Treedoc

A Commutative Replicated Data Type Designed for Cooperative Text Editing

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29 -30 November, 2010, Nancy

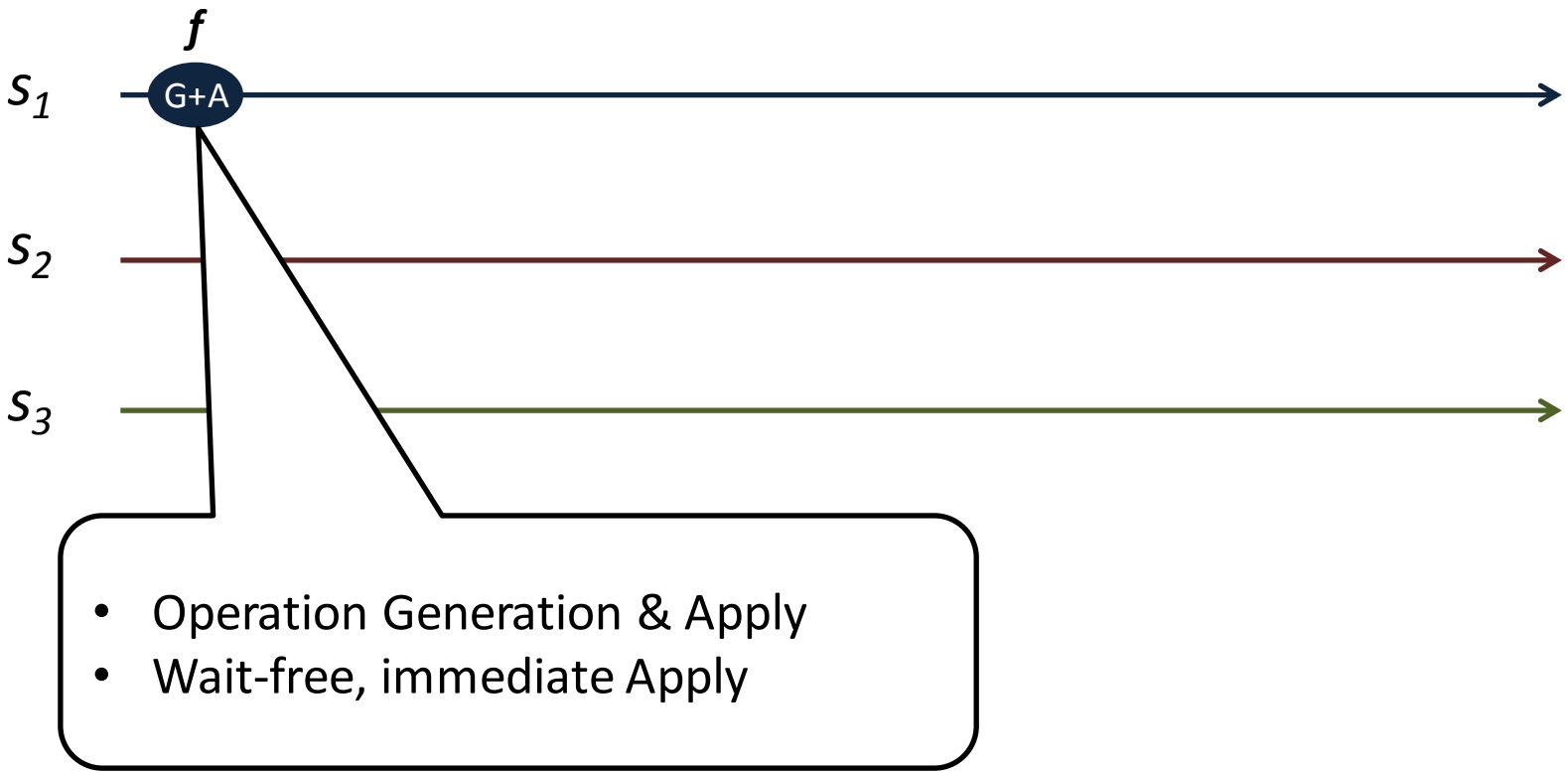
Summary

- Wait-free collaborative editing solution
- Eventually consistent *(CRDT)*
- Sequence
- Separates concurrently-inserted subsequences

System model

- Dynamic set of sites (replicas)
- No permanent crashes

System model



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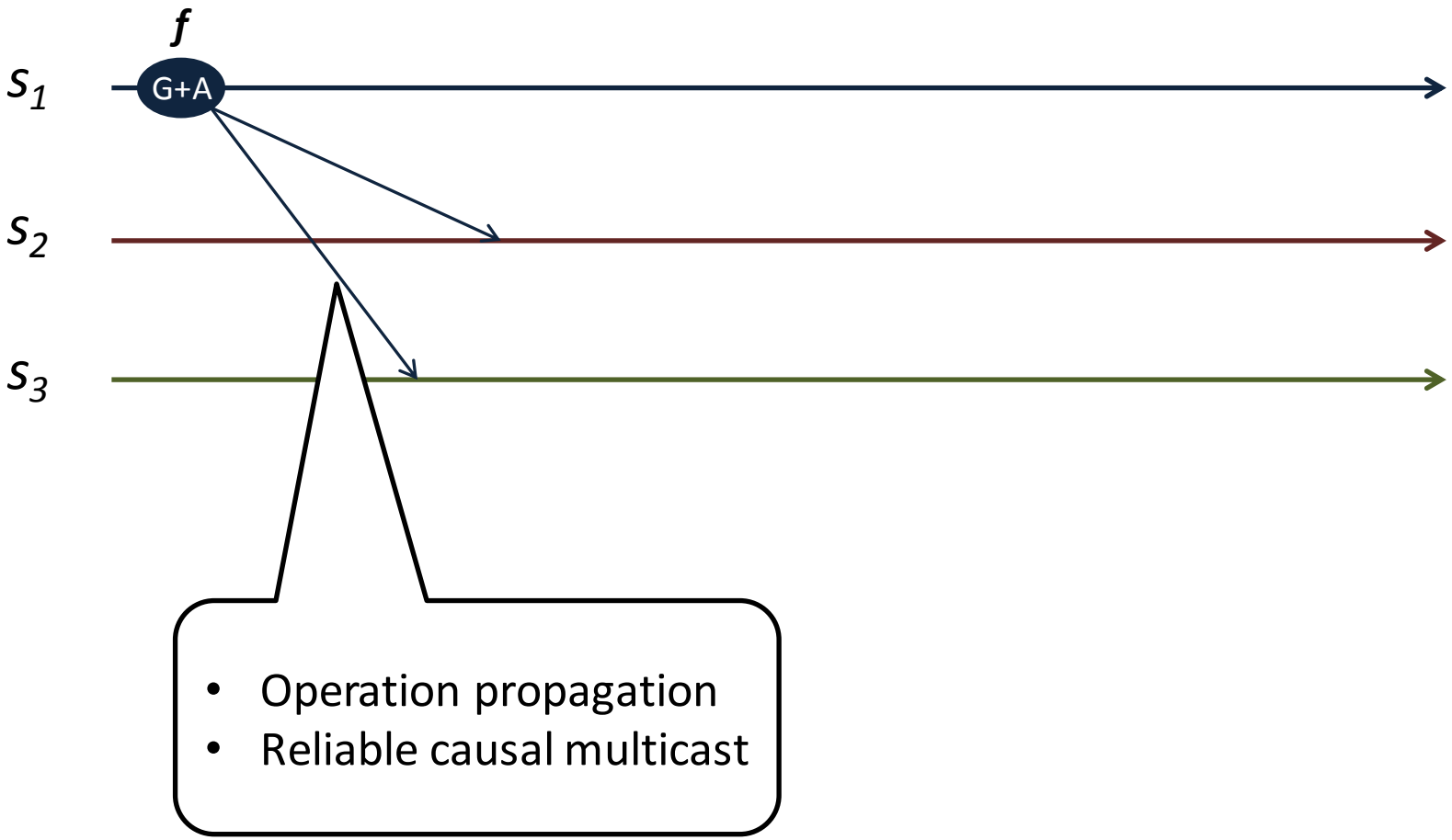

