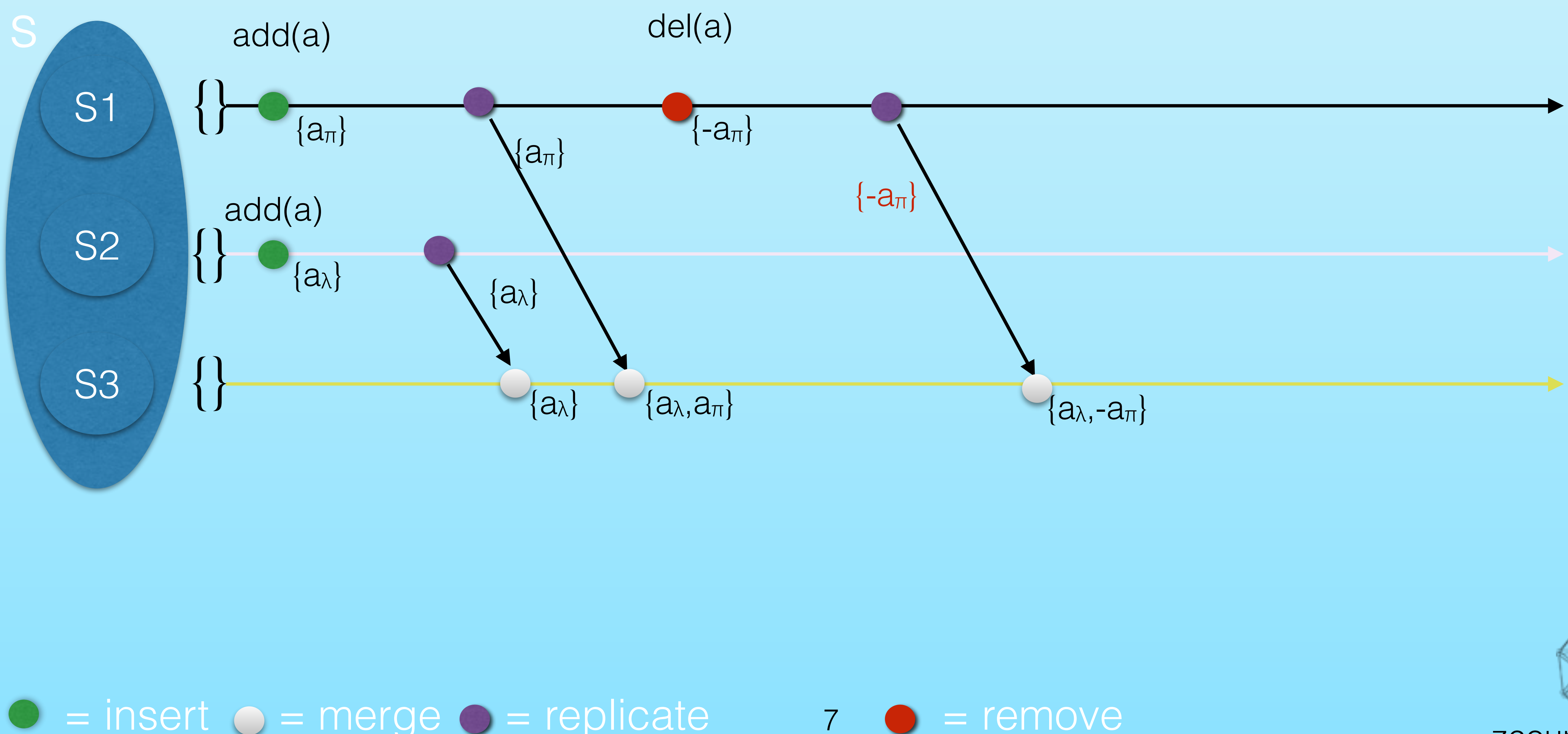

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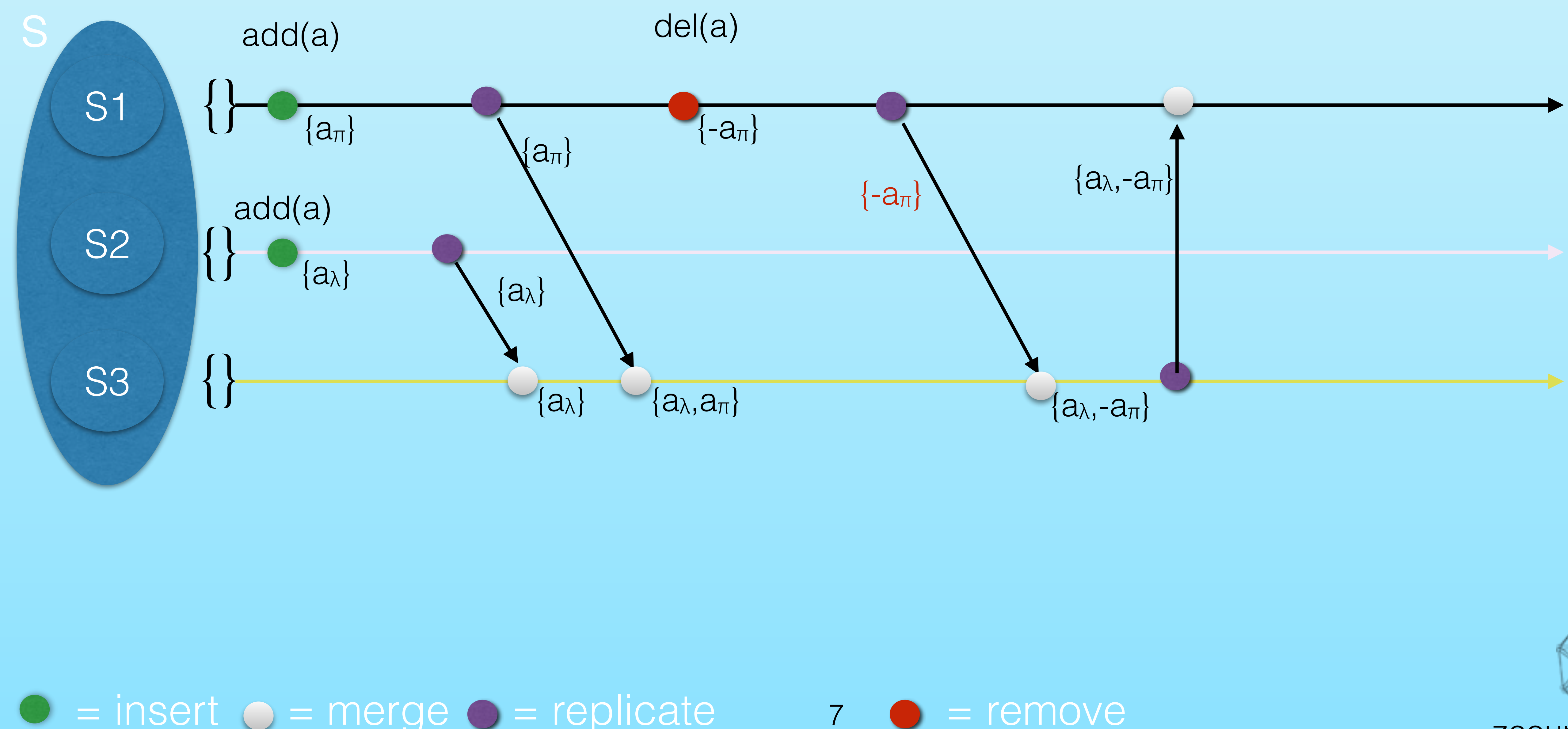

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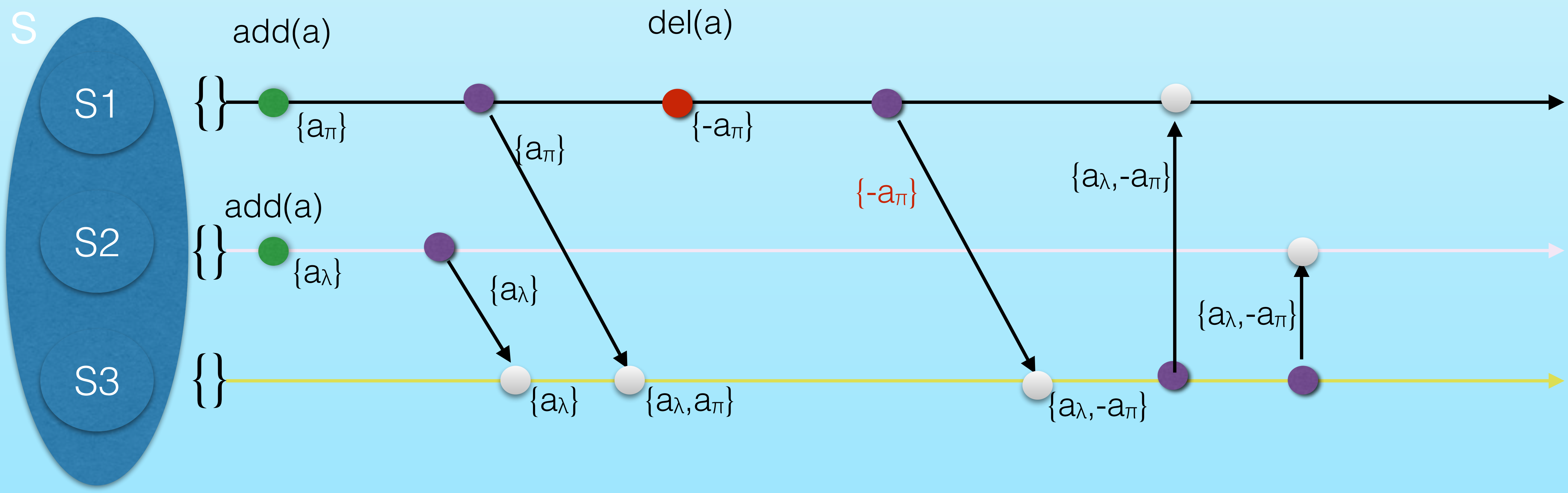

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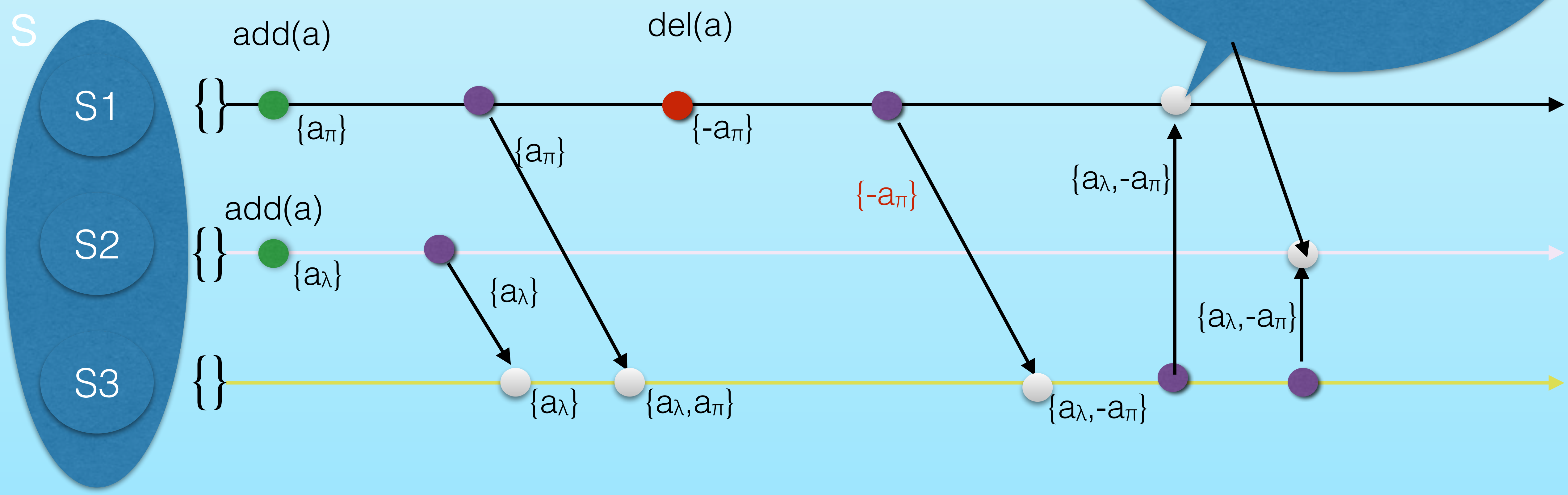
Merge takes symmetrical difference of the local and remote sets resulting in a_λ being in the set



