Incremental Updates for Graph Queries

Oracle VM meetup – September 2014

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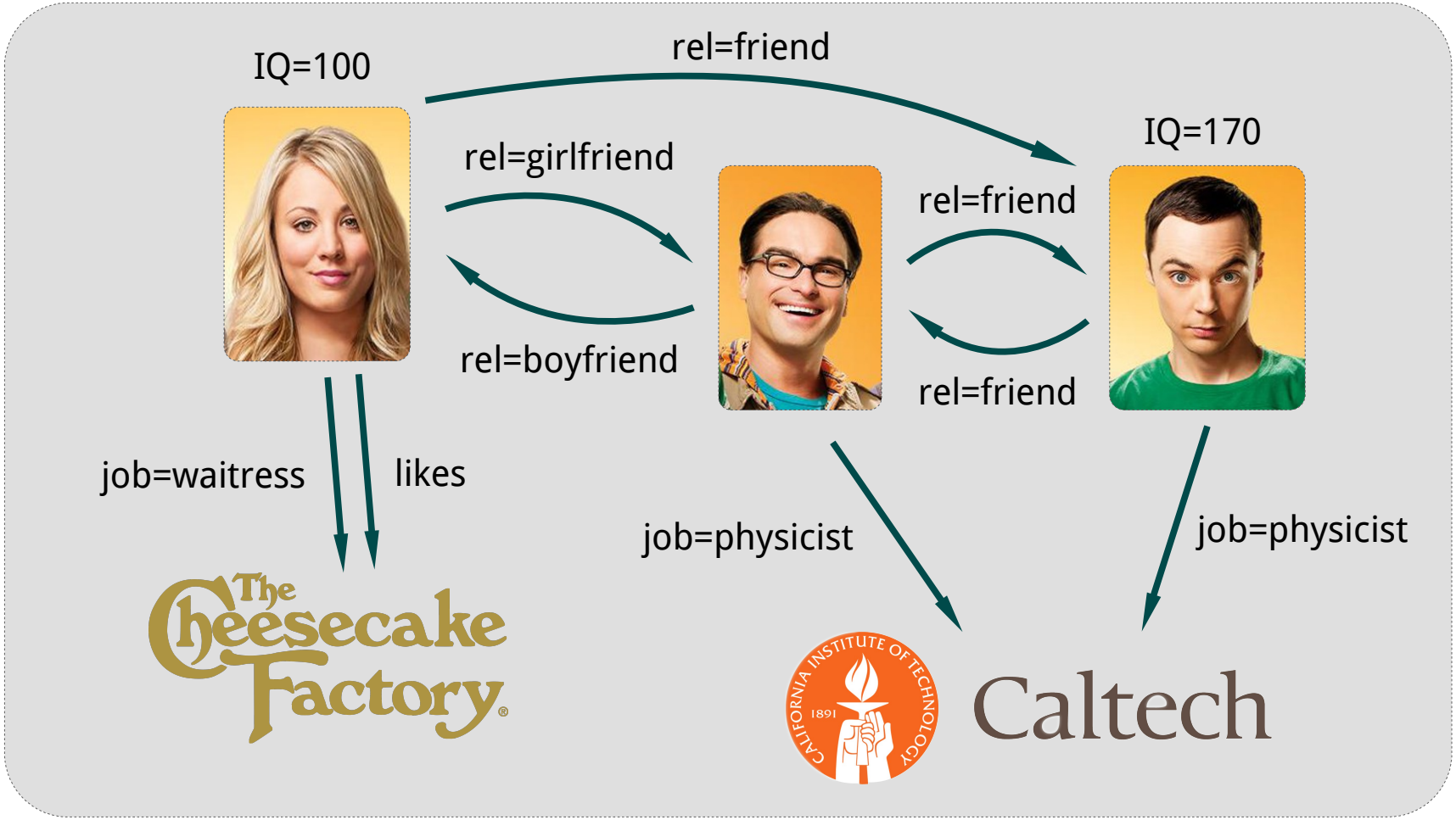
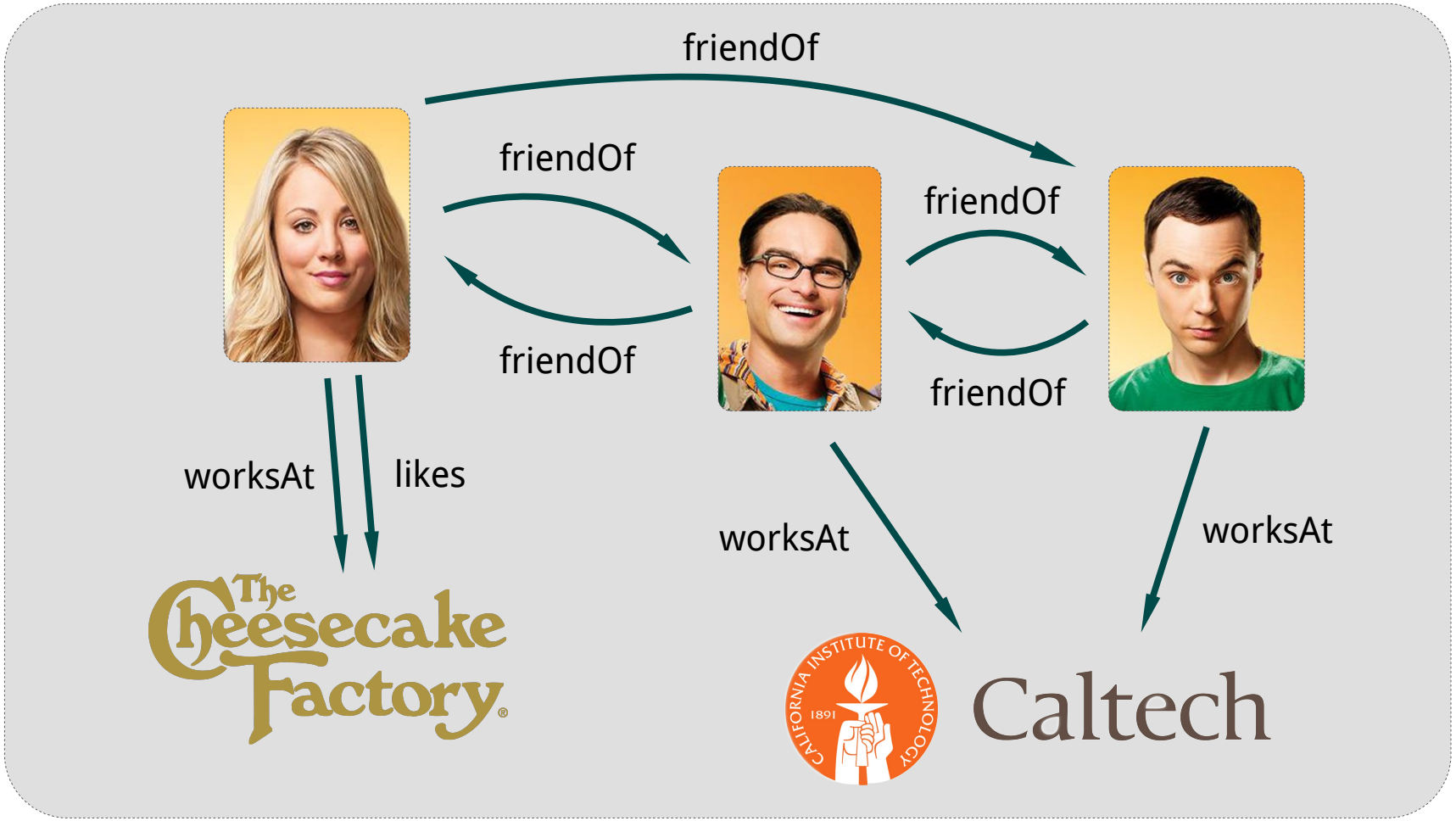
Graph Databases