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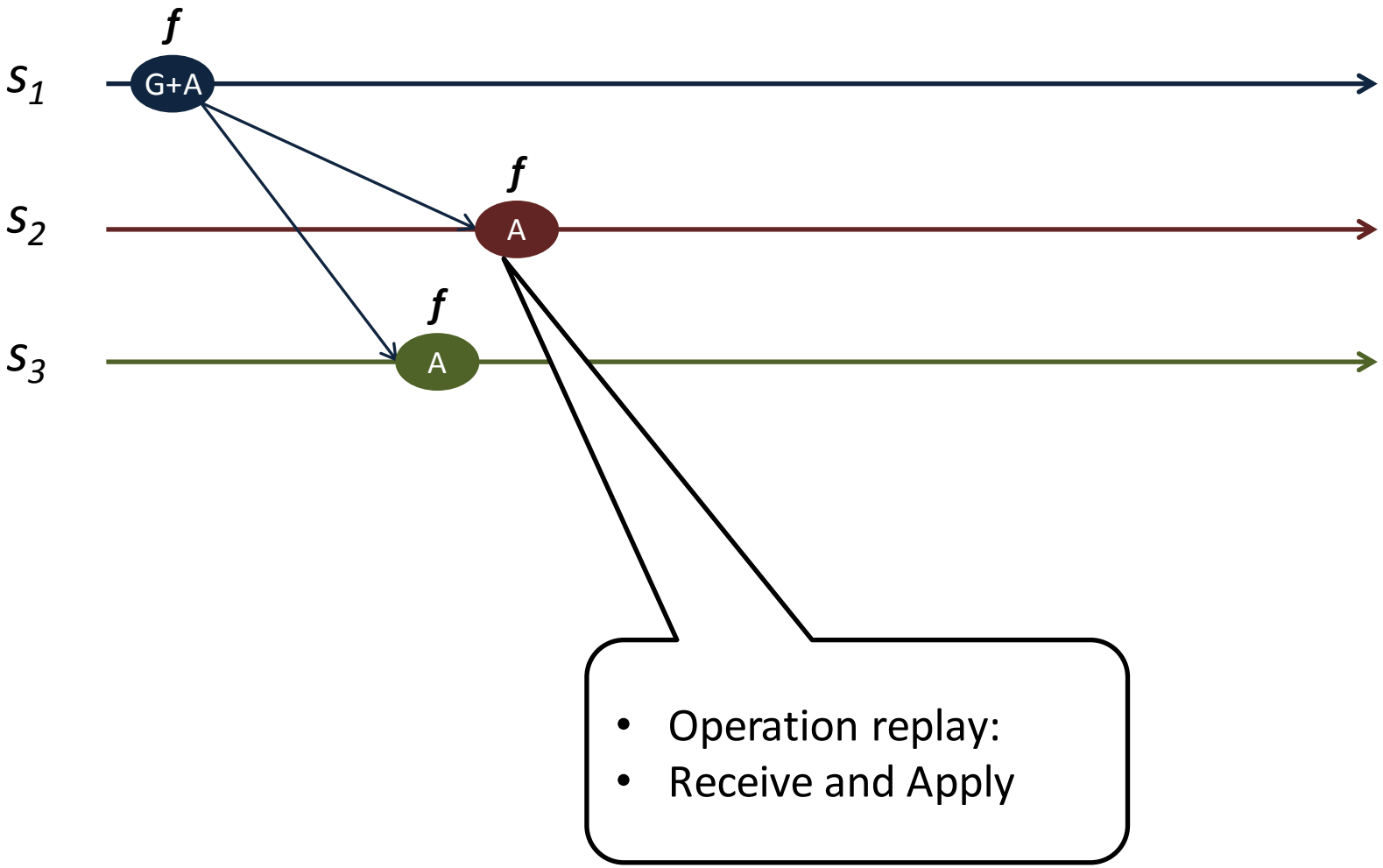

