NEDB Day 2012

G*

A Parallel System for Efficiently Managing Large Graphs

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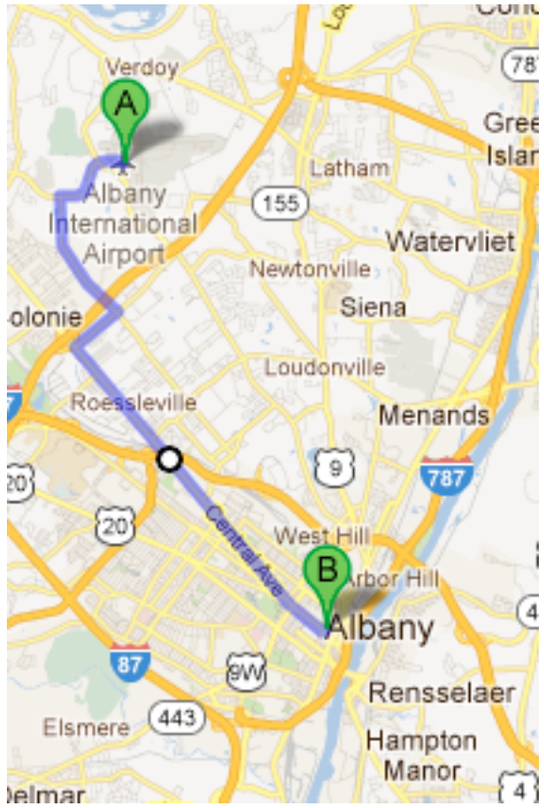
Daniel Kemp, Jayadevan Vijayan, Jeremy Birnbaum

State University of New York - Albany

Graph Data Analytics

- Transportation

5:00 AM - 6:00 AM



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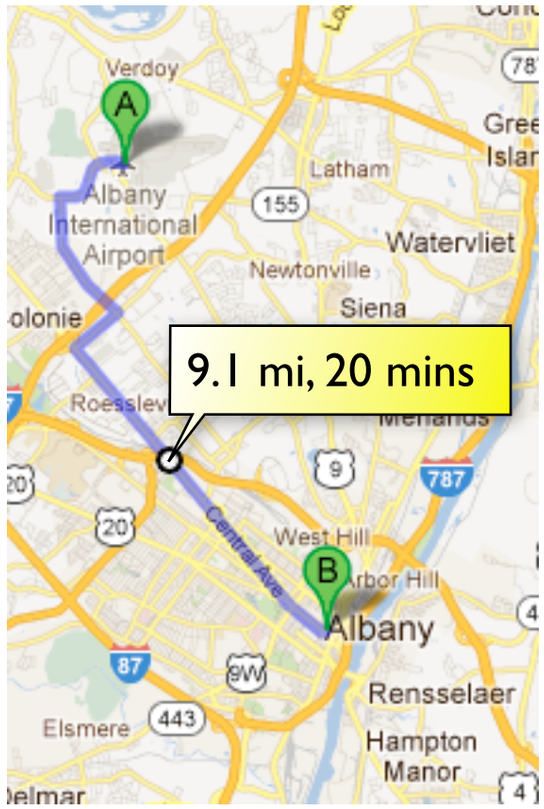

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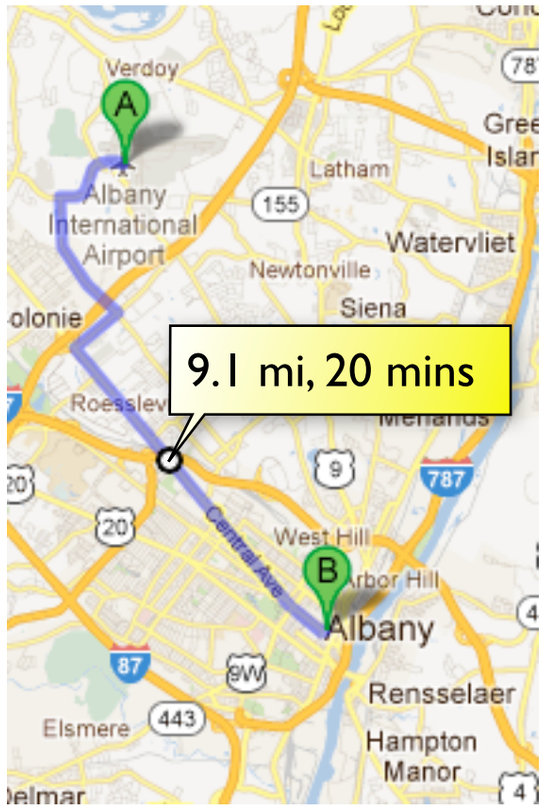