Graph Databases



PGX.ISO

- Parallel in-memory graph query engine
- Developed by Oracle Labs
- Based on Green-Marl runtime

PGX.ISO: Parallel and Efficient In-Memory Engine for Subgraph Isomorphism

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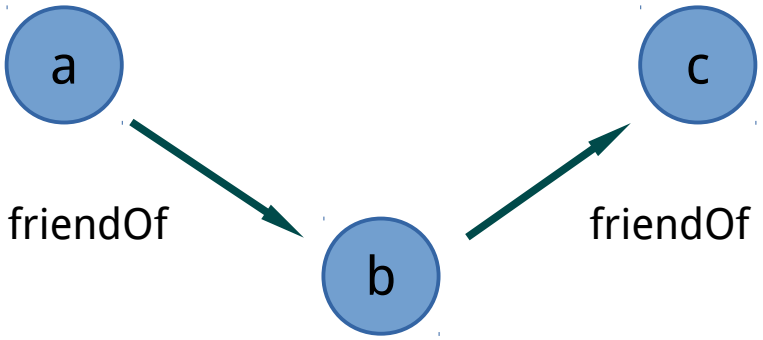
ABSTRACT

Subgraph isomorphism, or finding matching patterns in a graph, is a classic graph problem that has many practical use

Consequently, many solutions have been proposed for this problem, including commercialized ones. First, there are graph databases [9, 3] which adopt the classic RDF graph

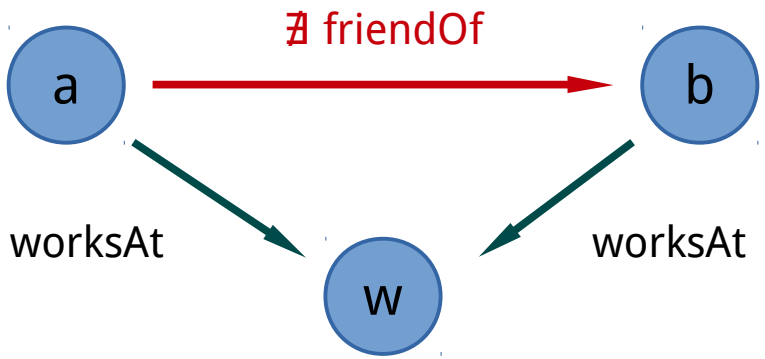
Graph Queries

```
SELECT ?a ?c
WHERE {
     ?a friendOf ?b .
     ?b friendOf ?c .
}
```



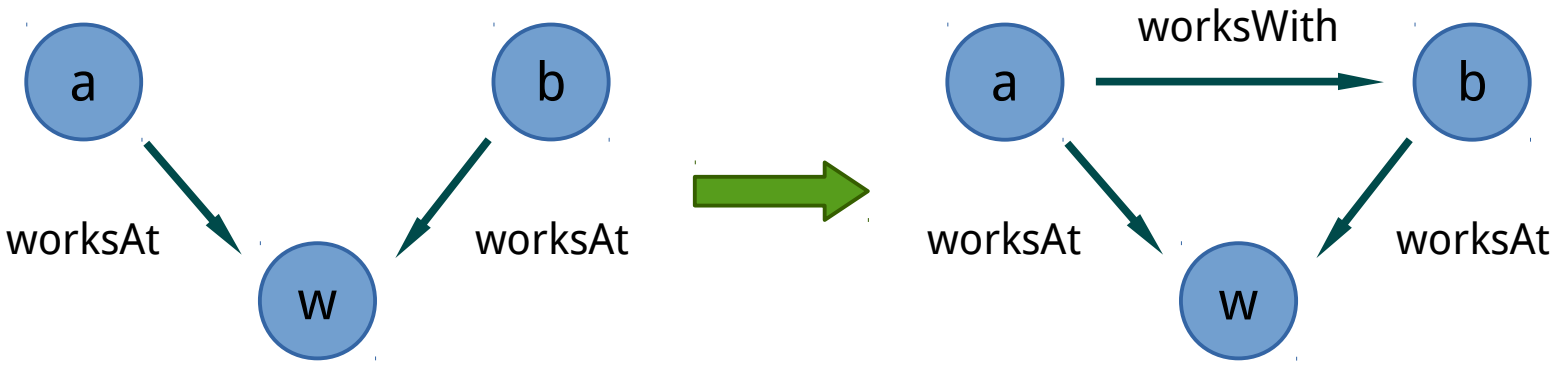
Filters

```
SELECT ?a ?b
WHERE {
     ?a worksAt ?w .
     ?b worksAt ?w .
     FILTER NOT EXISTS { ?a friendOf ?b }
}
```



Updates

```
INSERT { ?a worksWith ?b }
WHERE {
     ?a worksAt ?w .
     ?b worksAt ?w .
}
```



Updates

- Caused by
  - update queries
  - “external” changes to the DB
- Performance issues
  - Data structures allowing fast in-memory updates
  - Update query results after updates to DB

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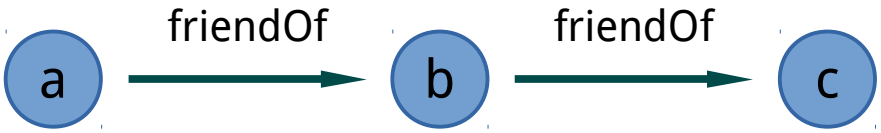
Why should I care?

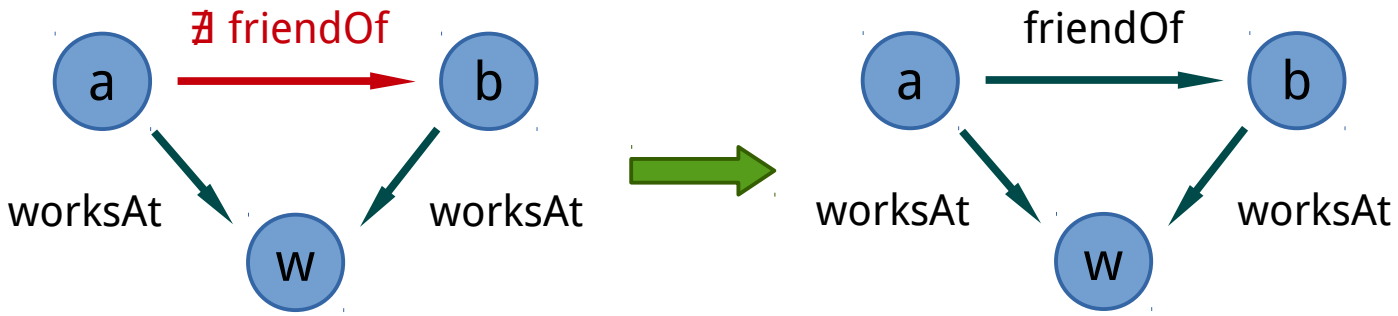
- We want graph analysis to be fast
- But also...
  - ... enables fast, large-scale graph rewriting
  - useful for some types of program analysis
  - used in “VMs” for modeling/simulating complex systems
    - biochemical system (Kappa/BNGL)
    - statistical physics
    - social networks
    - etc.