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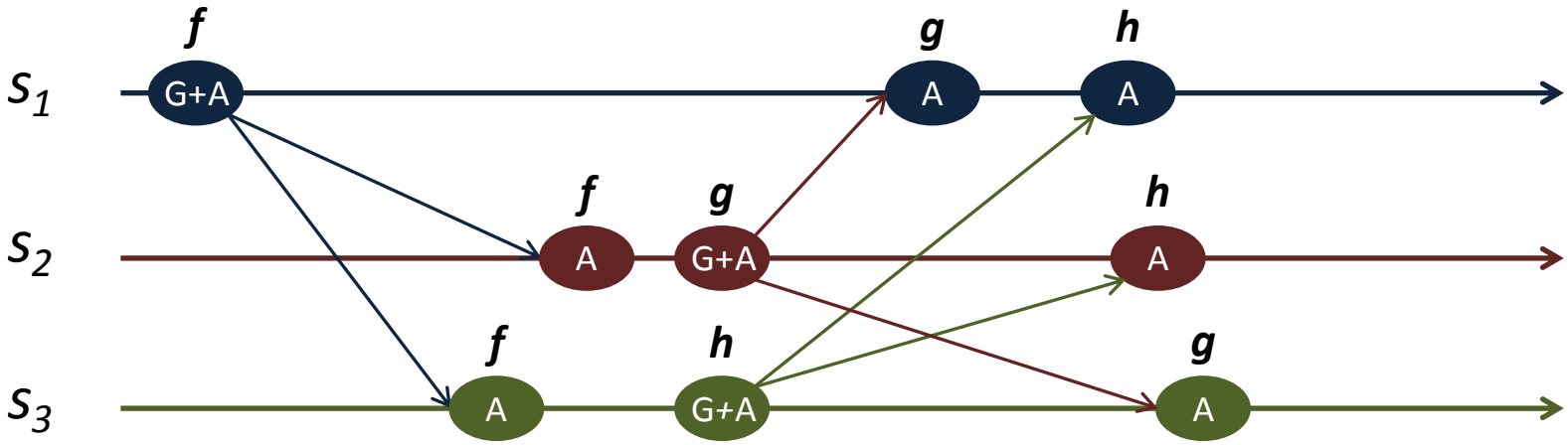
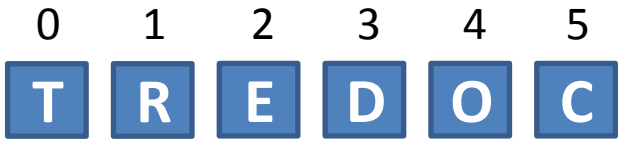


- Concurrent operations **commute**
- Replicas converge

Treedoc – Sequential Buffer CRDT

- **Application view:**
  - Sequential buffer of atoms
  - *buffer.insert(index, atom)*
  - *buffer.remove(index)*
  - Inconvenient for replication



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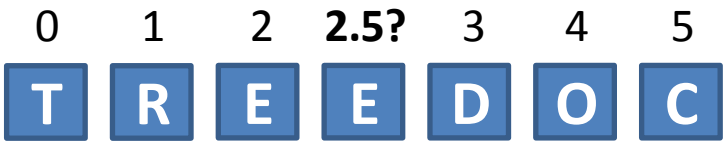

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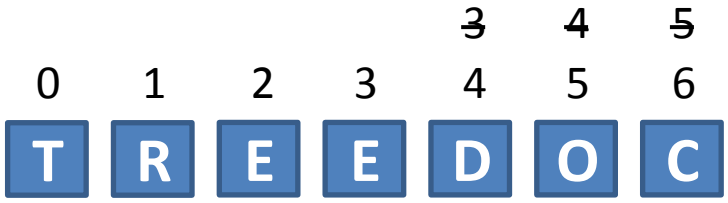

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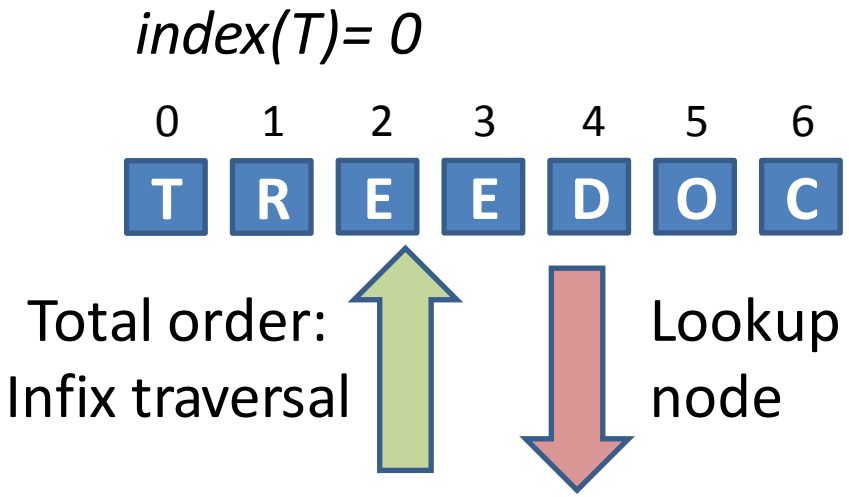
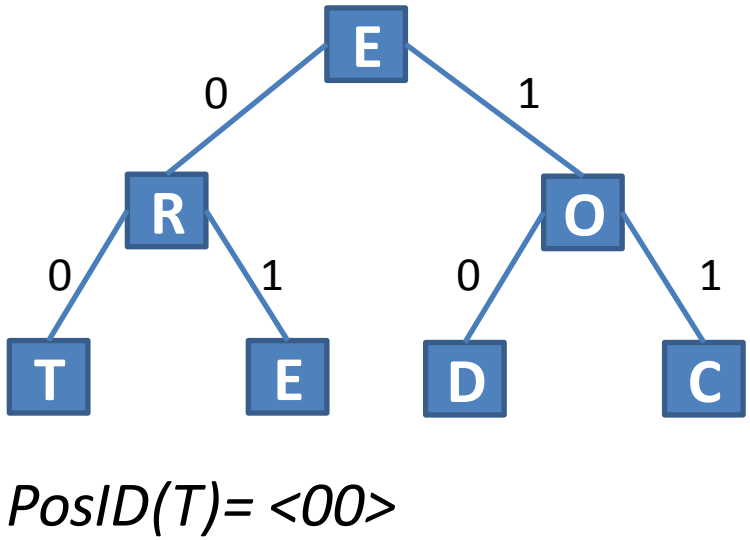


- **Internal state representation:**
  - Grow-only tree of atoms
  - *tree.insert(PosID, atom)*
  - *tree.remove(PosID)*
  - Stable, unique positions *PosID*
  - Commutativity