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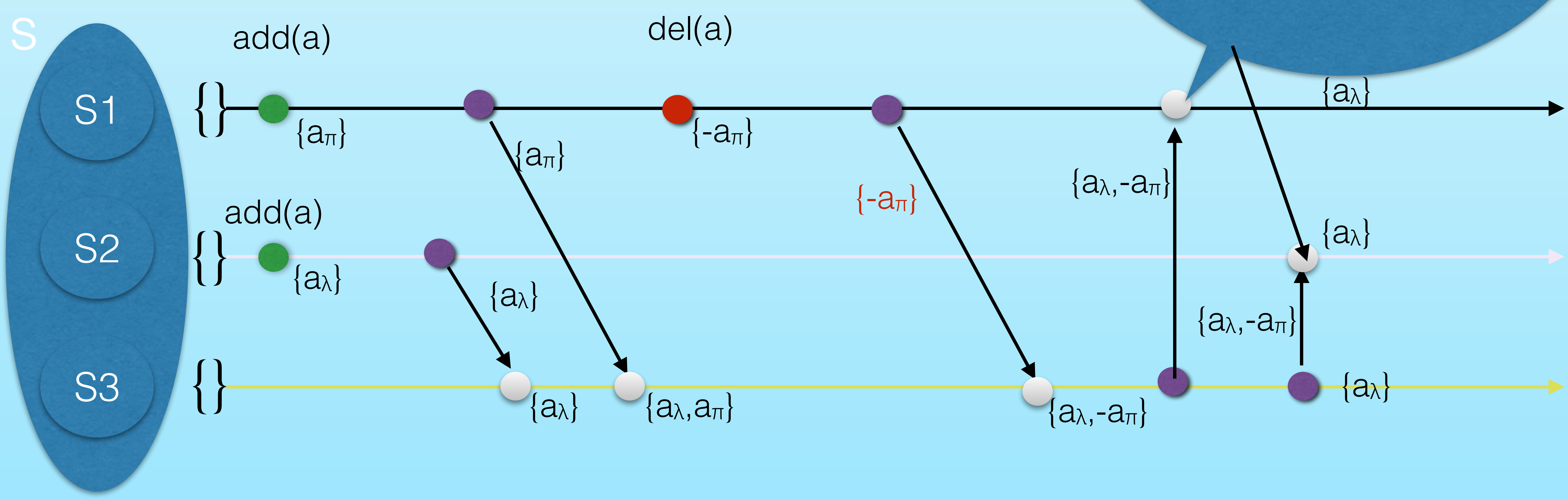

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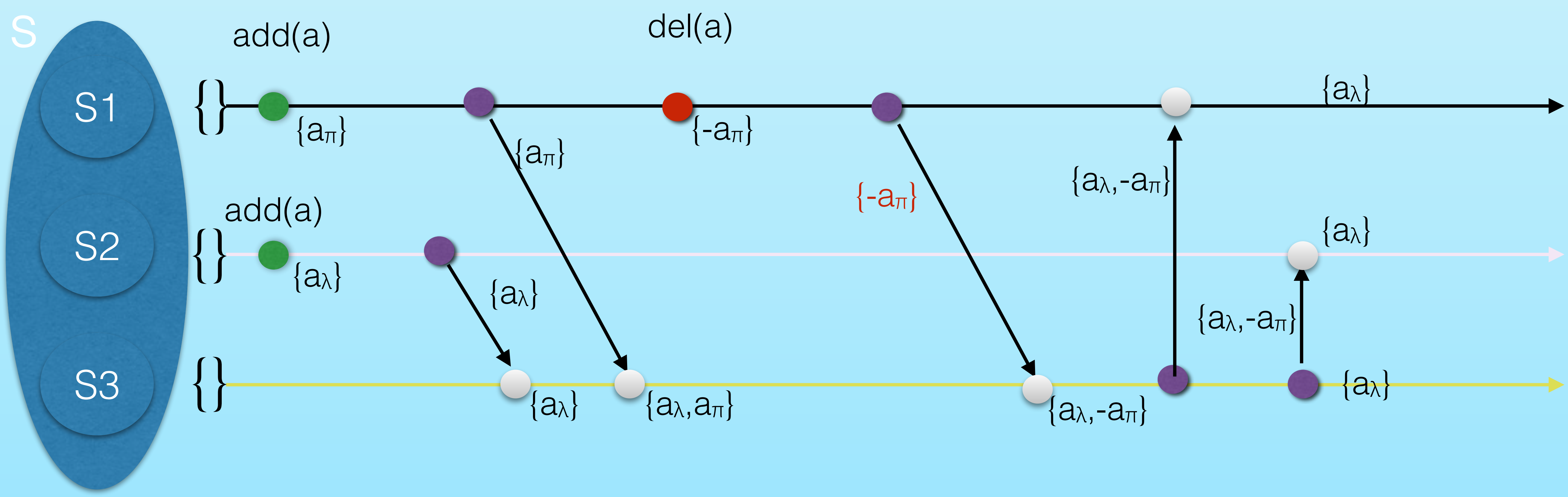

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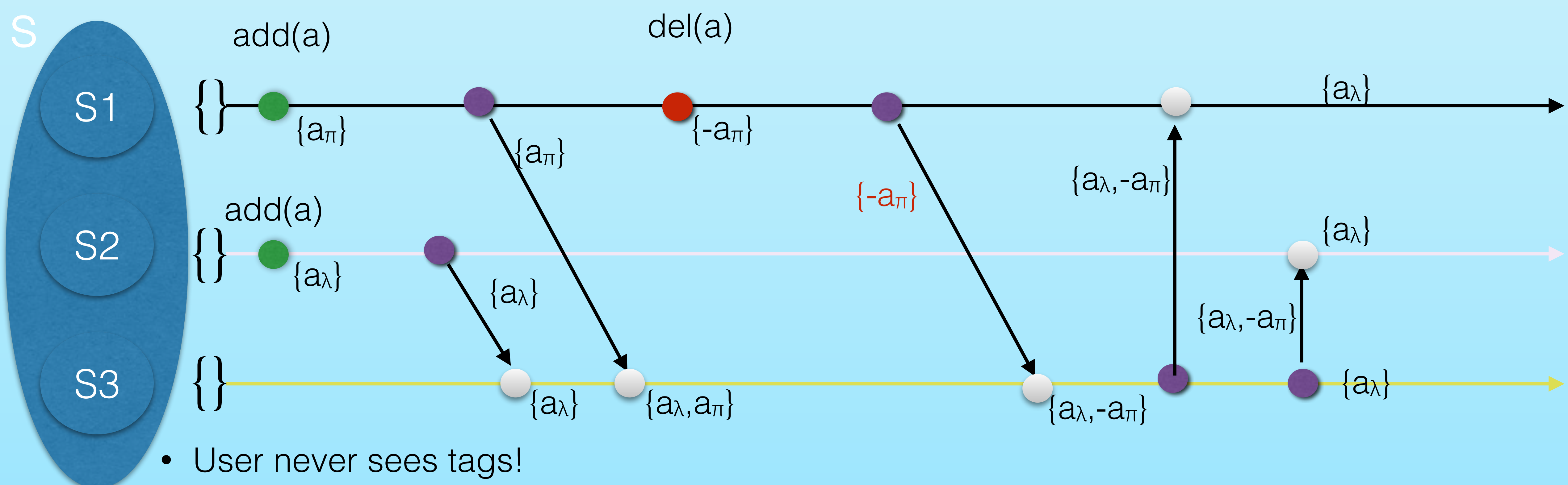

- User never sees tags!
- Query time checks are used to enable DAGs (if violation of DAG constraint is detected then the runtime simply says the violating edge does not exist and triggers clean up)
- Note,the deleted "a" is optionally kept as a tombstone if the runtime is configured to support "snapshots"

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Aims of the Tesseract

1. Implement distributed eventually consistent graph database

2. Develop a distributed graph partitioning algorithm

3. Develop a computational model able to support both real time and batch processing on a distributed graph

CRDTs again…because they're important

- One very important property of a CRDT is:

$$\{a,b,c,d\} :\Leftrightarrow \{a,b\} \cup \{c,d\}$$

- Those two sets being logically equivalent is a desirable property
- Enables partitioning (with rendezvous hashing for e.g.)

Naïve “cascading vertices”

- Naïve graph partitioning
- Depends on the query model to make up for its Naïvety
- Uses hashing to place data
- Two cascading algorithms formulated from:

  V = the vertex to cascade

  n = max nodes to cascade across

  ń = auto-determined value of n, using logistics growth model

  d = deg(v) = Degree of V

  e = $\langle \forall_{deg(v)} \in G \rangle$ i.e. average degree of all vertices in the graph

  lnVl = Max number of edges per node for a vertex

  i.e. cascading point (min number of edges before cascading occurs)

1. |nV| = d / n - user provides n, split evenly across nodes
2. |nV| = max(d,e) / n - user provides n, split evenly based on d or e if e is bigger

“Cascading vertices” by example

- Let’s use Twitter followers as an example
- Each letter represents a unique follower

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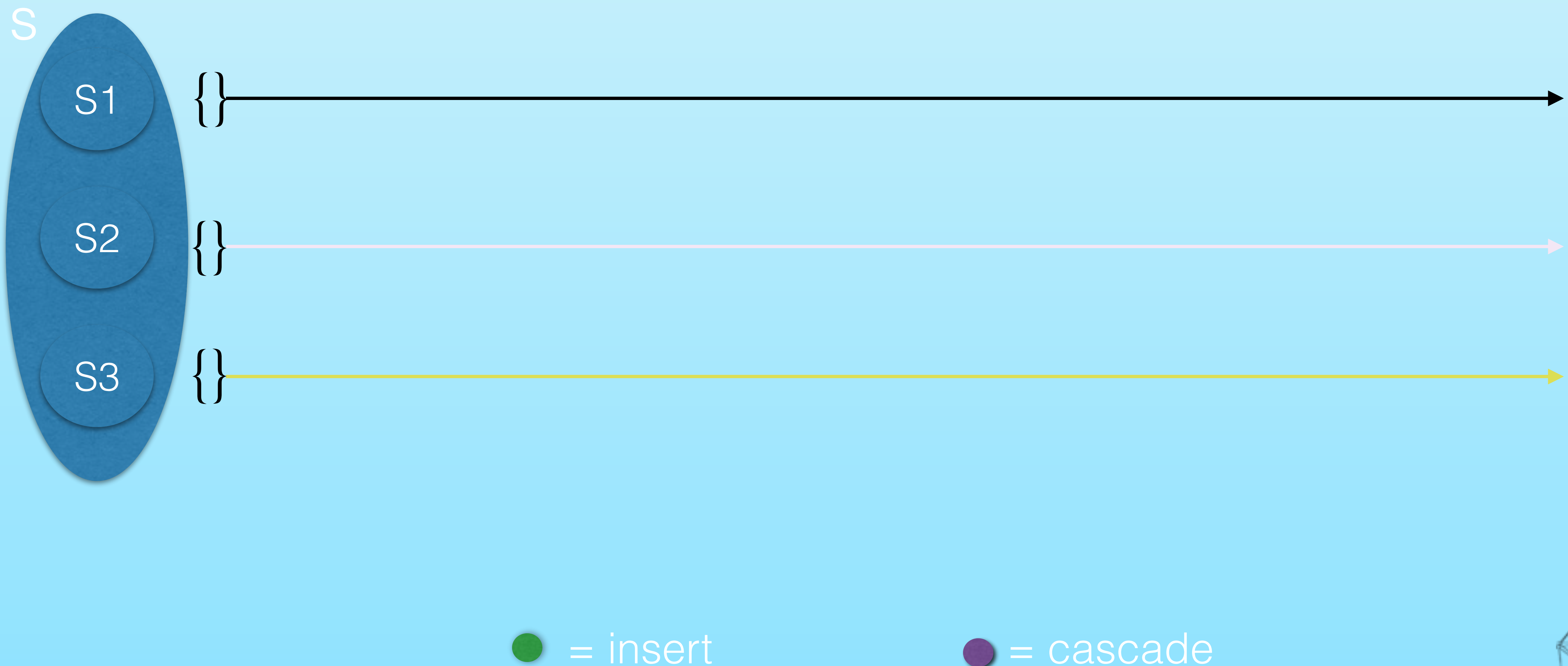