Updating query results

Example query



Example update

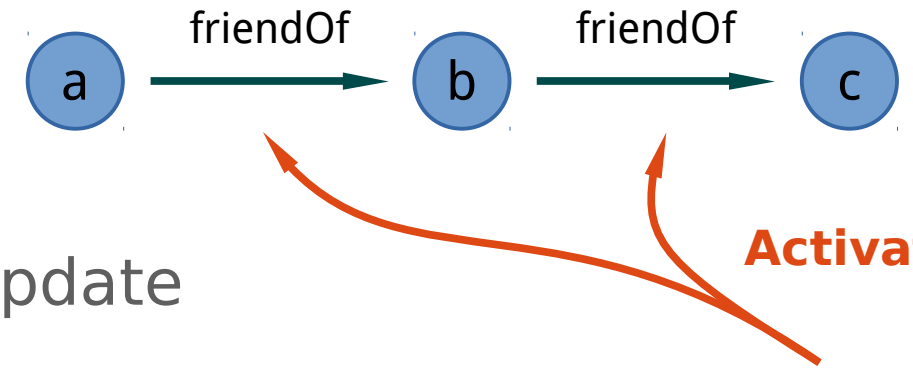


Updating query results

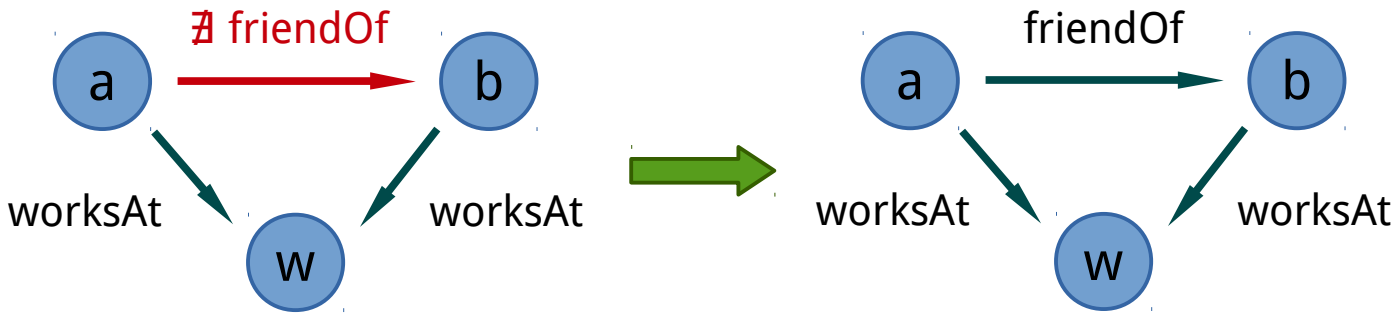
- Naive approach
  - Just re-run all queries upon updates
  - Inefficient, especially for small changes
- Which queries need updating?
- What type of update?
  - Addition/deletion of result
  - Location of result
- We'll need a bit of static analysis...

Dependencies

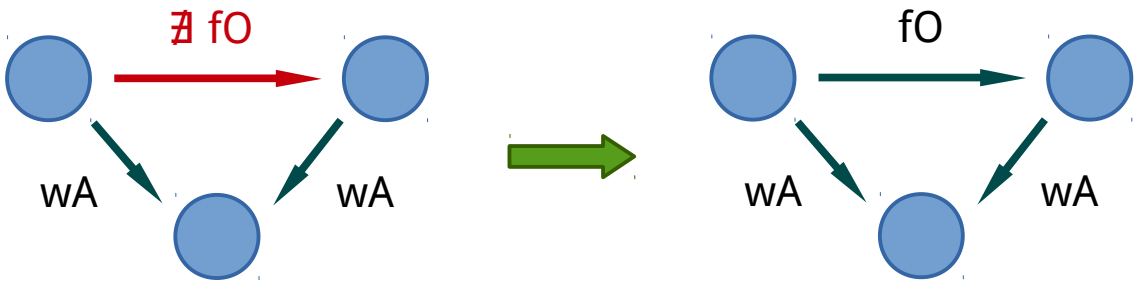
Example query



Example update



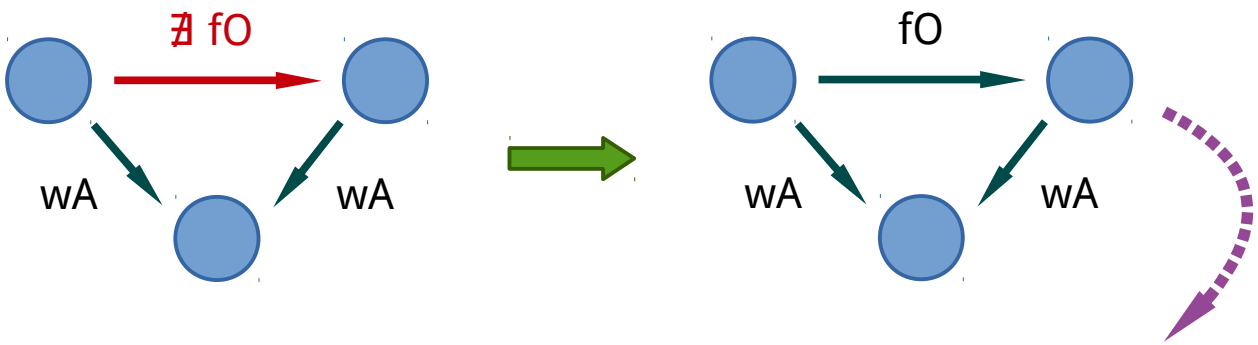
Overlaps



Observations

- dependencies correspond to overlaps

Overlaps



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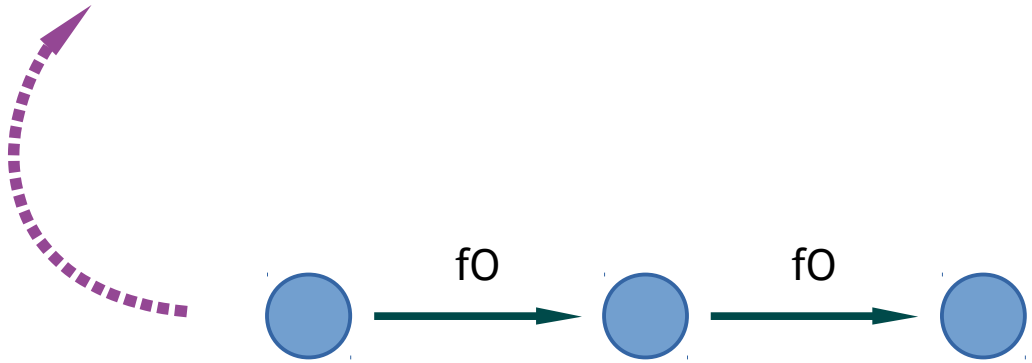