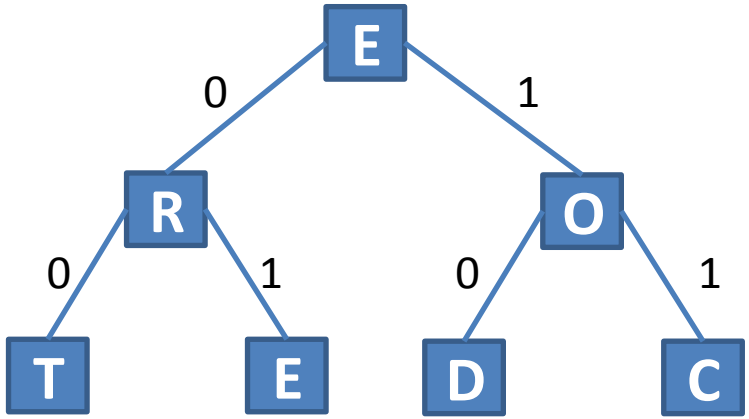


Operations on Treedoc: *insert*

buffer.insert(index, atom) -> tree.insert(PosID, atom)

- Create a new **leaf node** *PosID* such that it corresponds to *index* (it is always possible)
- Put an *atom* there
- Propagate to other replicas

e.g. buffer.insert(4, "S")



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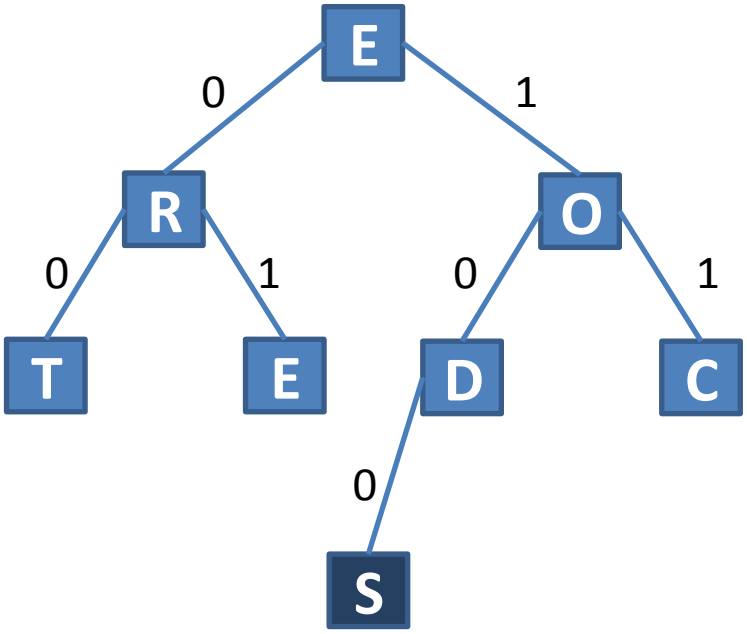
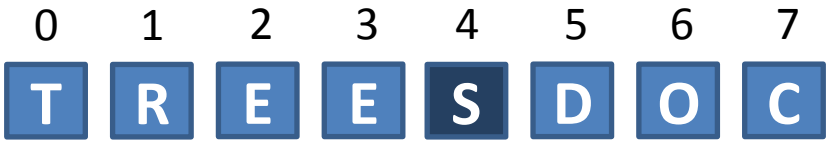
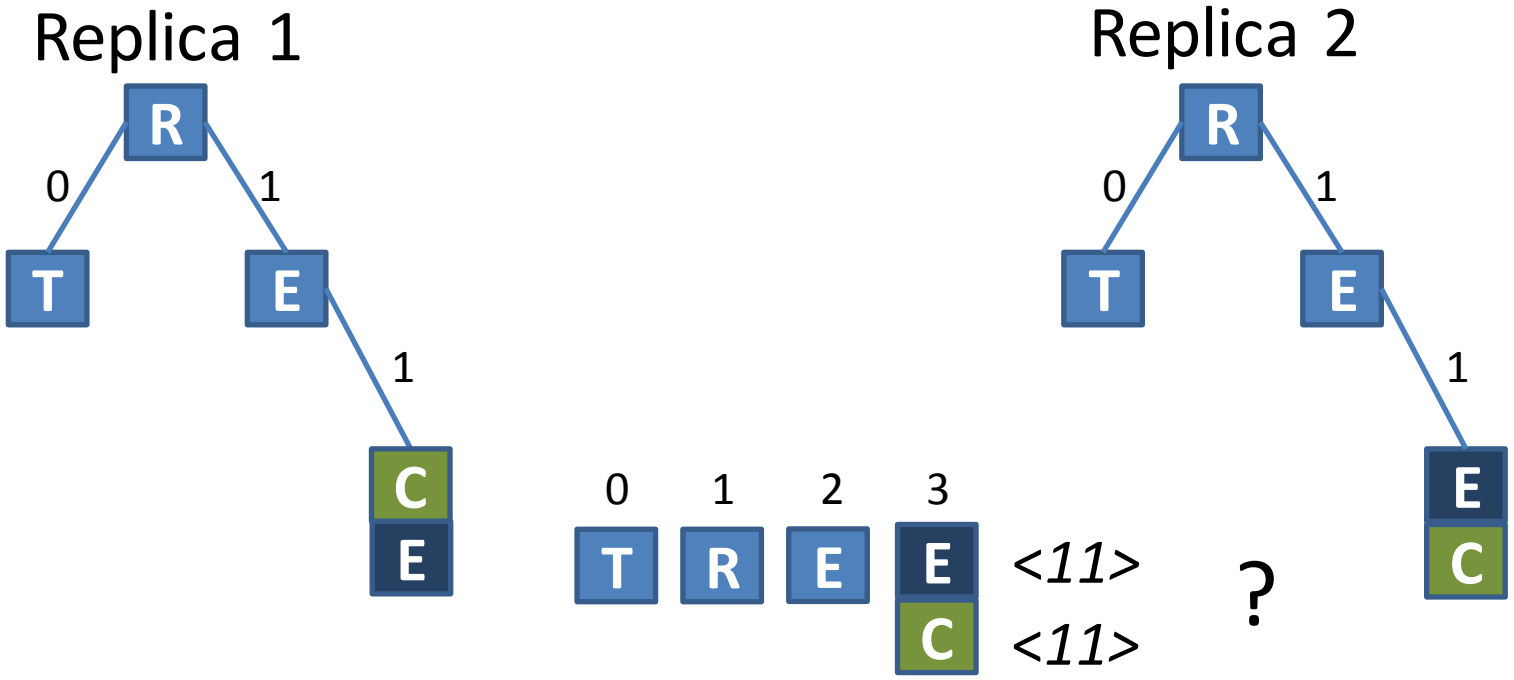
tree.insert(<100>, "S")