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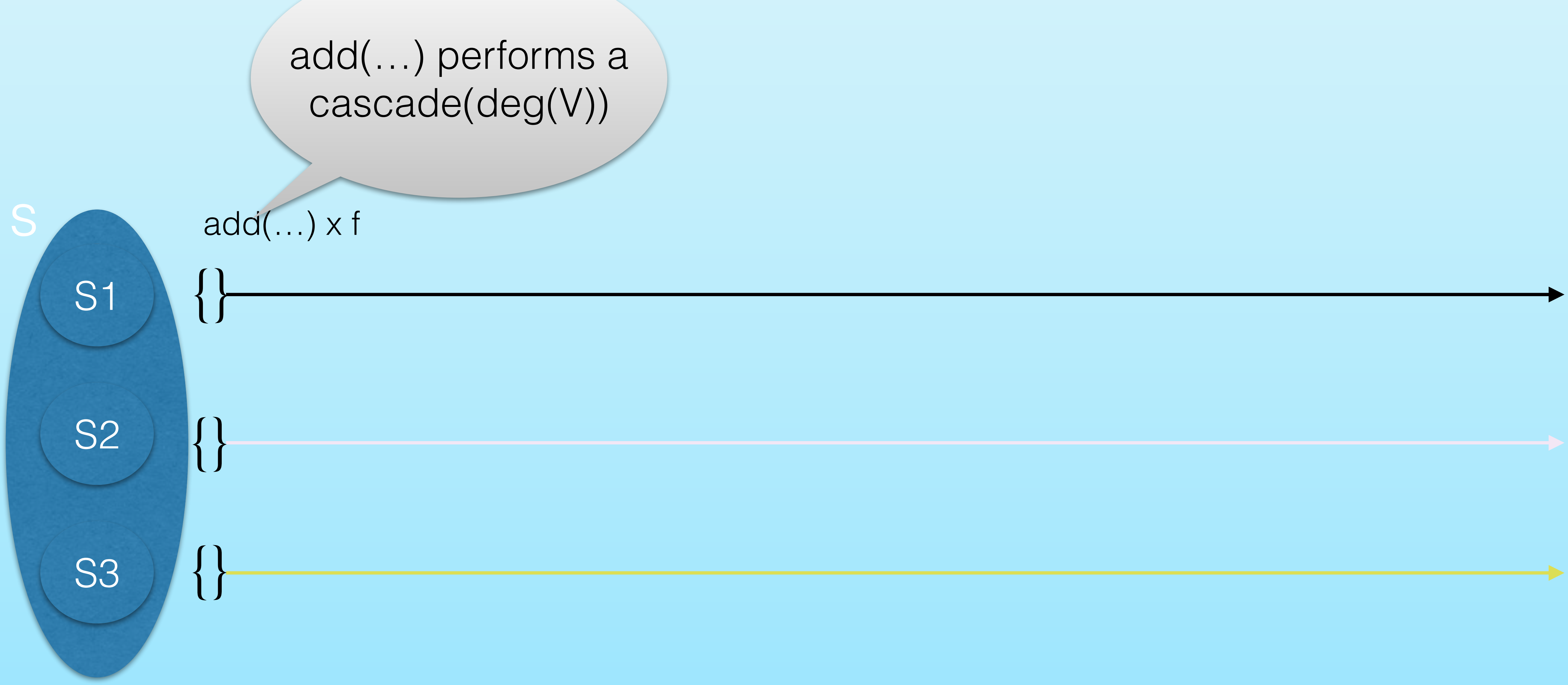

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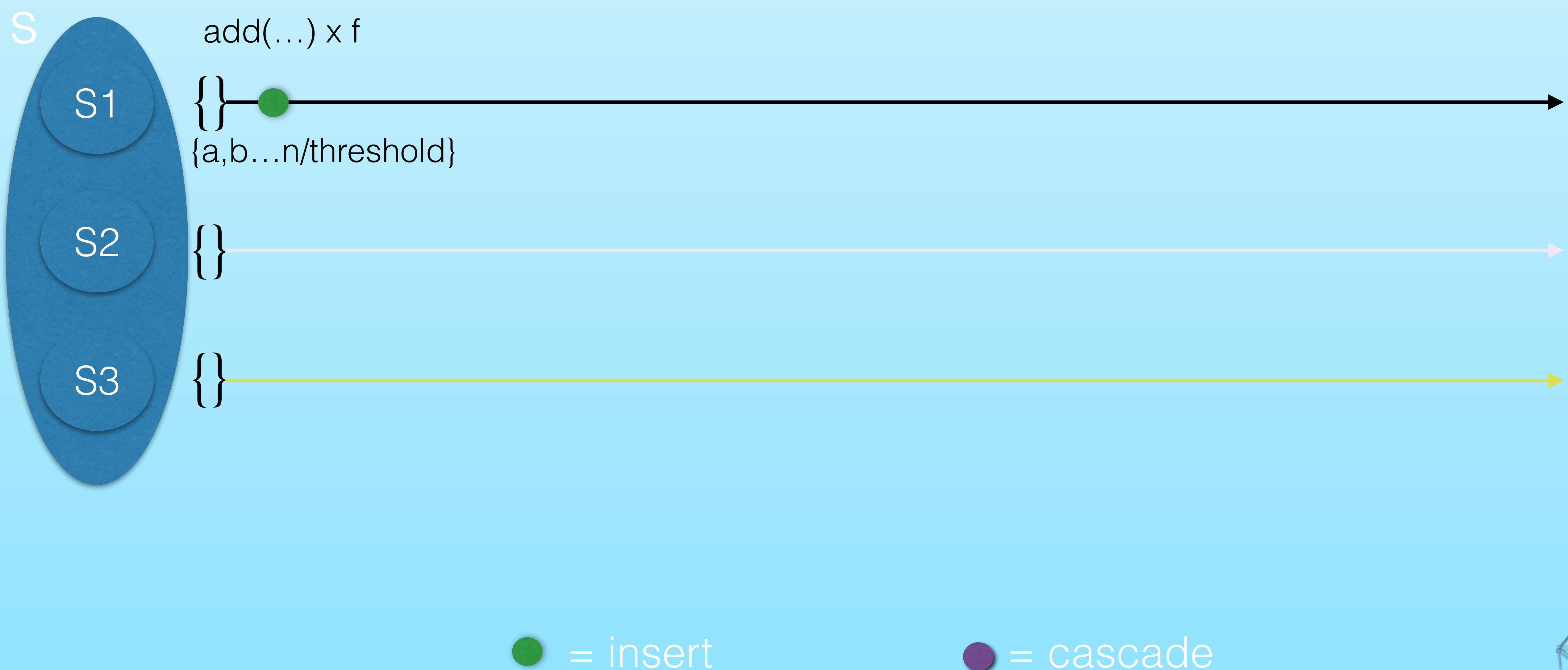

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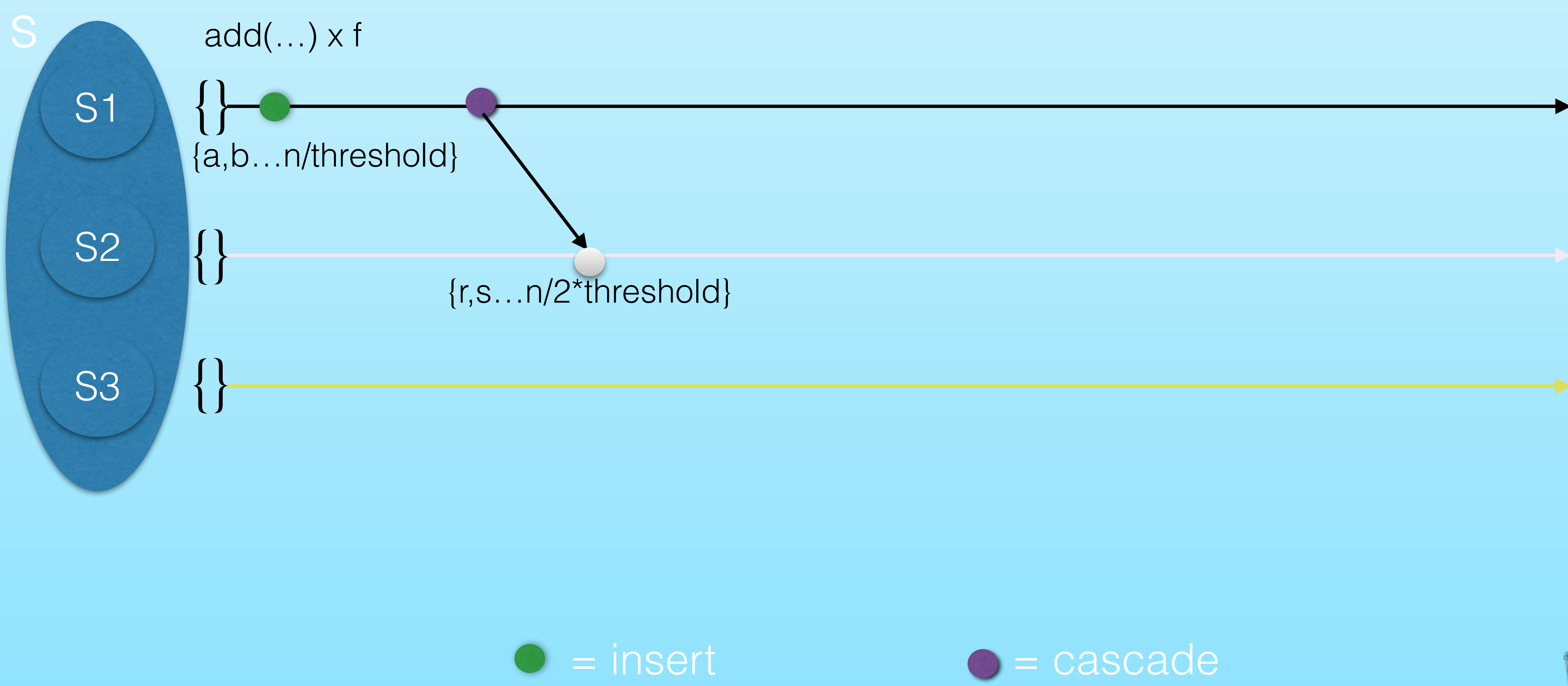