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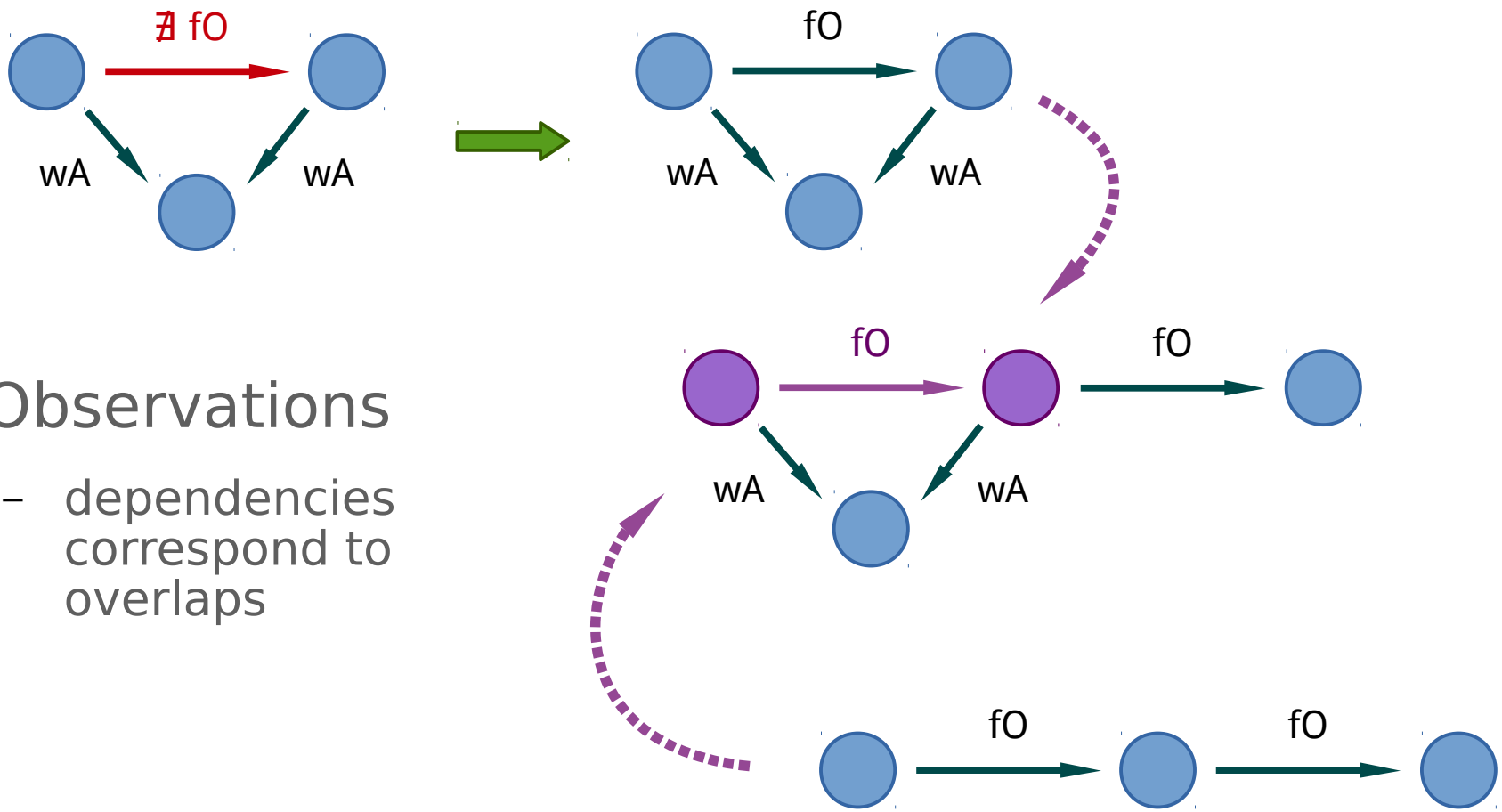

Observations

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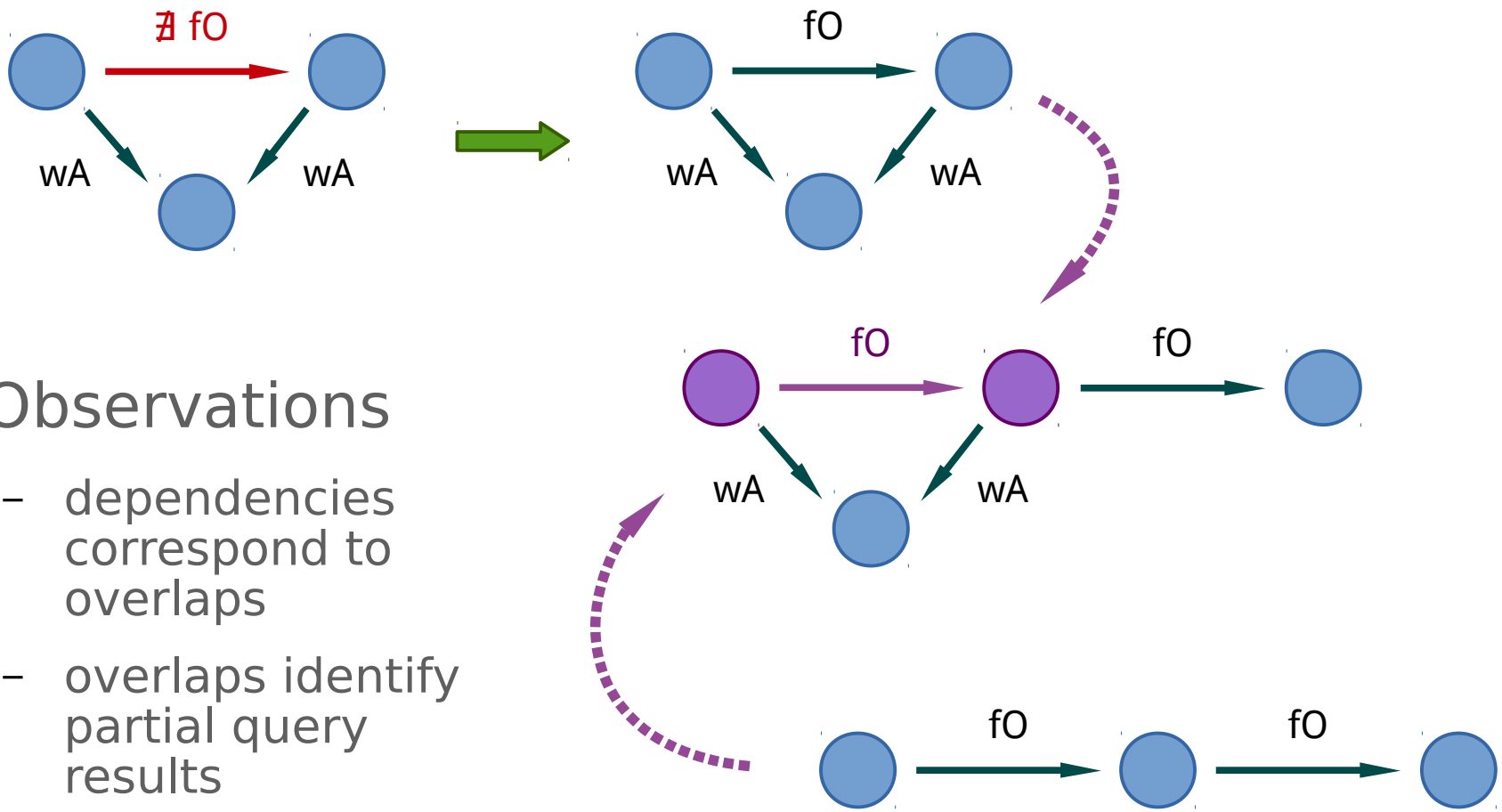