Operations on Treedoc: conc. *insert*



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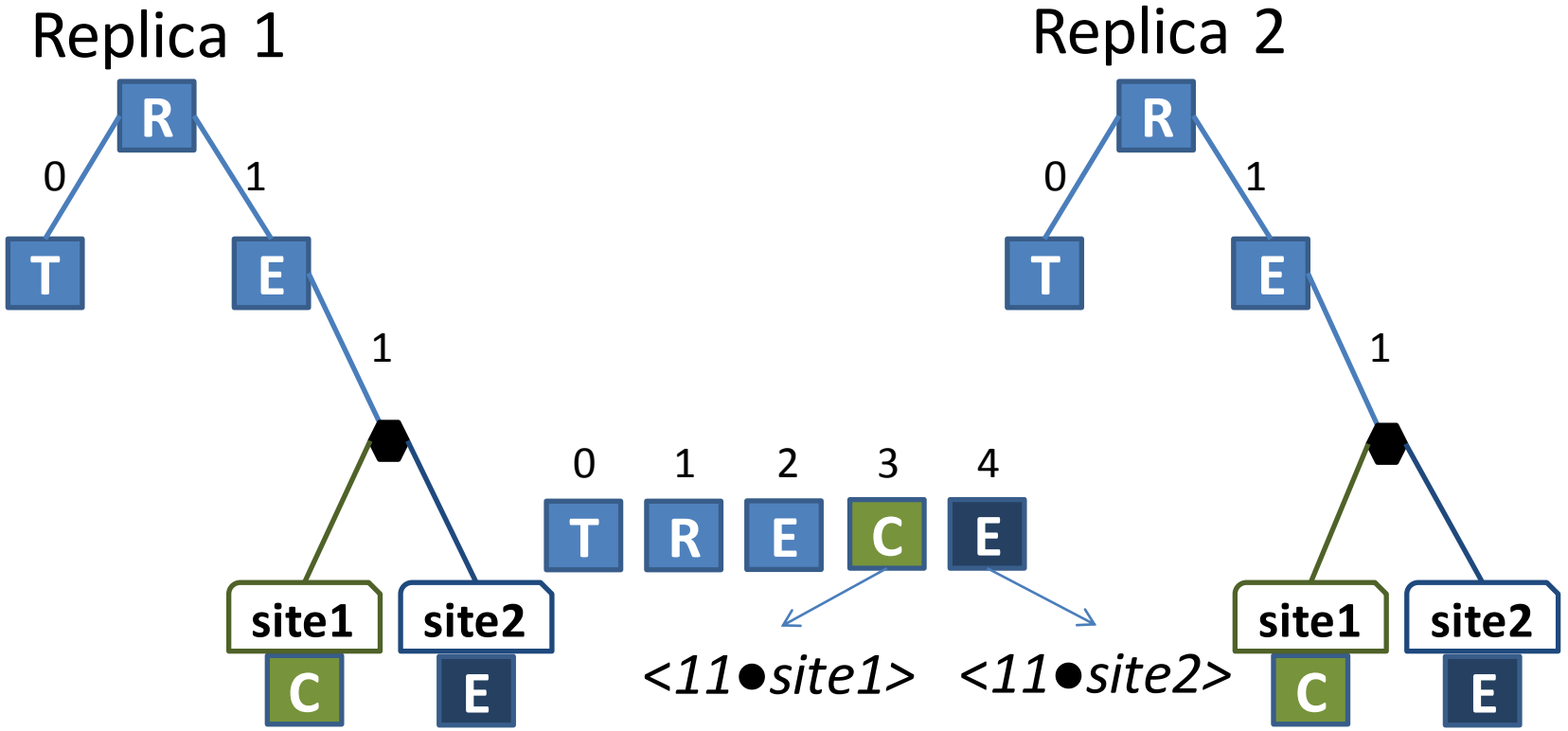
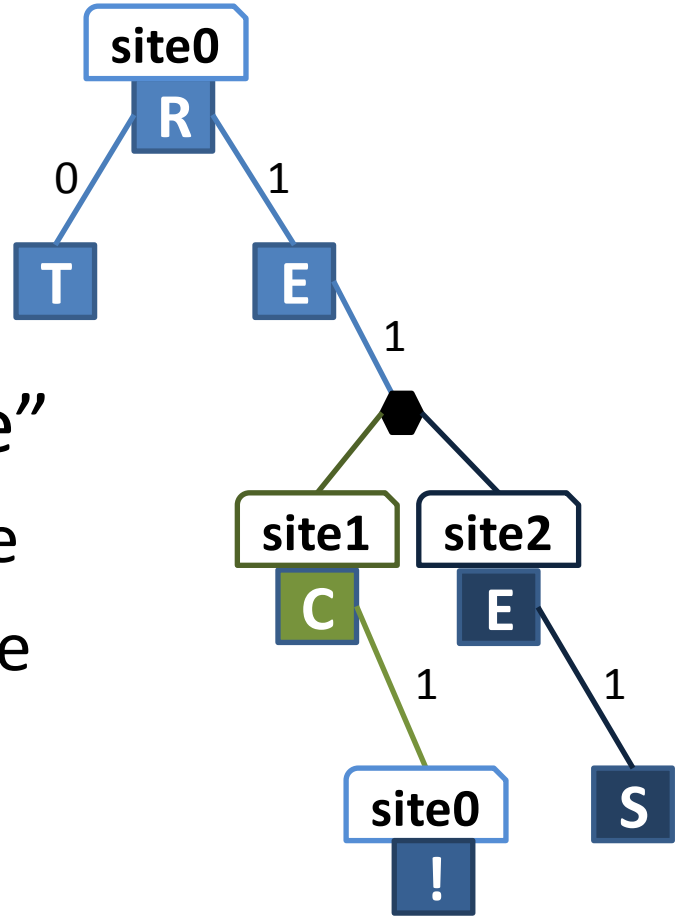
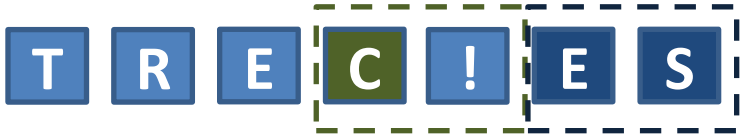