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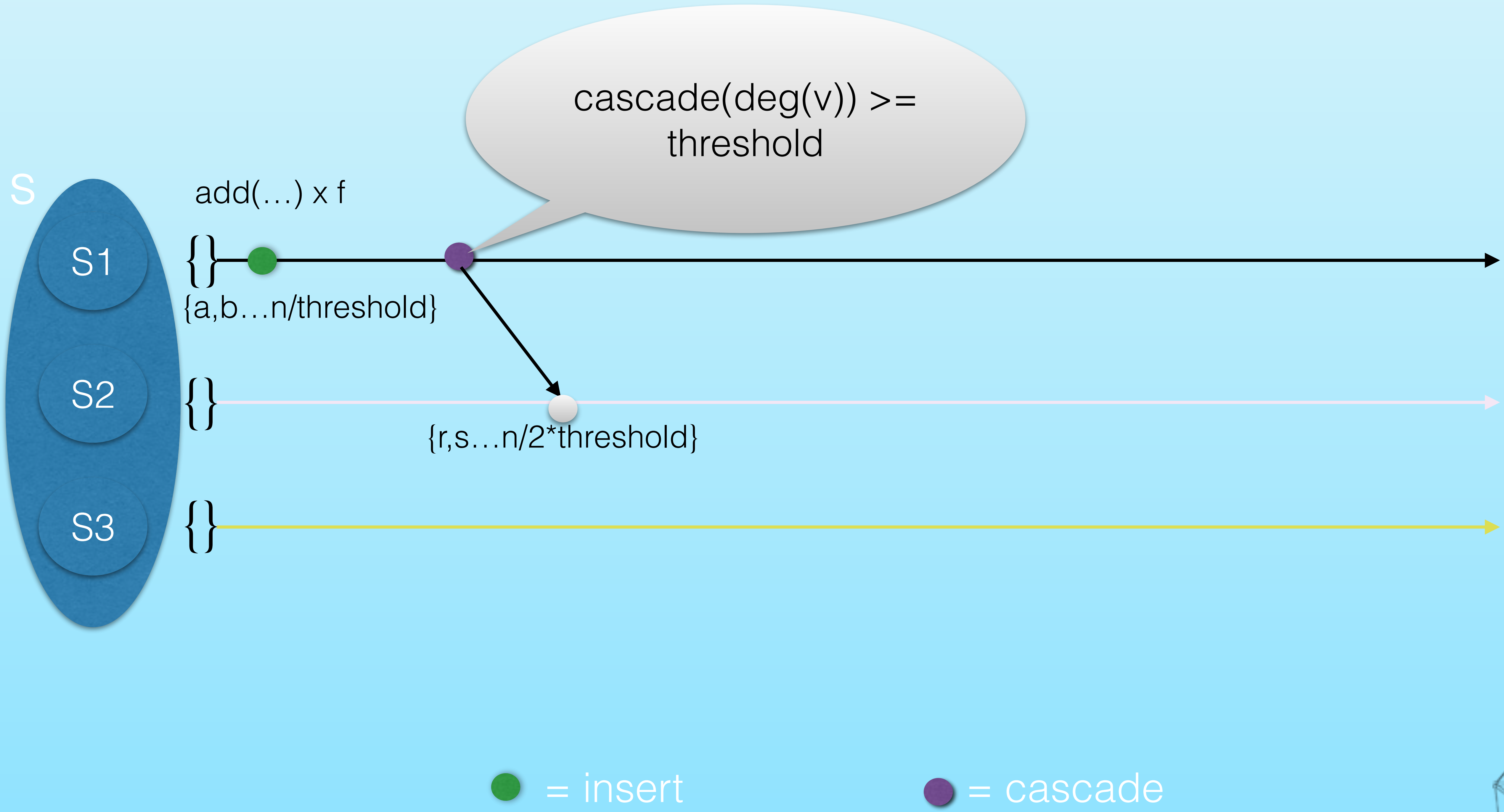

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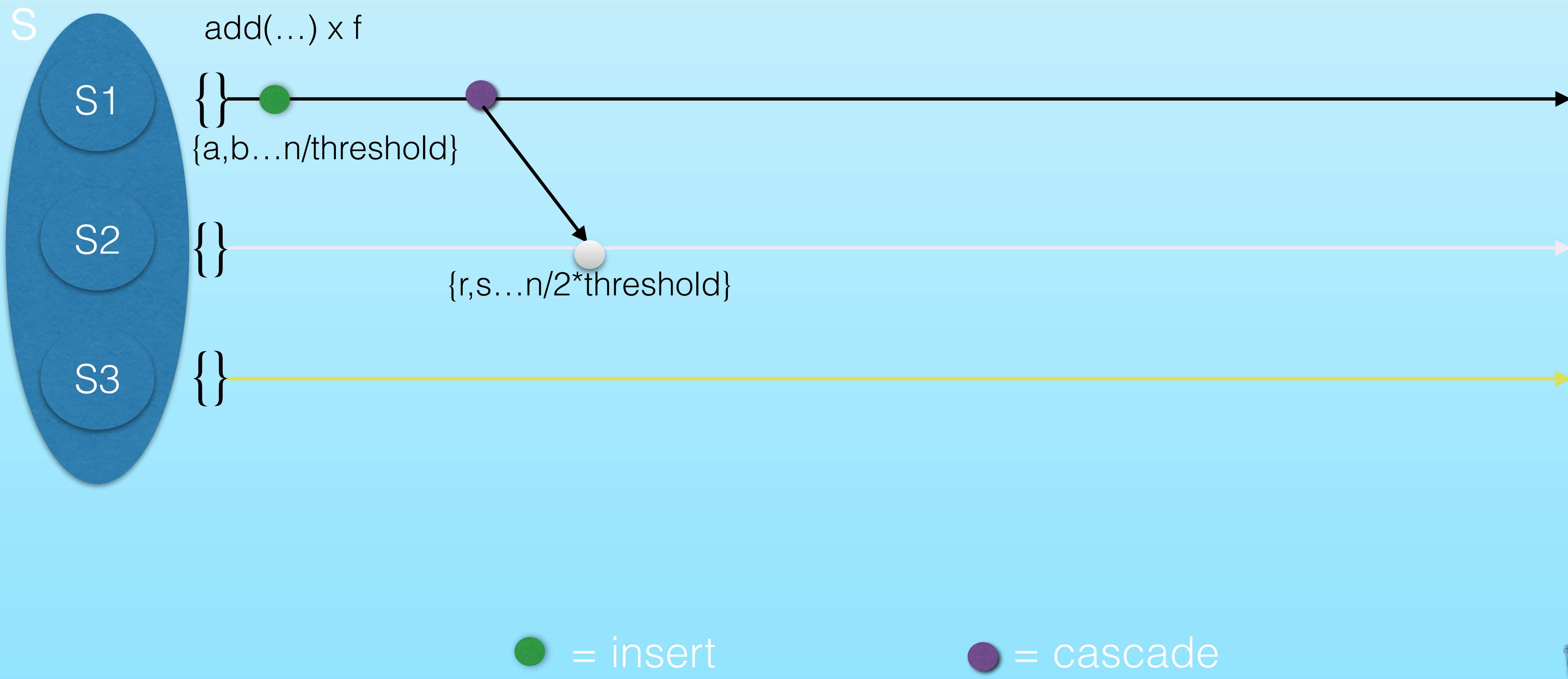

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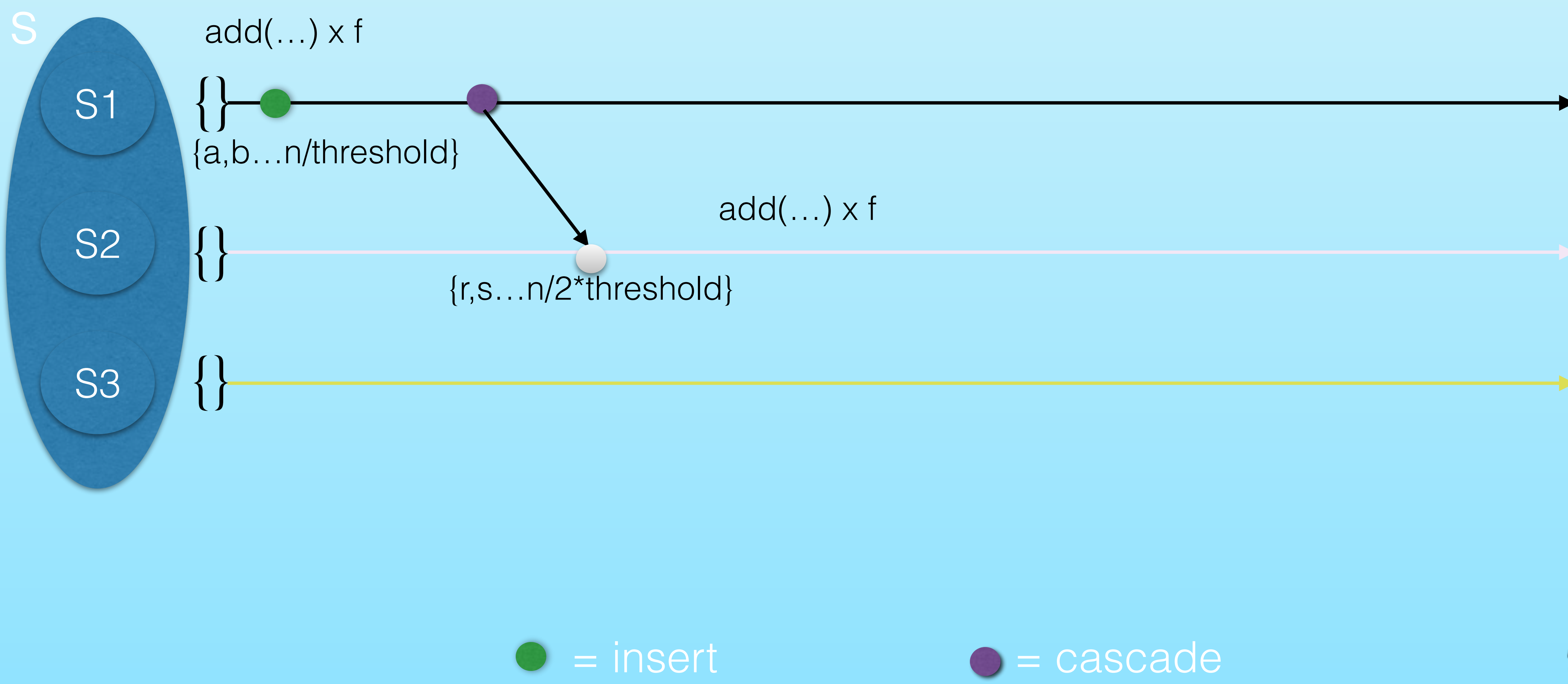

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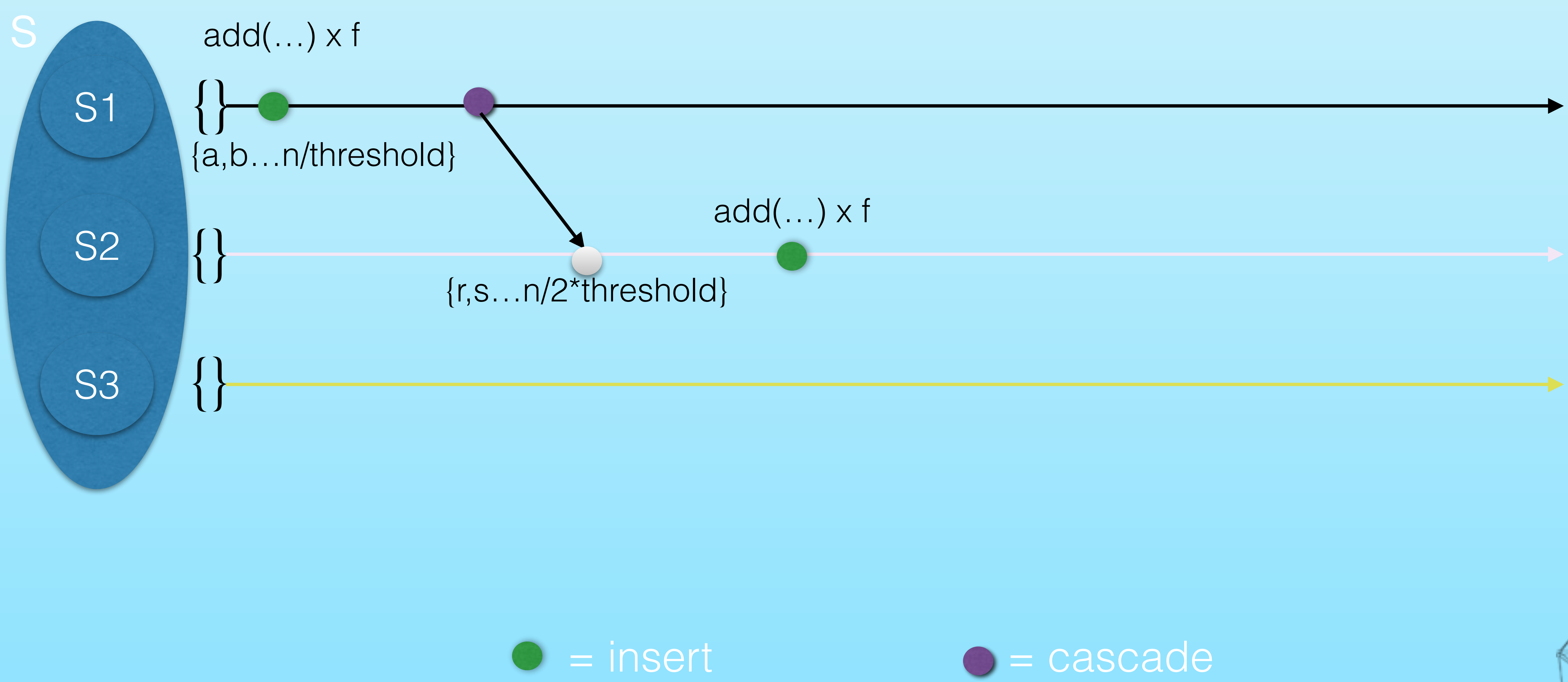