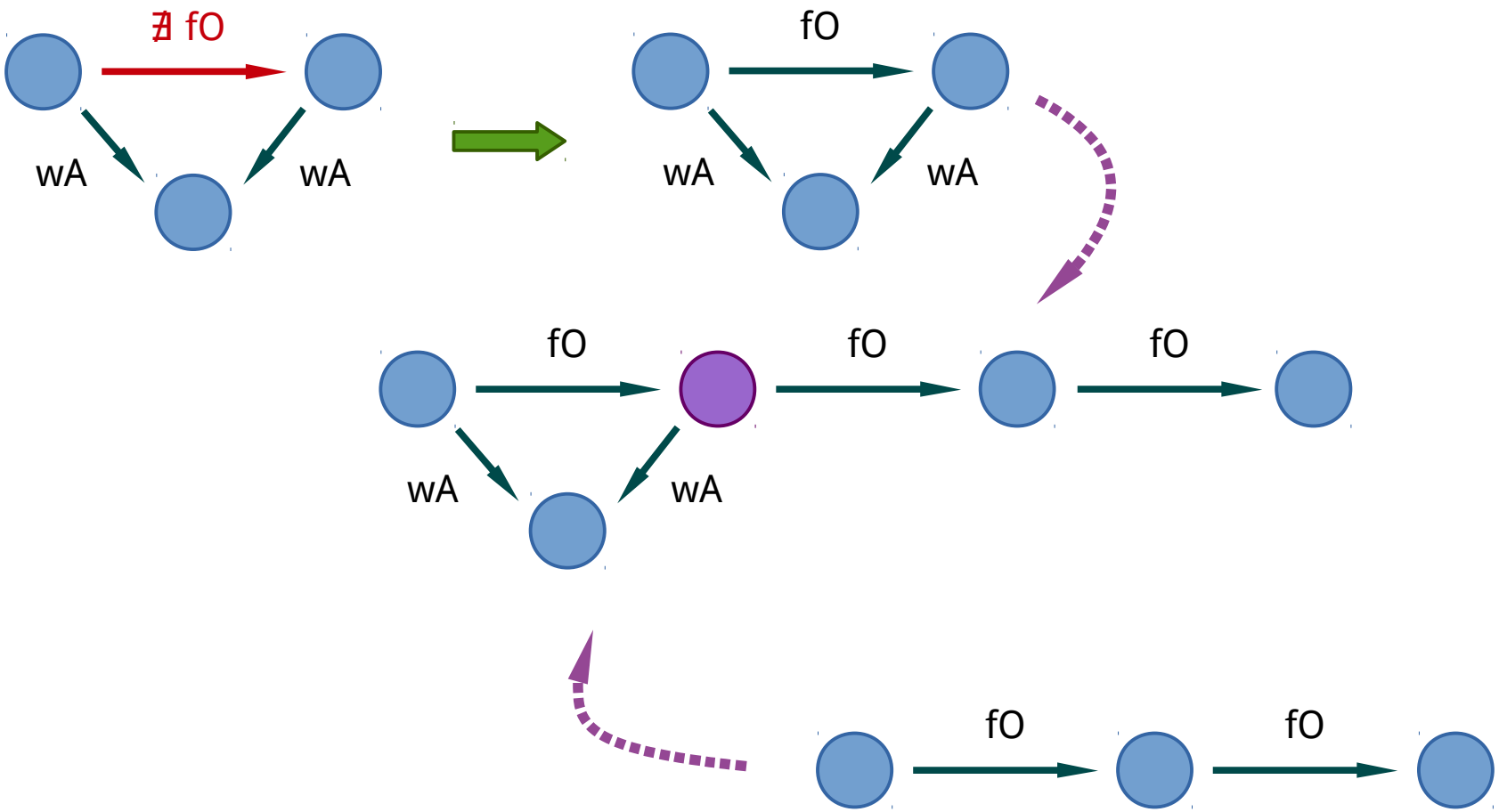
Observations

- dependencies correspond to overlaps
- overlaps identify partial query results

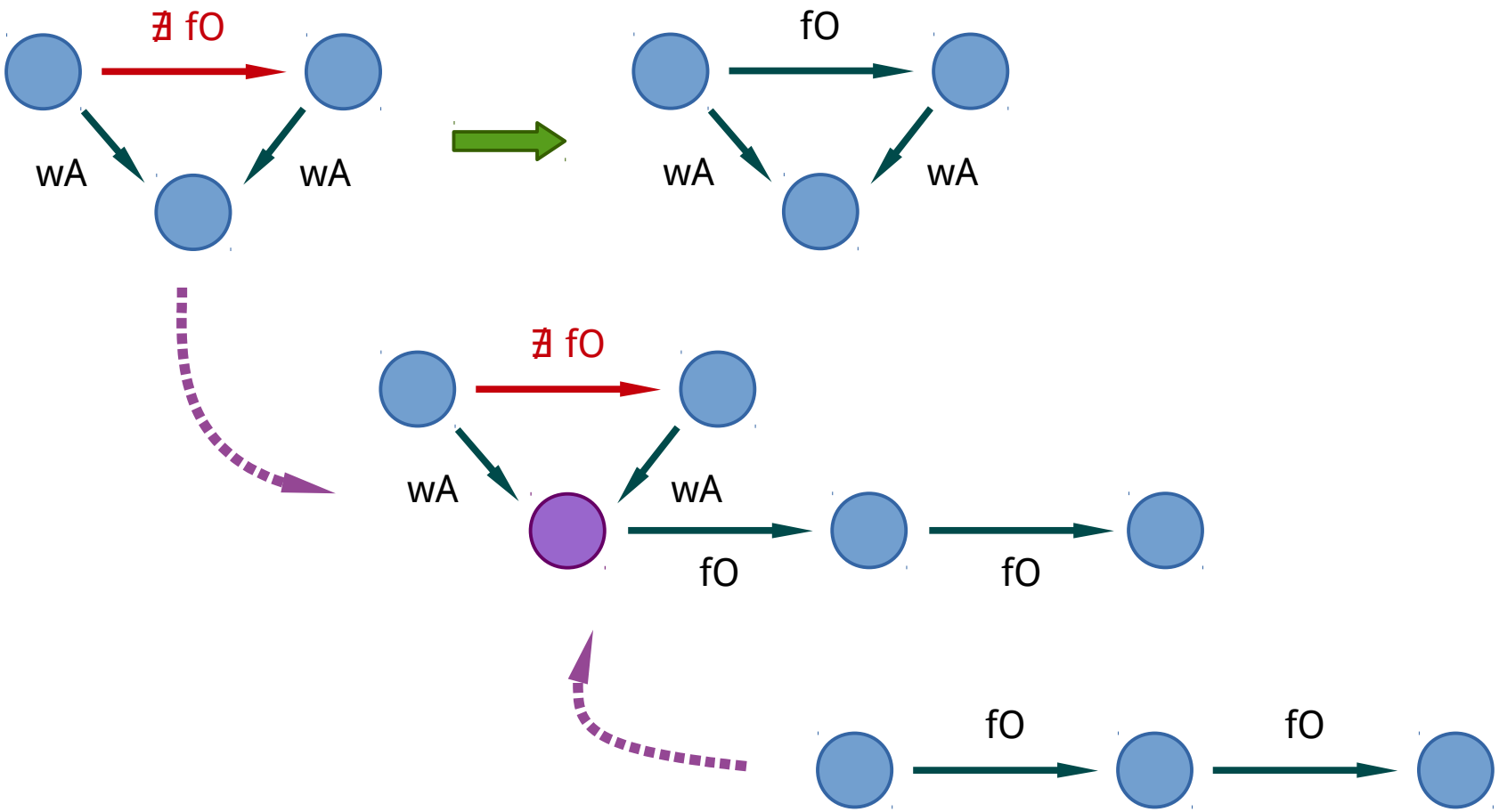
Dependency analysis

- Idea: find overlaps of queries and updates
  - Overlaps on left-hand sides → inhibition
  - Overlaps on right-hand sides → activation
  - Use overlaps as “seeds” for query engine
  - Basic theory dates back to the 70ies (GTS, parallel/sequential dependence, critical pairs, Rete networks)
- Issues…
  - There are lots of overlaps, most are irrelevant
  - How to deal with “external” updates?