- Always include unique ID in inserted tree node
  - In case of "conflict" -> resolves into arbitrary order
- Could be a unique site ID

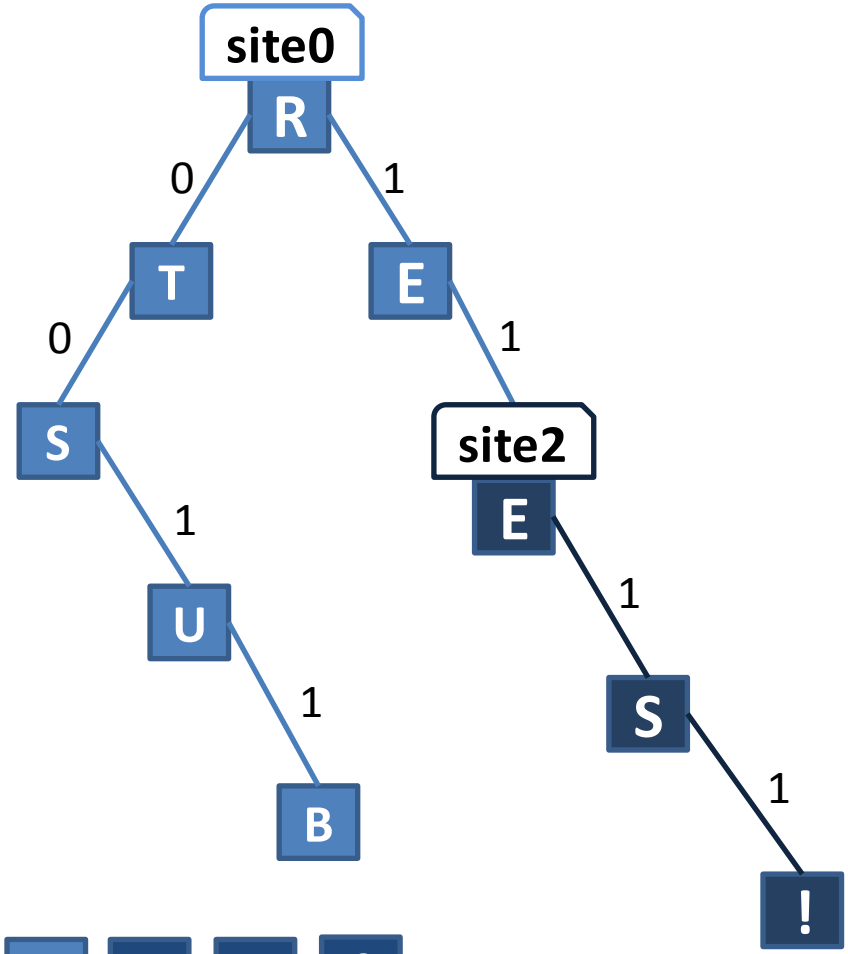
Treedoc: A Layered Tree

- Treedoc composed of layers:
  - Compact binary tree
  - Sparse site ID layer
- Site ID denotes “private space”
  - Space owner uses compact tree
  - Others create new private space
  - Separates concurrent inserts





Treedoc: Independent Private Spaces



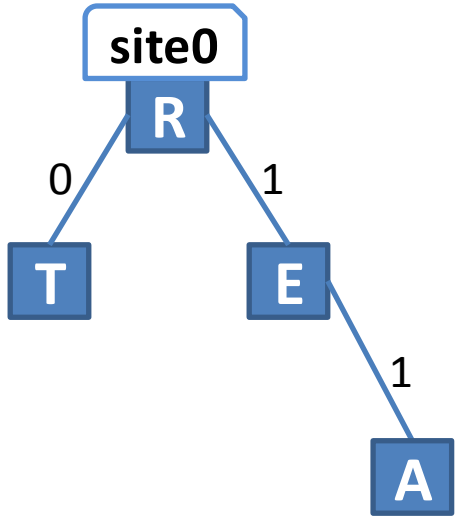
S U B T R E E S !