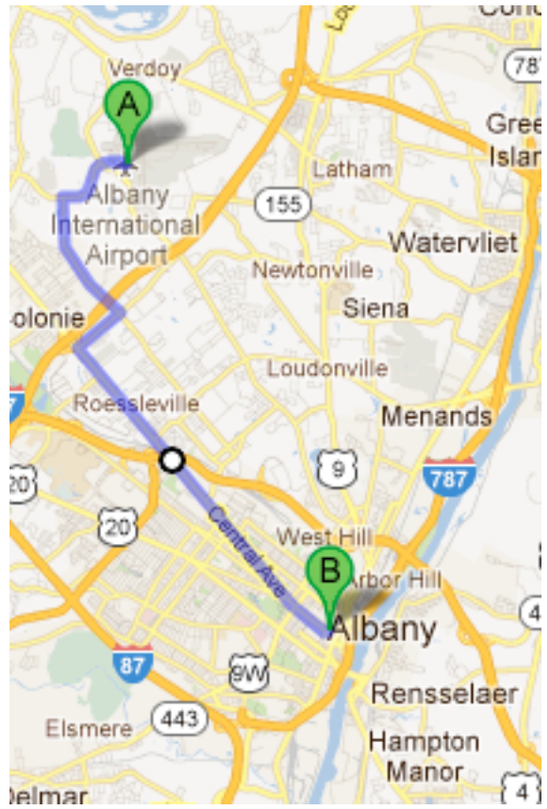

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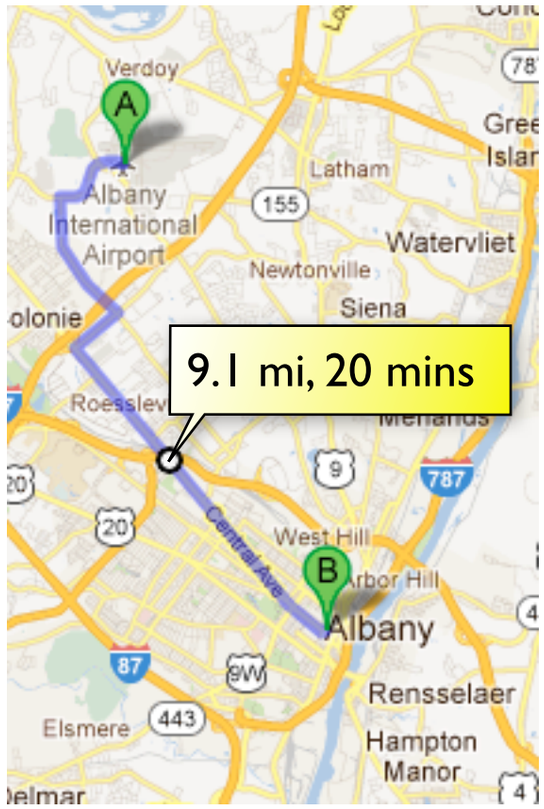