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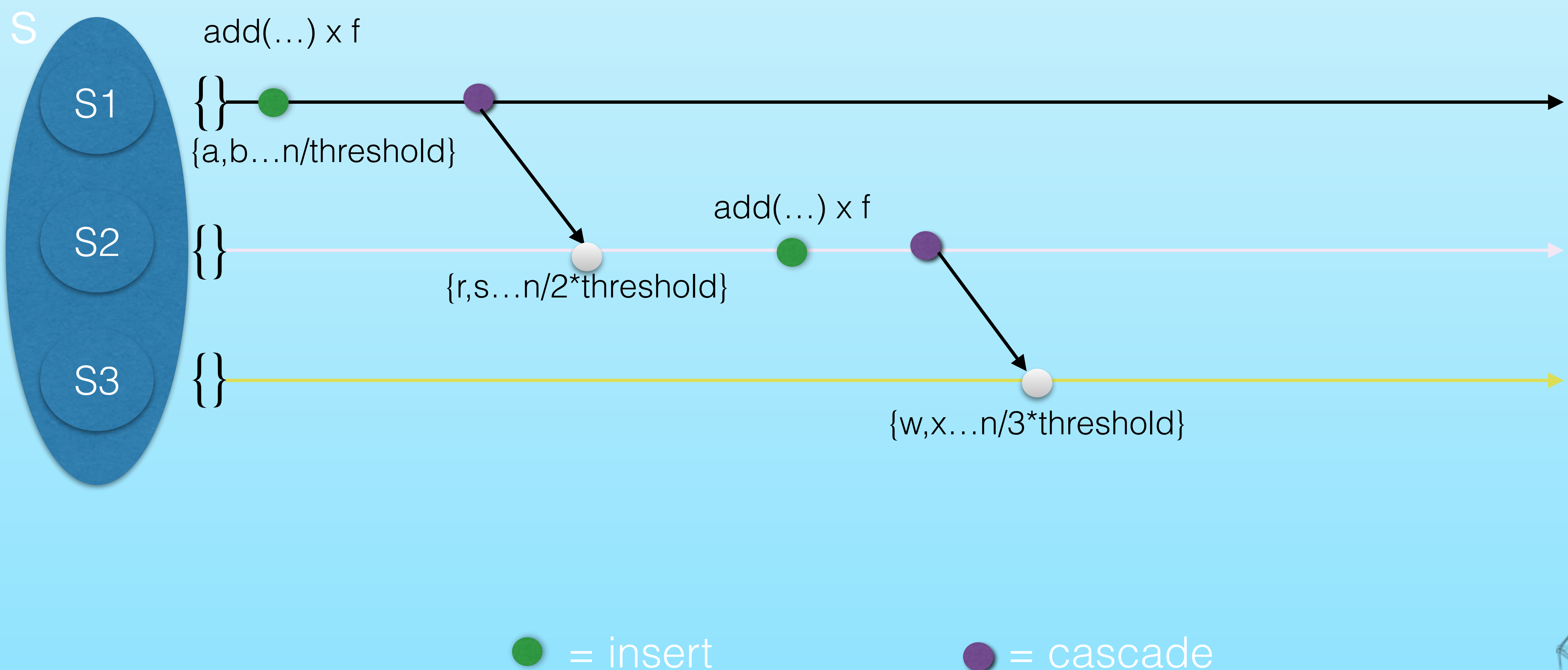

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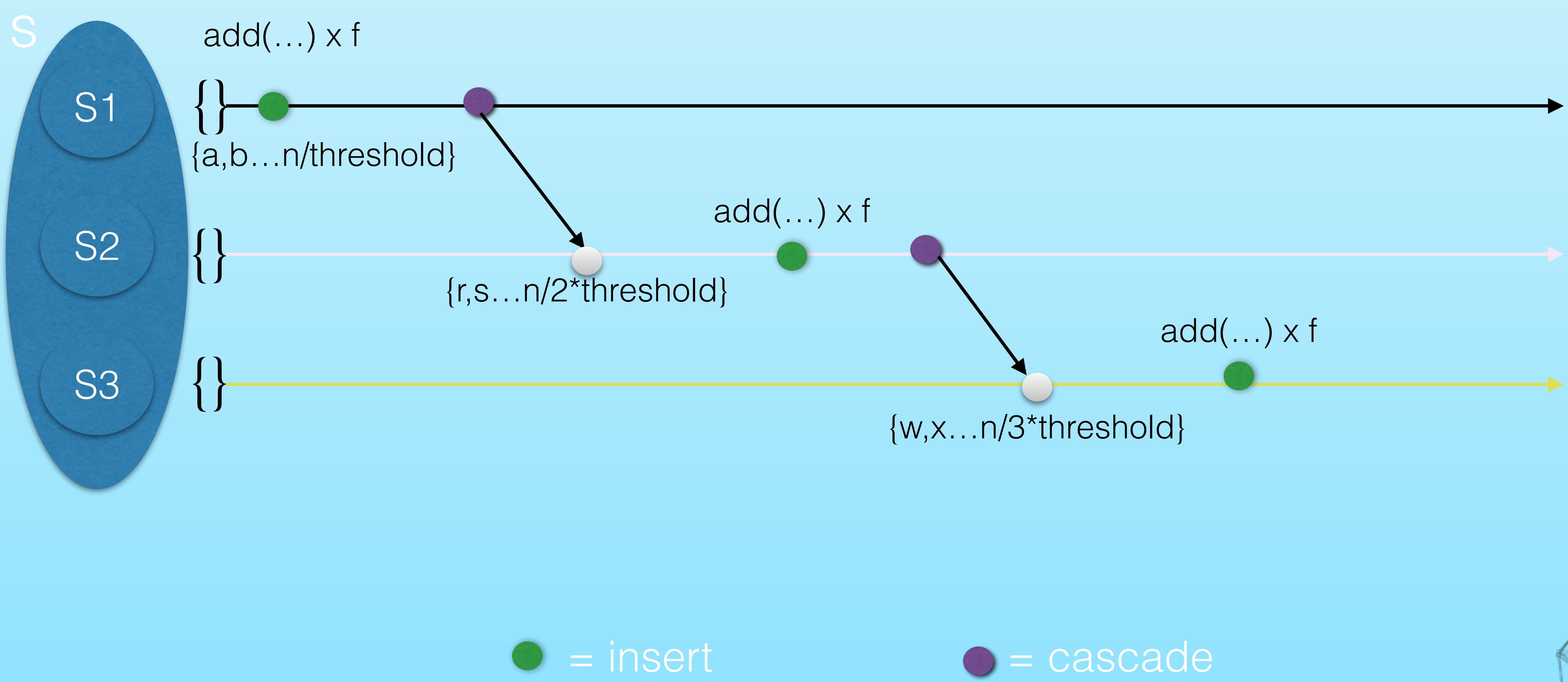

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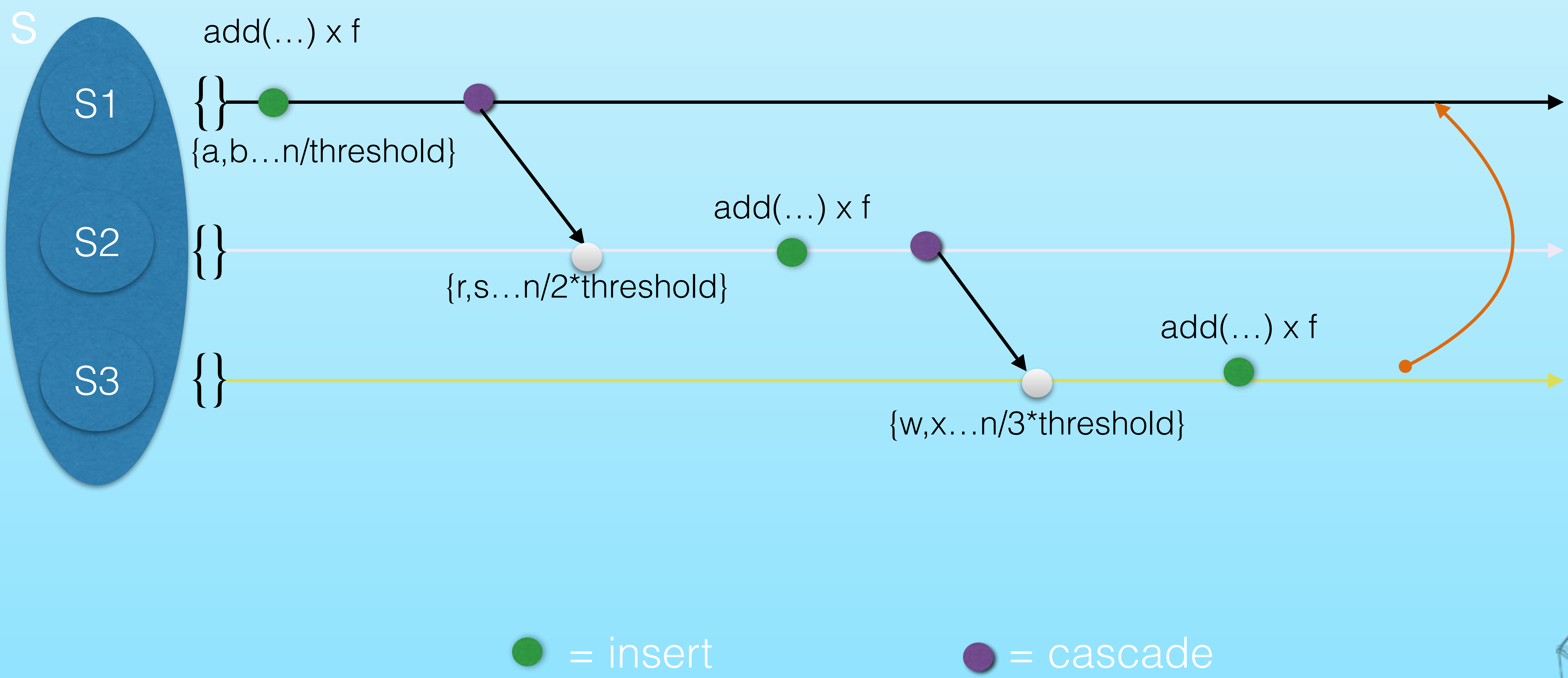