Operations on Treedoc: *remove*

- Remove atom
- Keep *unused* node

  (alternative designs possible)
- Ignore in application view

  e.g. *buffer.remove(1)*



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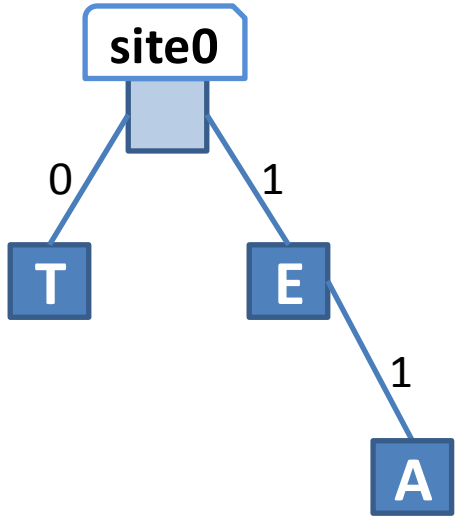
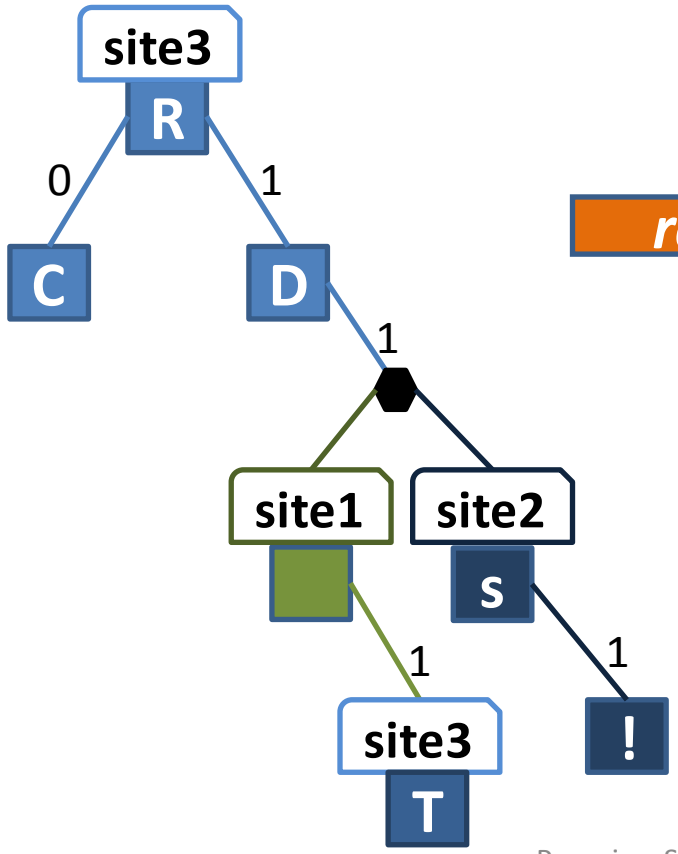
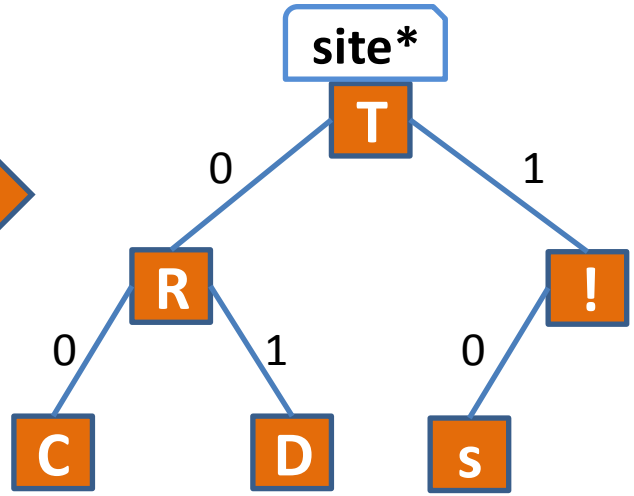


Why Is Tree Rebalance Required?

Tree may become unbalanced
Unused nodes waste space
Number of site IDs increases

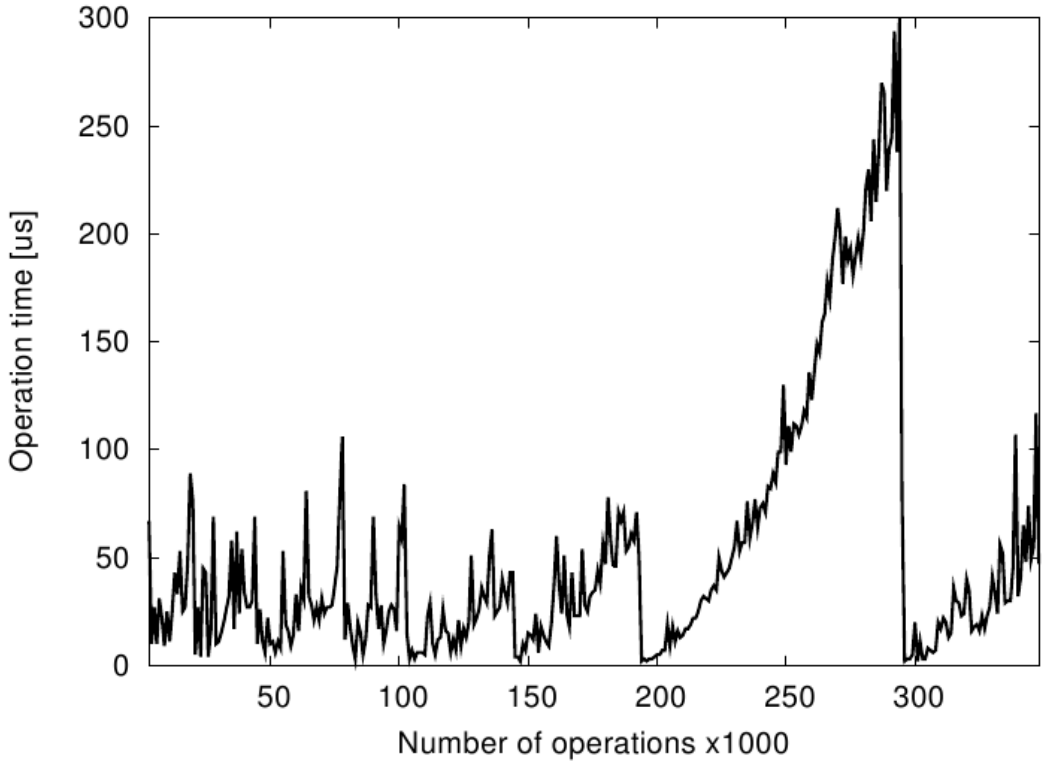
Access time grows
PosID length grows (communication cost)





- Unused nodes discarded
- Minimal tree maintaining identical order
- Single space – compact tree

Measurements: GWB Wikipedia page



[Letia 09]
old impl.

Sequential replay of Wikipedia traces
(atom: paragraph)