Irrelevant overlaps



Irrelevant overlaps



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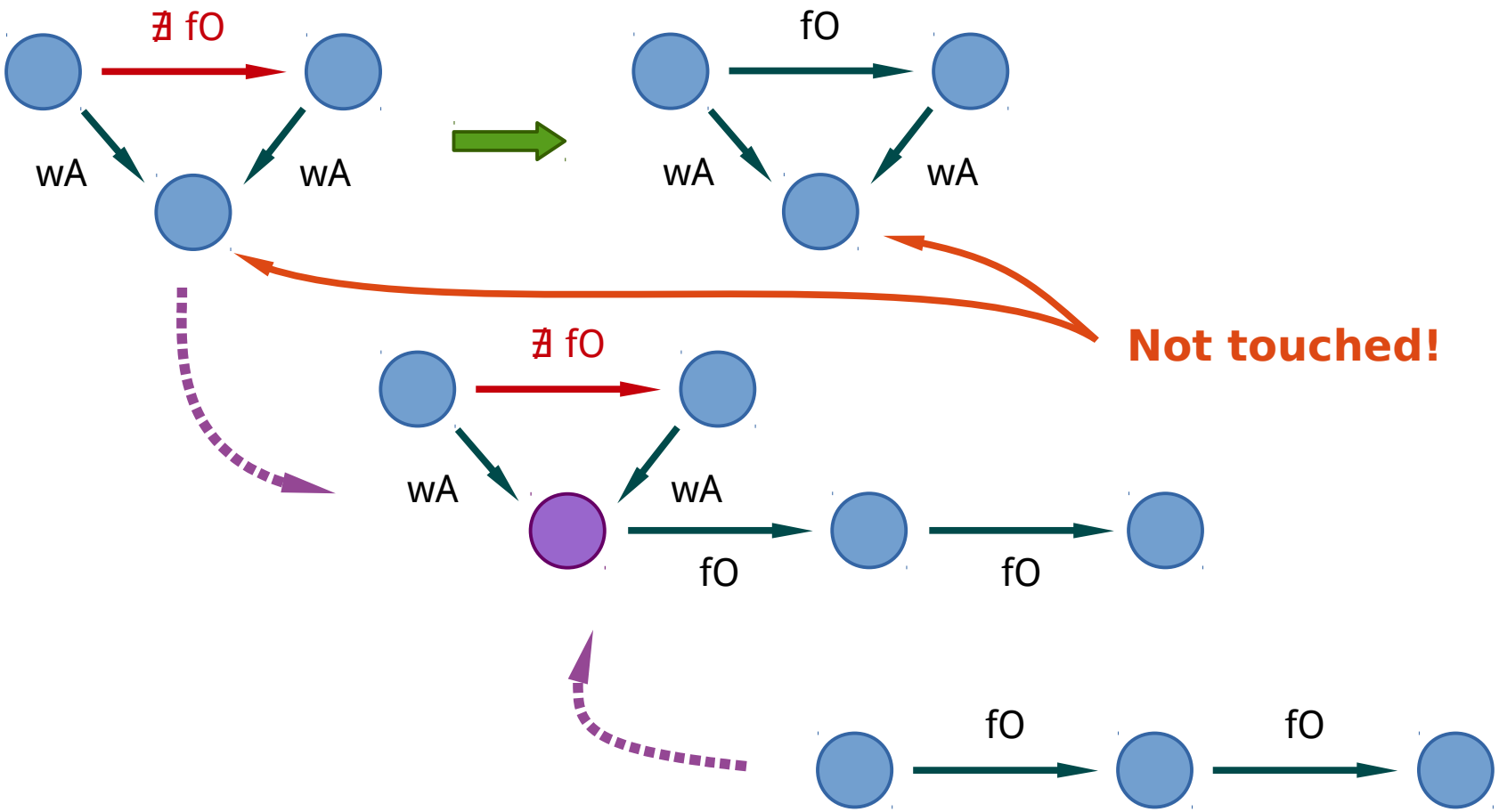