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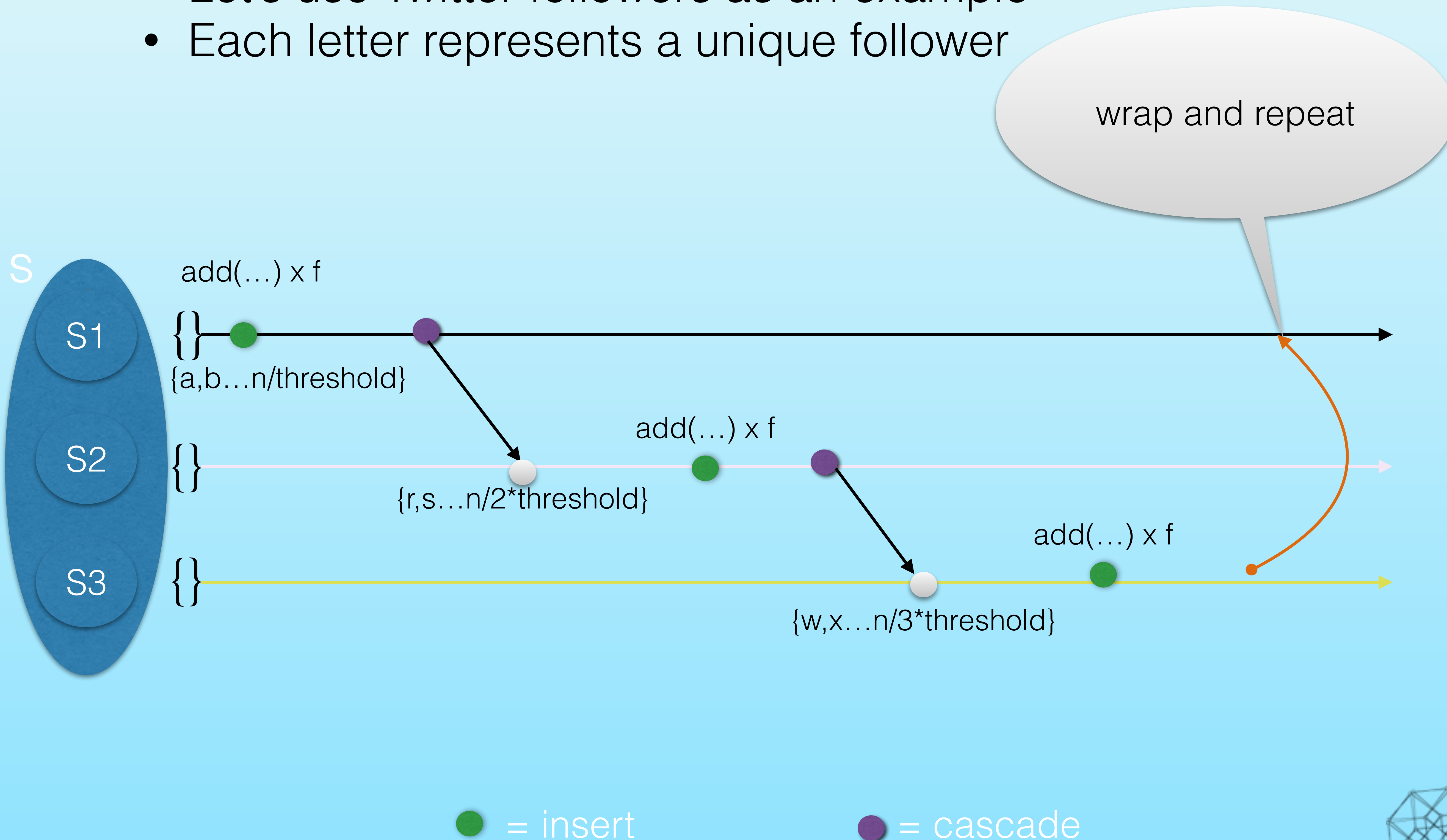

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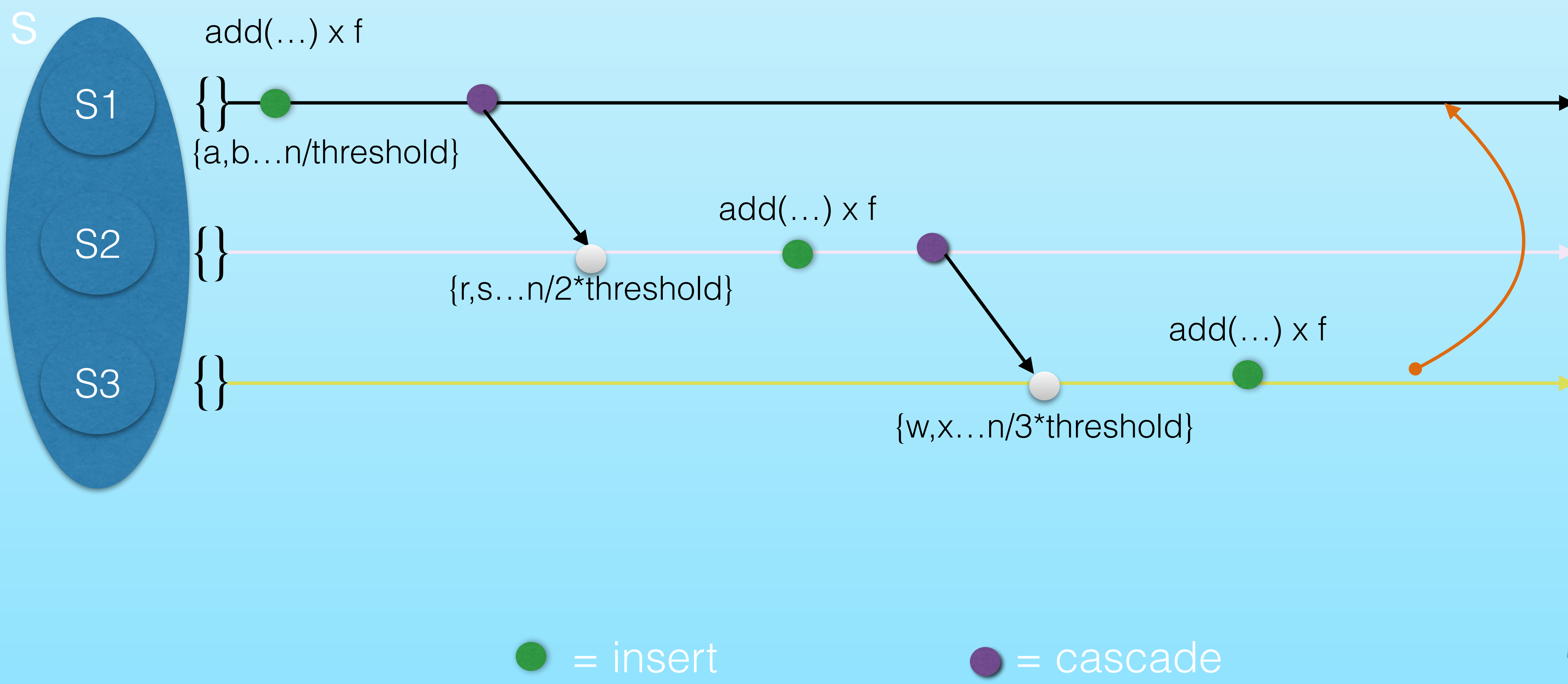

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Distributed computation

Localised calculations

Amortisation

Memoization

Amortisation

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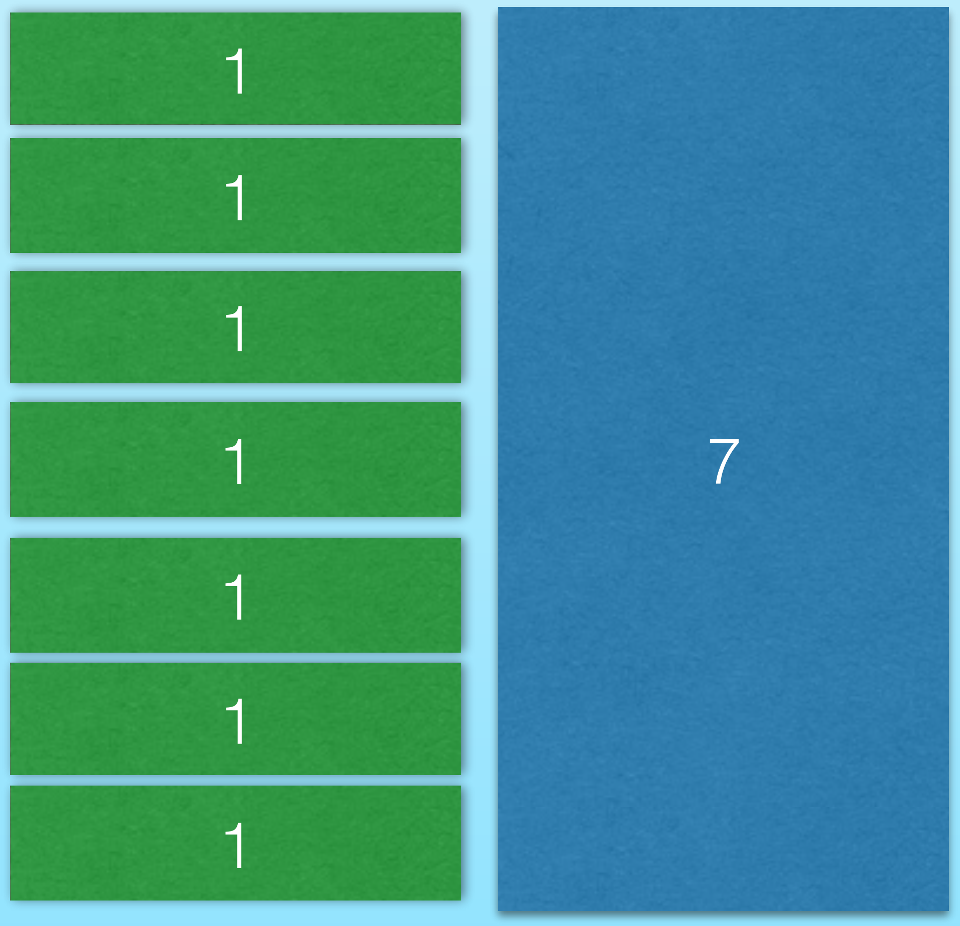
- This allows us to occasionally pay the cost of more “expensive” operations such that they computationally balance out
- e.g. Checking data locally on a node vs querying over a network



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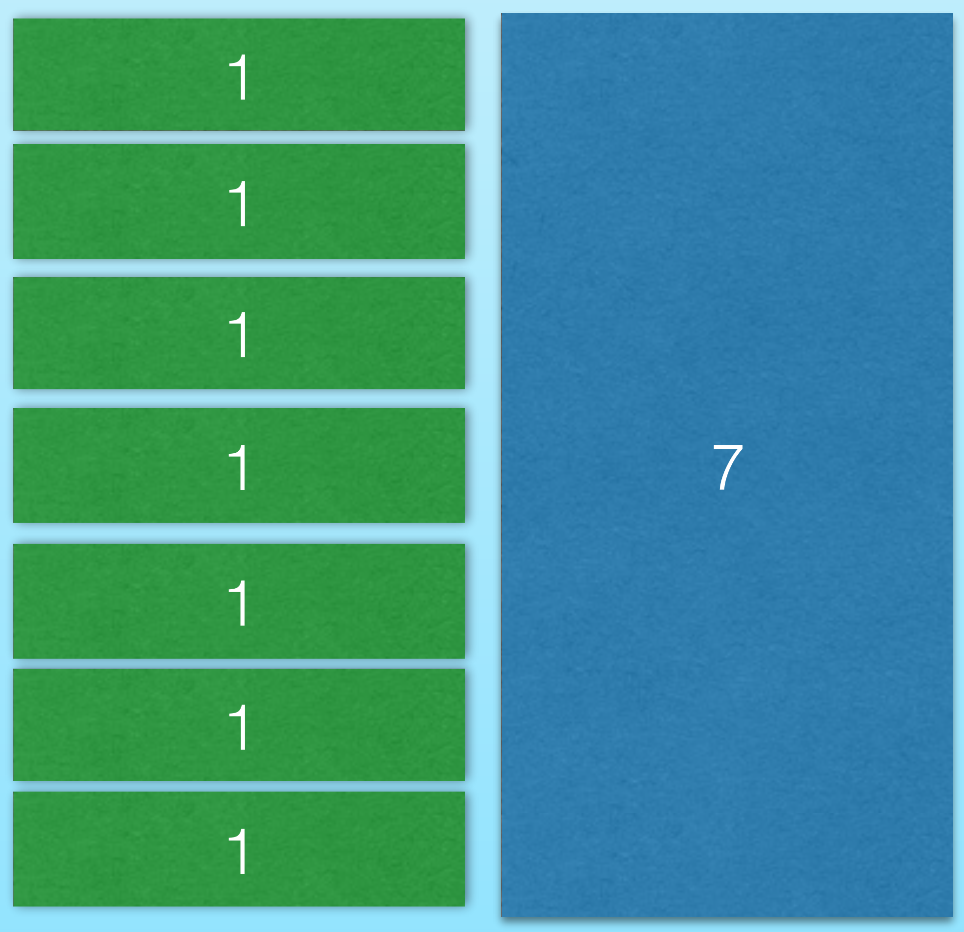