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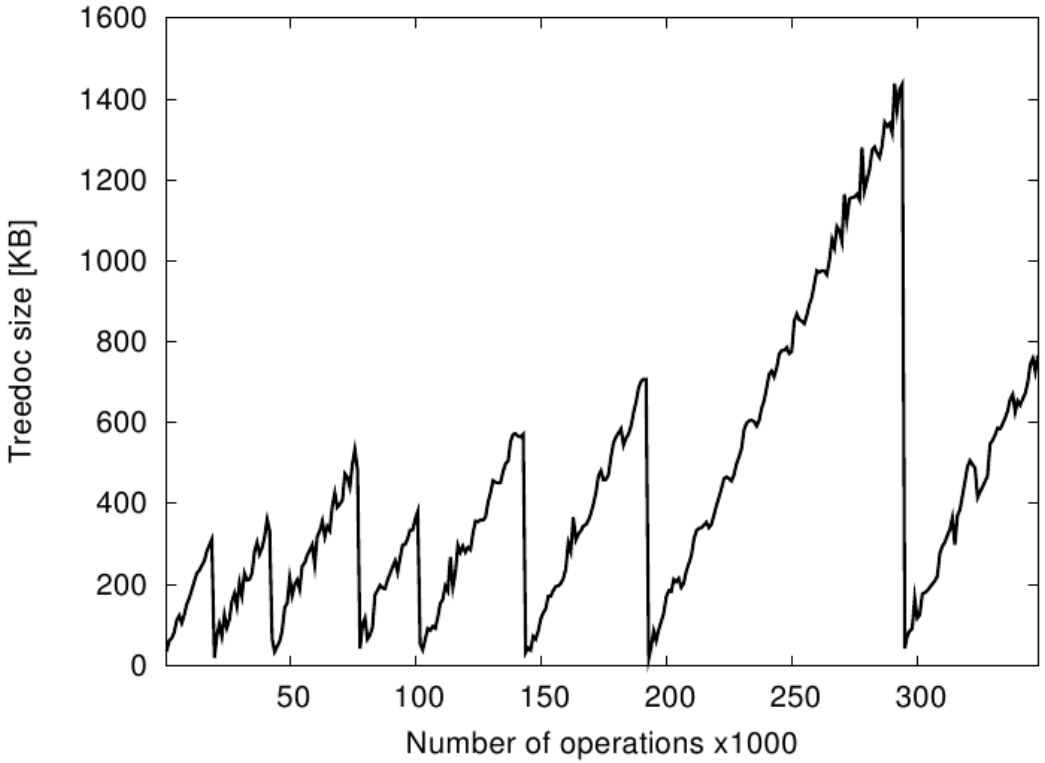

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Rebalance is beneficial, but ***non-commutative*** with edits.
Identifiers are changed => consensus is required.
Consensus => blocking operations, difficult in dynamic system.

The Core-Nebula Architecture

Idea: limit consensus to a smaller number of sites

Sites are divided into two disjoint sets:

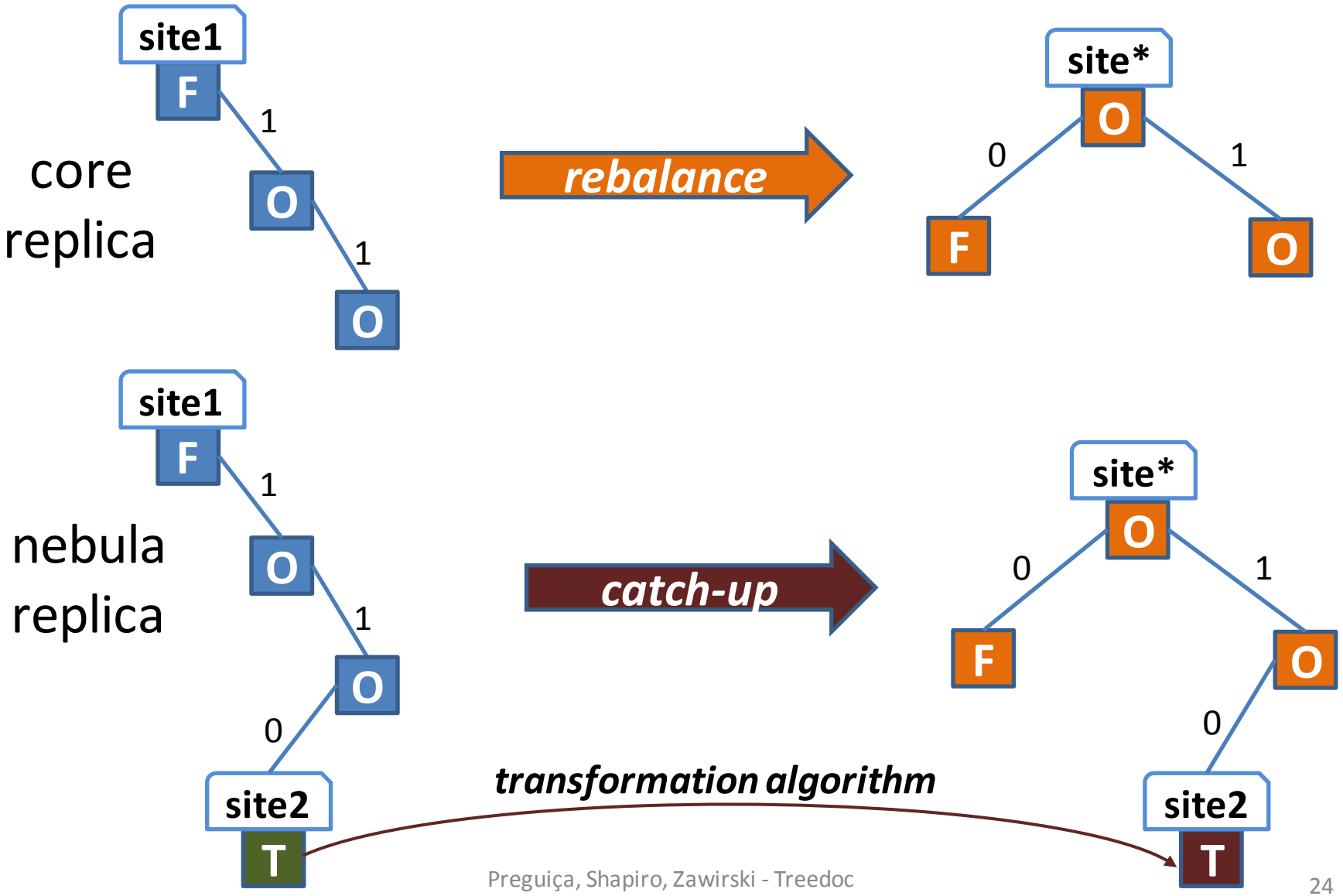
CORE

- a group managed by membership protocol
- stable
- both perform tree operations & agree on tree *rebalance*
- easier agreement

NEBULA

- sites freely join and leave
- dynamic
- perform tree operations only
- Informed about *rebalance,* perform ***catch-up*** protocol to integrate conc. changes

The Core-Nebula: catch-up



Current status

- Prototype core-nebula implementation:
  - 1 core node, simplified communication
  - 5 KLOC Java code (1.5 KLOC core-nebula code)
  - Test suite (boundary cases)

Work in progress:

  - Core-nebula: evaluation, proof generalization?
  - Combining private spaces and core-nebula (verification)
  - Optimization of *PosIDs* encoding
  - More theory on private spaces?

Summary

- Wait-free collaborative editing solution
- Eventually consistent *(CRDT)*
- Sequence
- Separates concurrently-inserted subsequences