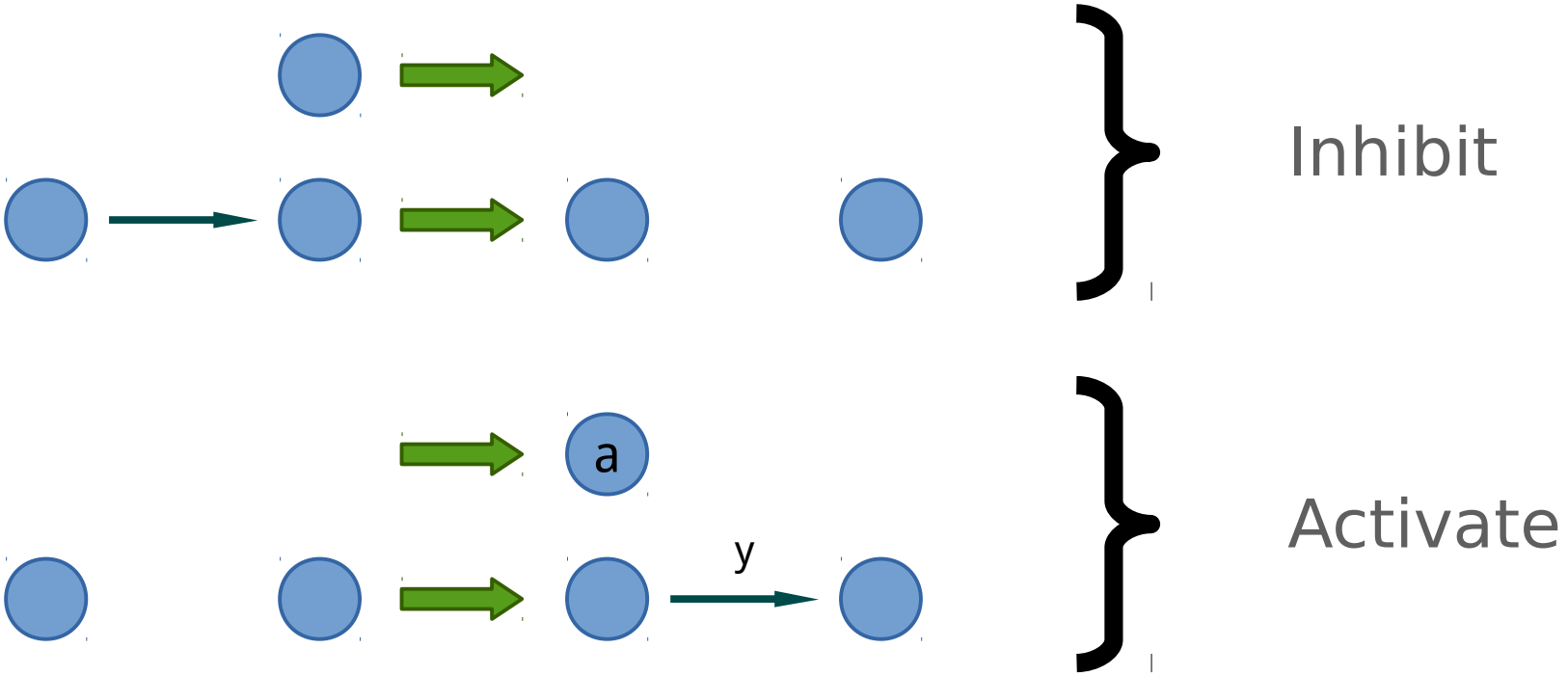
Improving dependency analysis

1. Only consider “relevant” overlaps

Basic updates

Observation

- treat updates as sequences of “atomic” updates

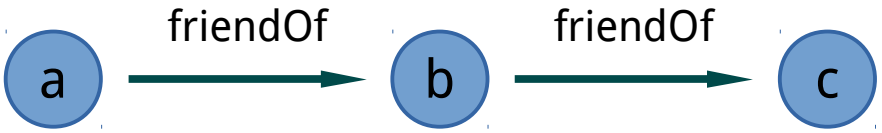


Improving dependency analysis

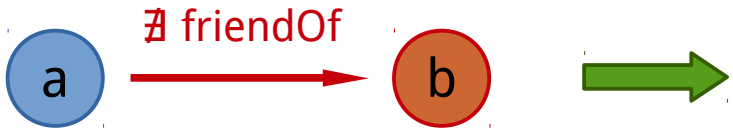
1. Only consider “relevant” overlaps
2. Analyze only basic updates
   - Break updates into basics and find overlaps
   - No dependency unless at least on basic update overlaps
   - Handles “external” updates too

Filter dependencies

Example query



Example update



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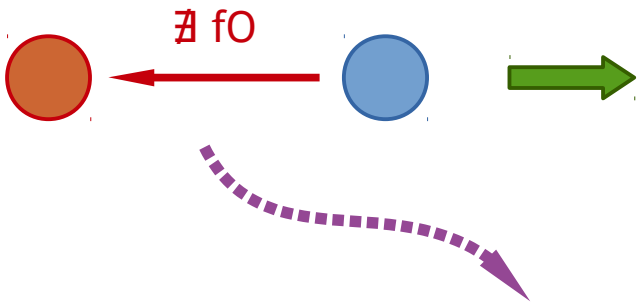

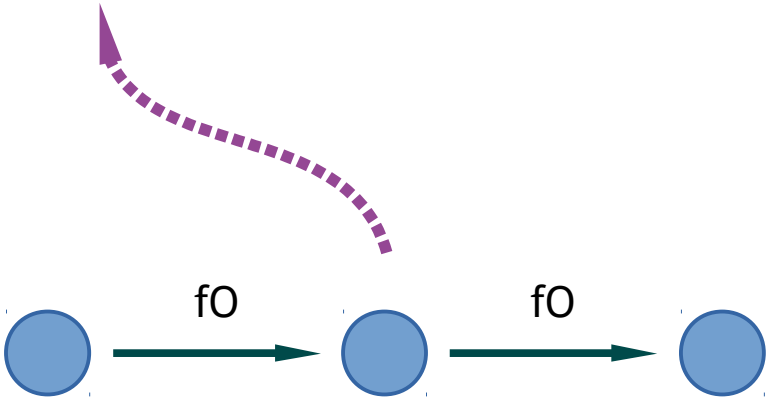

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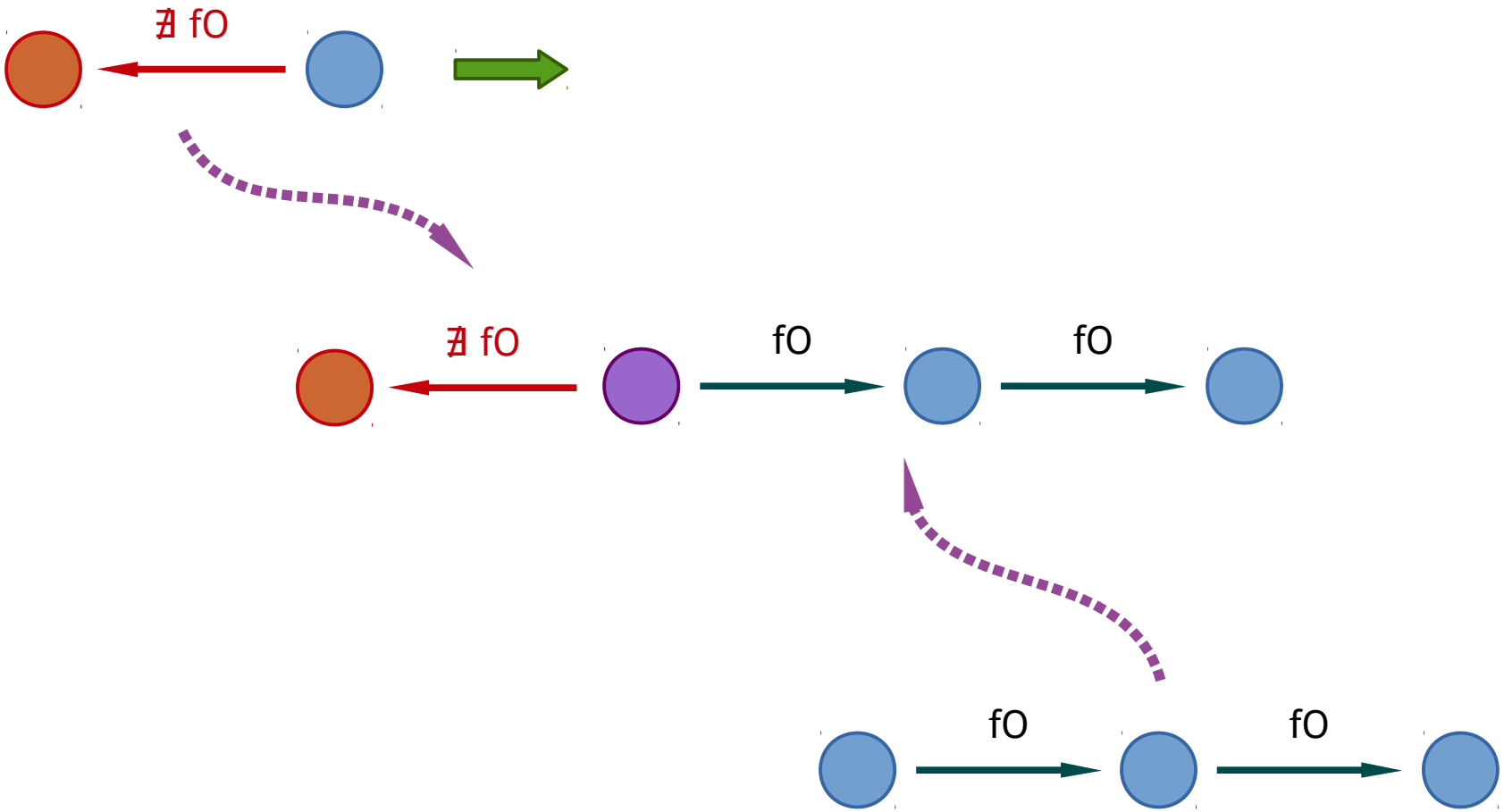