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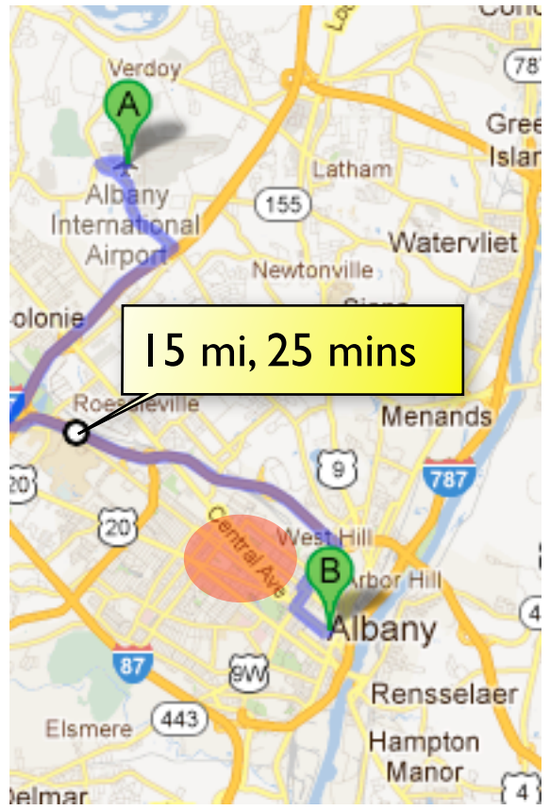

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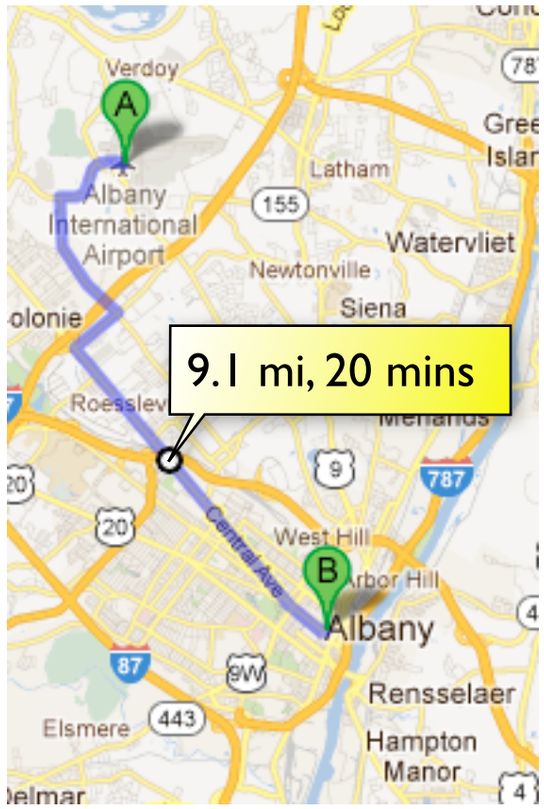

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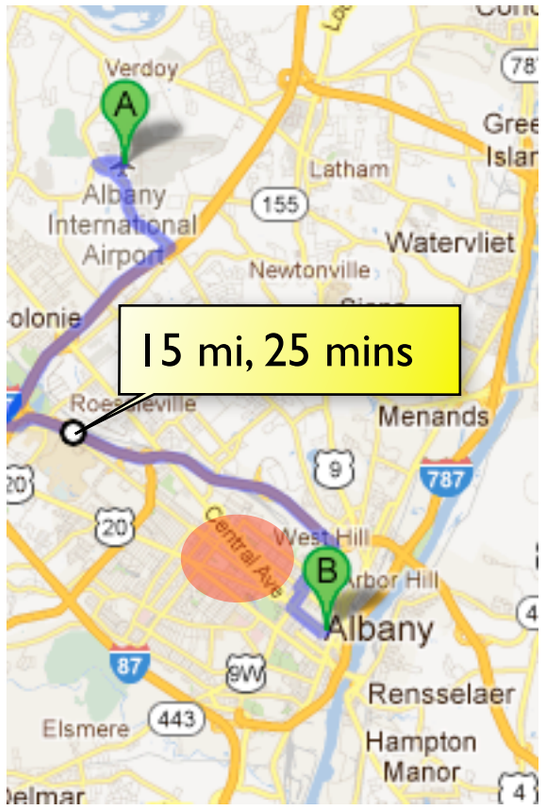