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  - A luxury afforded by immutability
- Sacrifices disk space and memory
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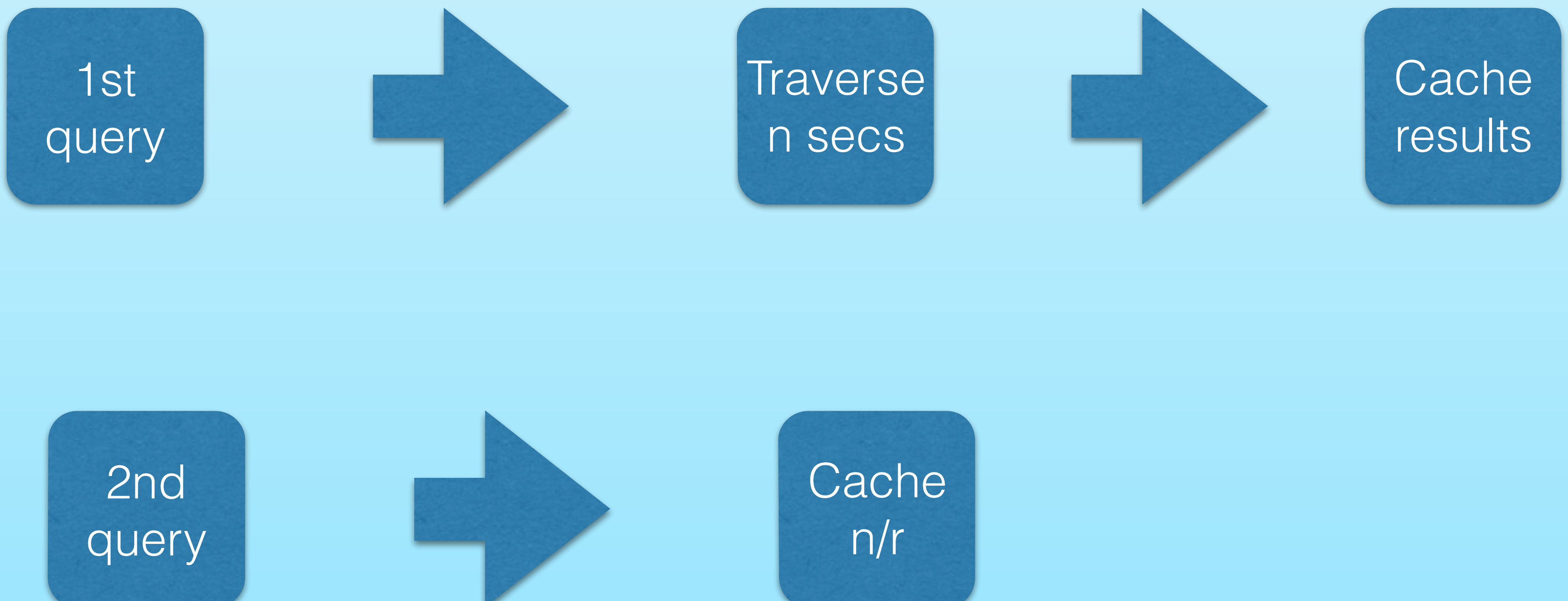
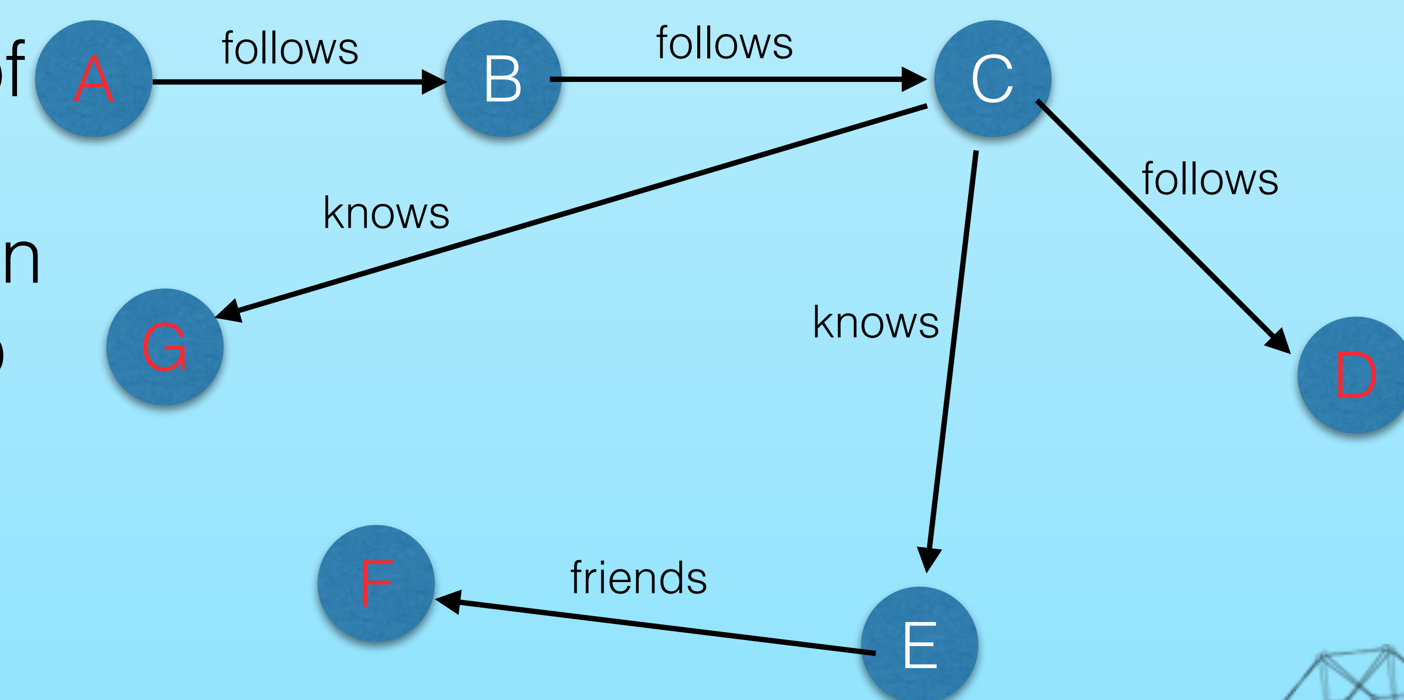


Wormhole traversals

- Immutability offers guarantees
- Place markers at every n vertex intervals
- When traversing, don't visit every vertex, jump to markers instead.
- Markers at A, G, F, D
- By pass B,C,E during traversal, almost halving the time.
- The resulting data has any skipped vertex asynchronously fetched
- A key part of this is in the use of "Path summaries"
- Path summary is an optimisation that enables the runtime to skip network requests
- Allows traversal to continue locally and async request is made to gather the remote results



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  - …but its semantics
    - Immutability
    - Purity
    - and some other stuff
    - and, well…functions!

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    - Immutability
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    - and some other stuff
    - and, well…functions!
- The whole graph thing is an optimisation problem
  - The properties of a purely functional language enables a run time to make a lot of assumptions
  - These assumptions open possibilities not otherwise available (some times by allowing us to pretend a problem isn't there)

Distributed Query Model: TQL, Tesseract Query Language

- Haskell?
- …before you start sneaking out the back doors
- What would that even look like…?

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- What you're looking at is TQL
  - a pure
  - functional language
  - it has type inferencing and all the cool functional widgets!

Distributed Query Model: TQL pt2

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Distributed Query Model: TQL pt2

- How was that functional?
- It employed use of:
  - Functions - relation between a set of input and a set of permissible outputs
  - Monads - structures that allow you to define computation in terms of the steps necessary to obtain the results of the computation.
  - Monoids - a set with a single associative (1+ 2) + 3 == 1 + (2+3) binary operation an identity element (an element where, when applied to any other in the set, the value of the other element remains unchanged. e.g. given * as the binary operation and the set S={1,2,3}, 1 is the identity element since 1 * 1 = 1, 2 * 1 = 2 and 3 * 1 = 3)
  - Currying - where a function which takes multiple arguments is converted into a series of functions which take a single argument, the currying technique produces partially applied functions.
  - Higher order functions - functions which takes other functions as its parameter
  - Function composition - the process of making the result of one function the argument of another

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- Don’t believe me? Let’s look at a definition for “INSERT” shown on the previous slide

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- Ability to define new modules/add or override functions
- Include additional modules (yours or a third party’s)

Distributed Query Model: Runtime

- The model places a lot of additional work server side.
- Previously enumerated properties enable the server to make a lot of assumptions and by proxy optimisations
- Client interface remains consistent
- While on going research can improve the run time without major client changes

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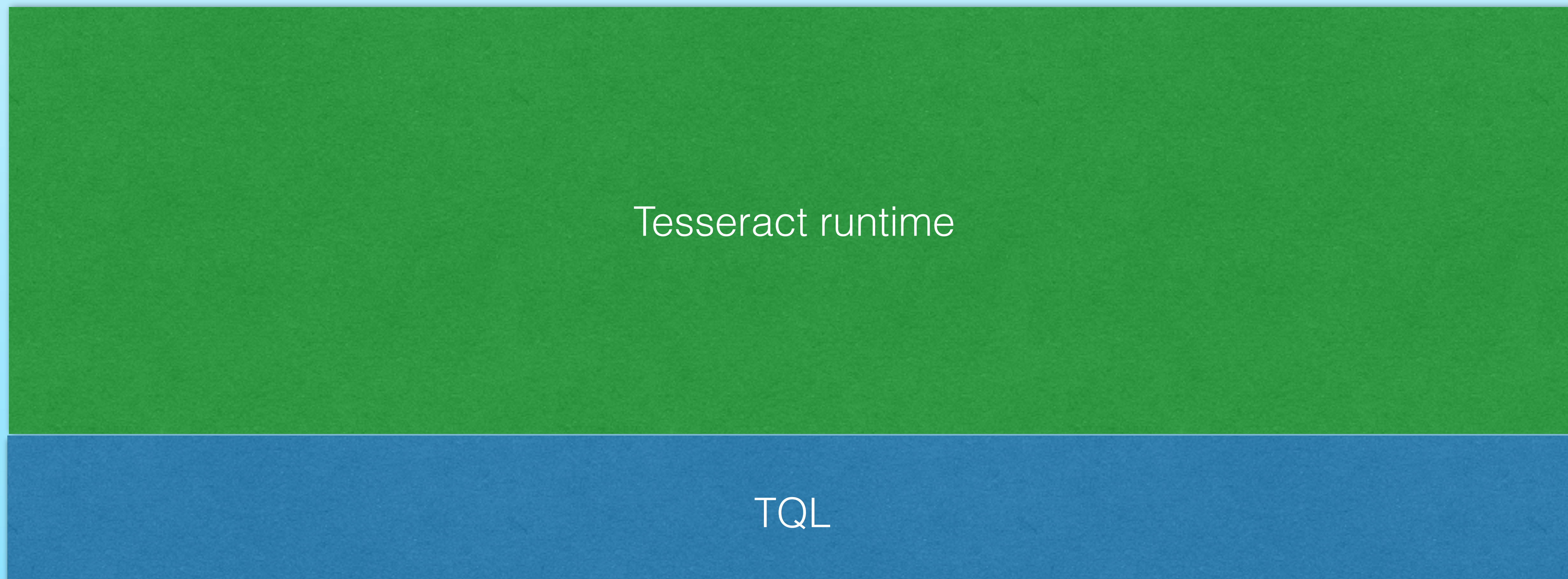