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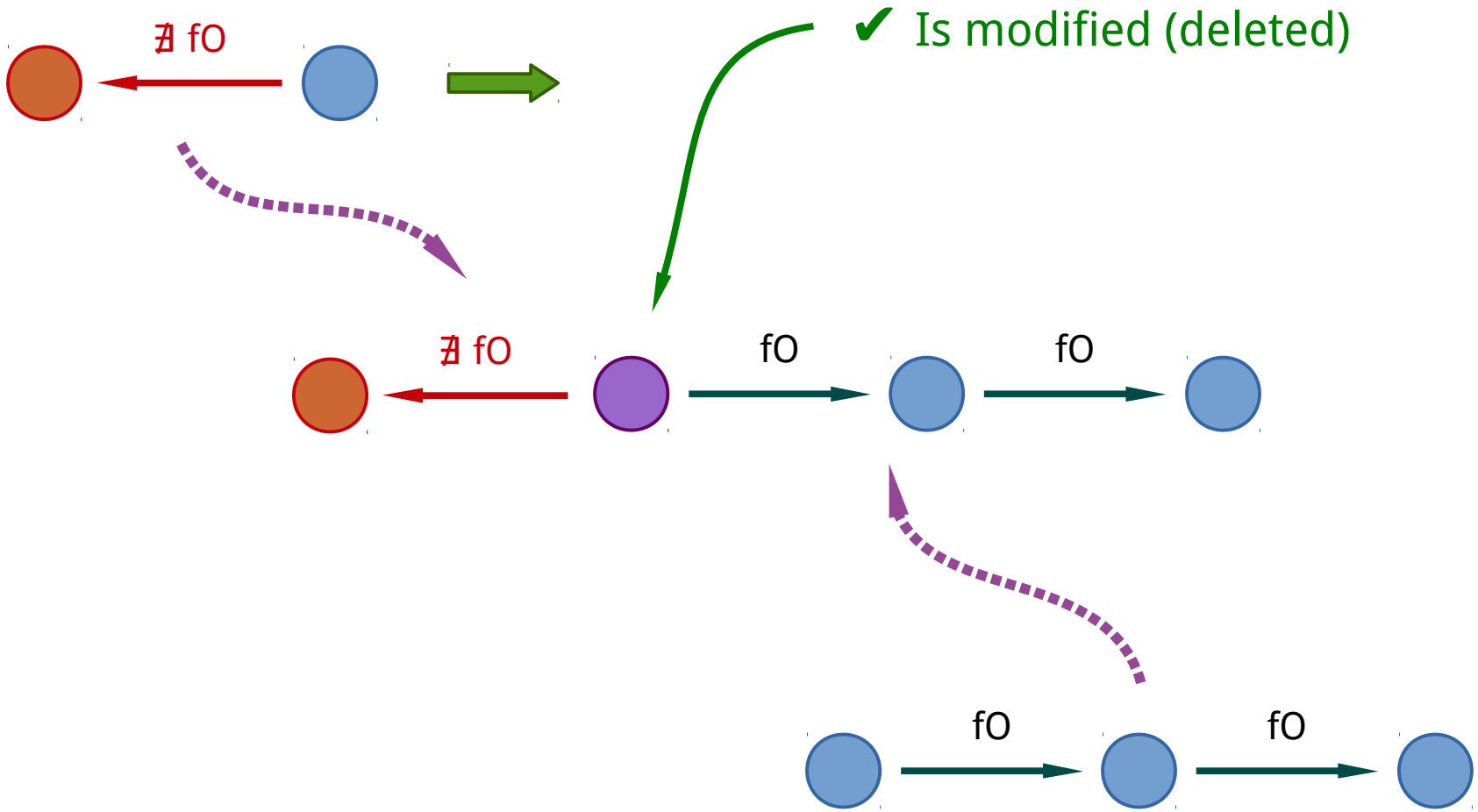

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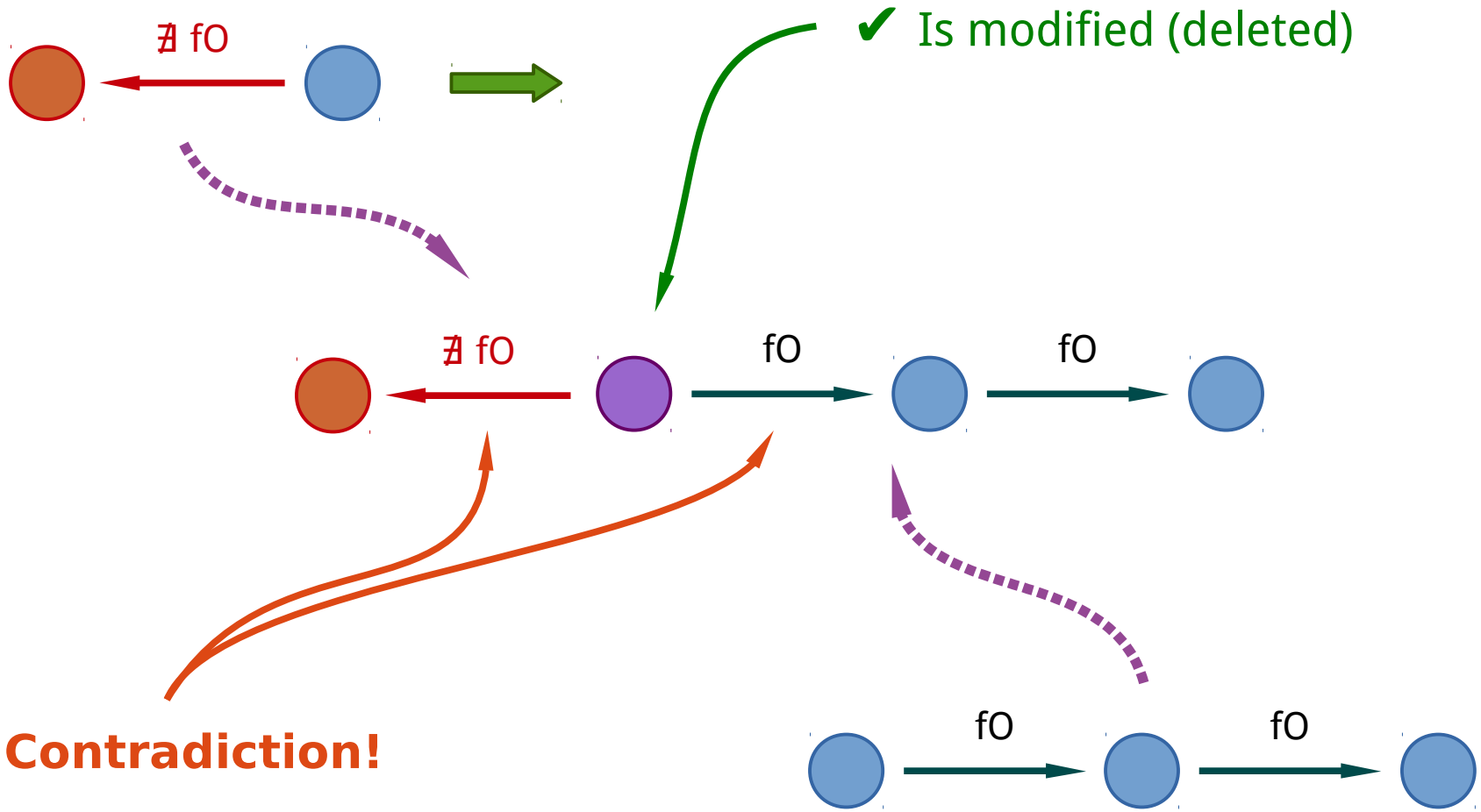

Improving dependency analysis

1. Only consider “relevant” overlaps
2. Analyze only basic updates
   - Break updates into basics and find overlaps
   - No dependency unless at least on basic update overlaps
   - Handles “external” updates too
3. Check consistency of filter overlaps
   - Expensive or even undecidable for nested filters
   - Check only to a given depth (over approximation)


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