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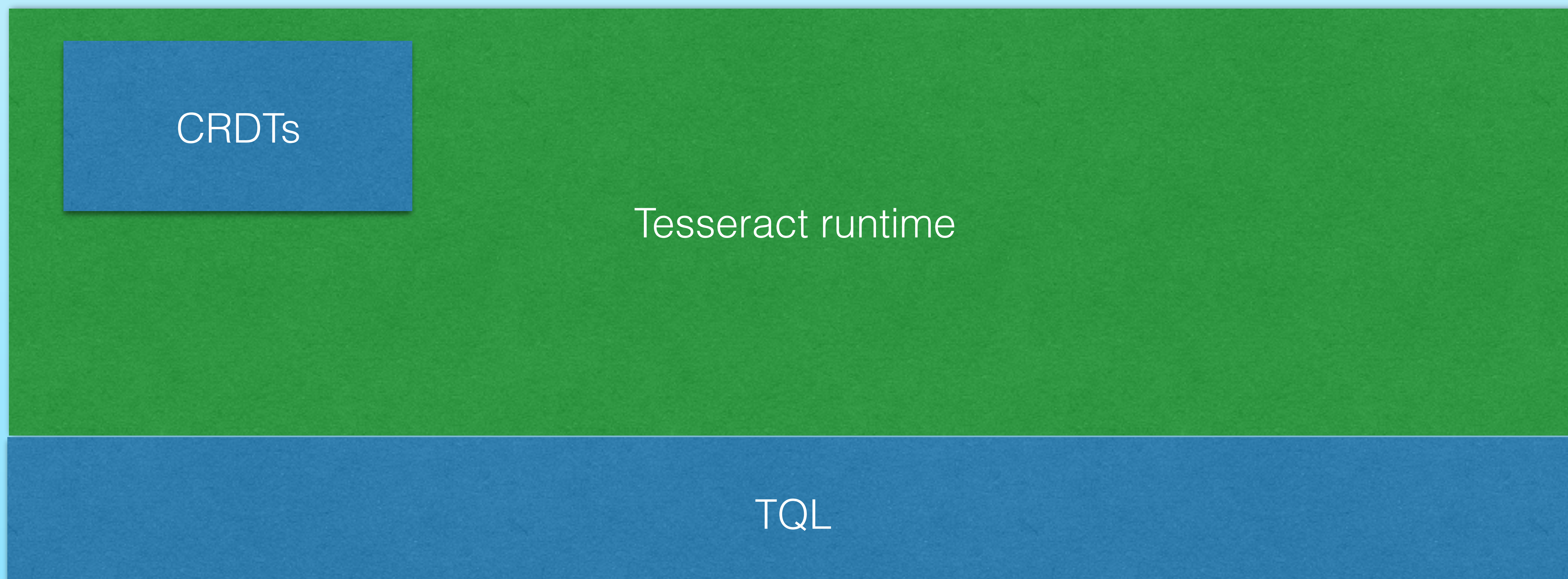

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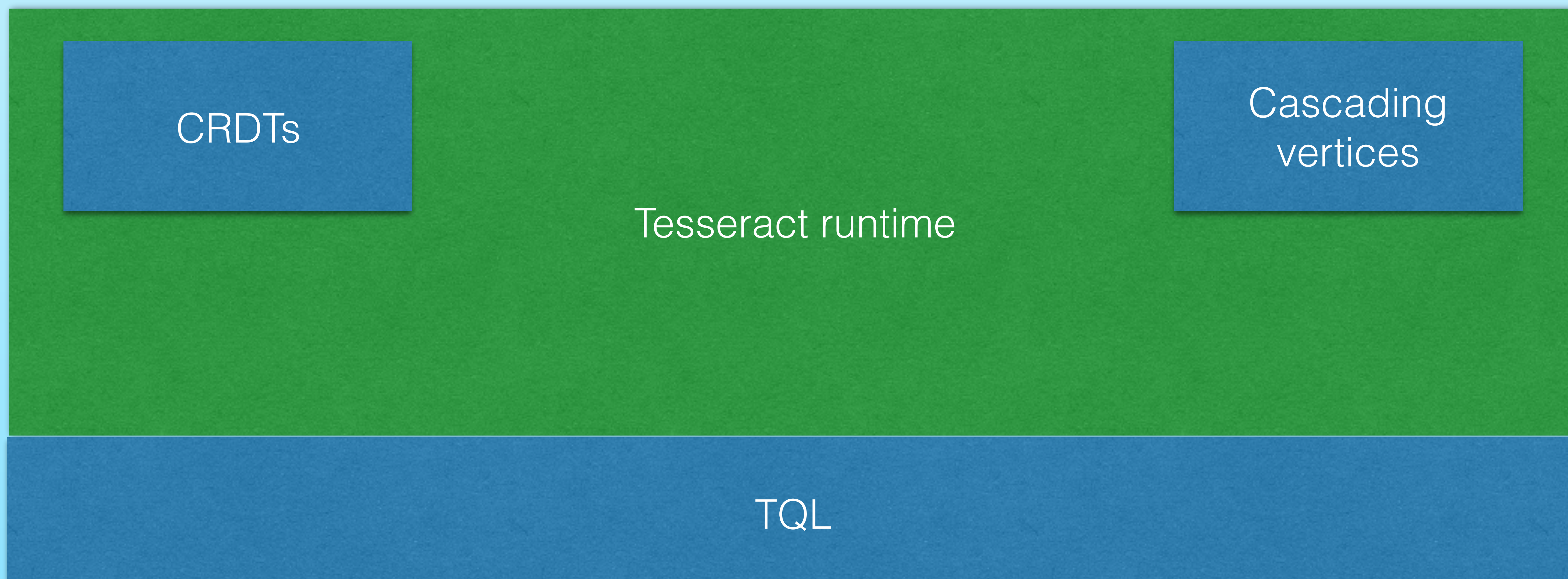

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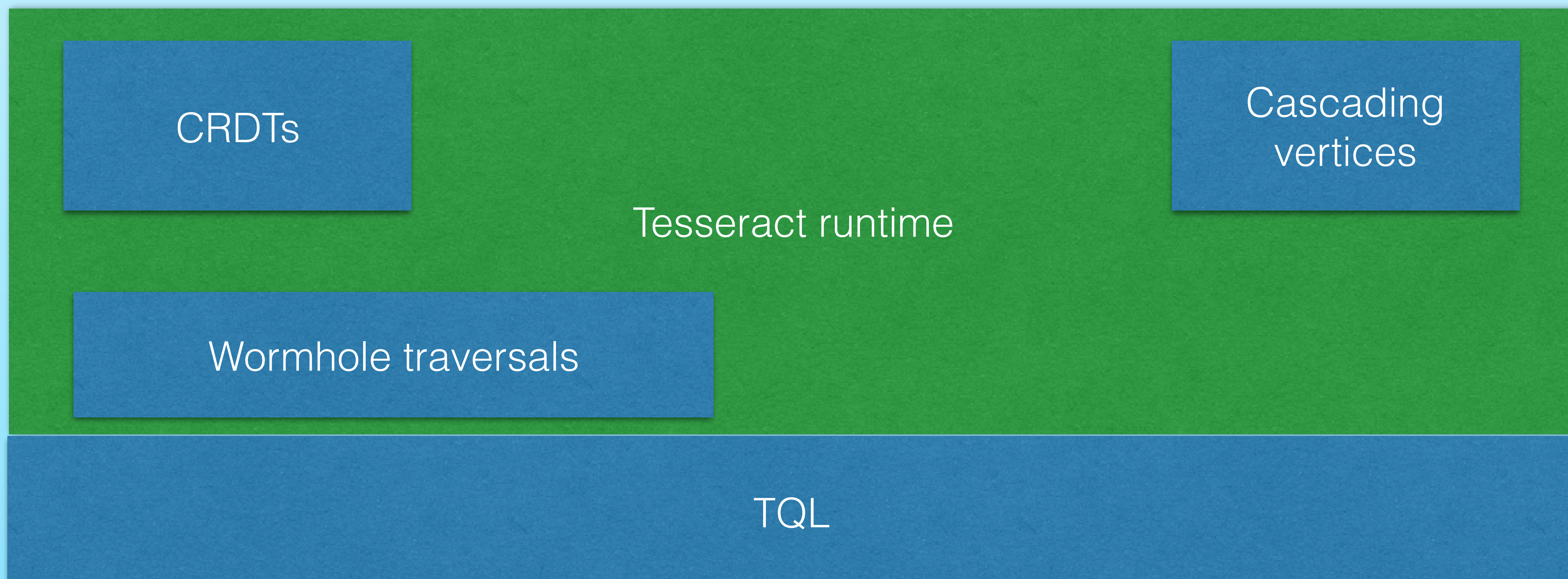

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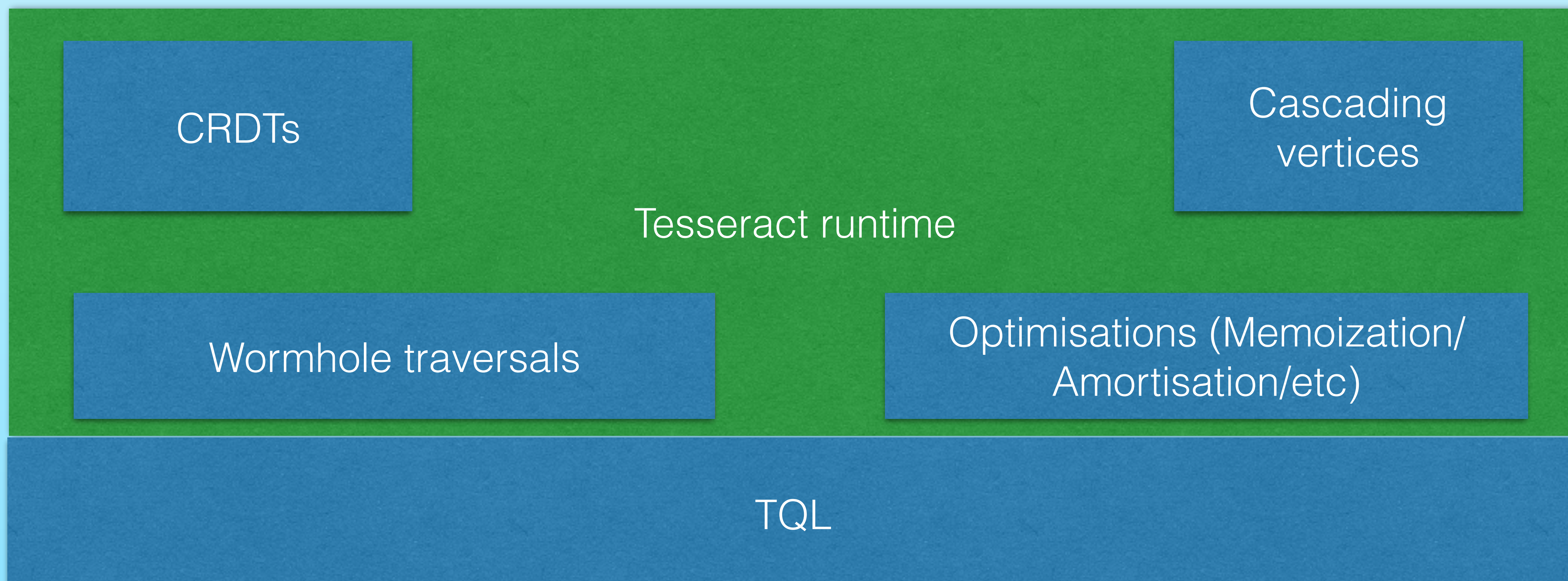

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- Compaction also serves as an opportunity to optimise data location
  - Write only means vertex properties and edges aren't always next to each other in a data file
  - During compaction we re-arrange contents
  - Helps reduce the amount of work required by spindle disks to fetch a vertex's data

First release due in 2-3 months

Will be Apache v2 Licensed

github.com/zcourts/Tesseract

End…

Questions?

Courtney Robinson
Google “zcourts”
courtney@zcourts.com

github.com/zcourts/Tesseract