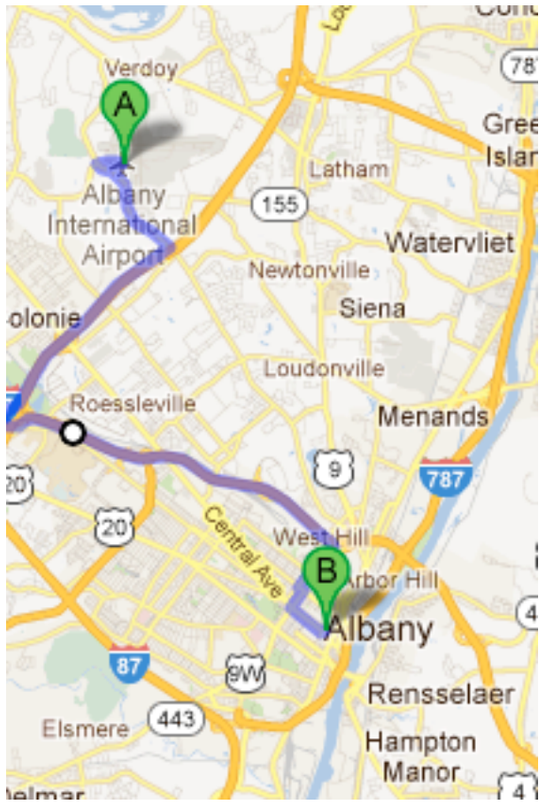

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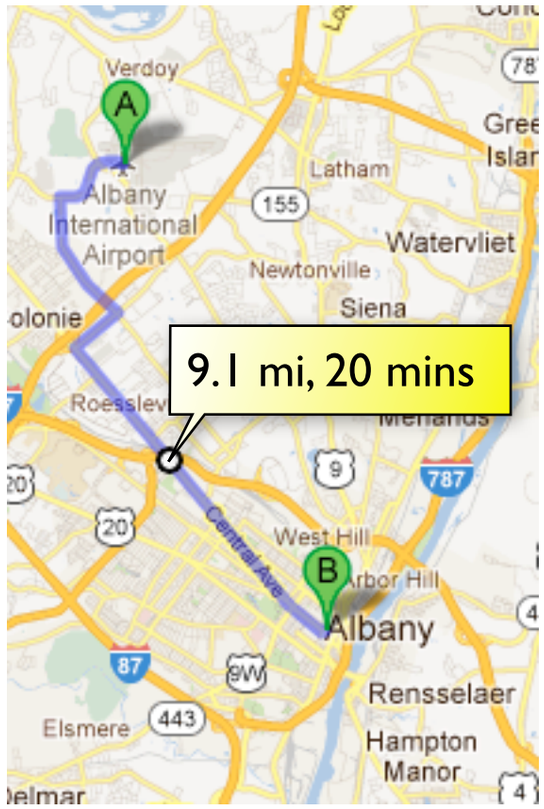

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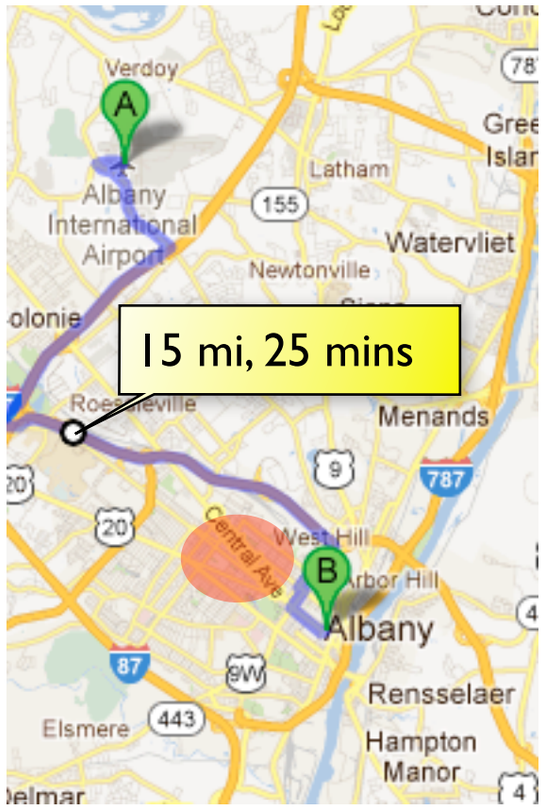

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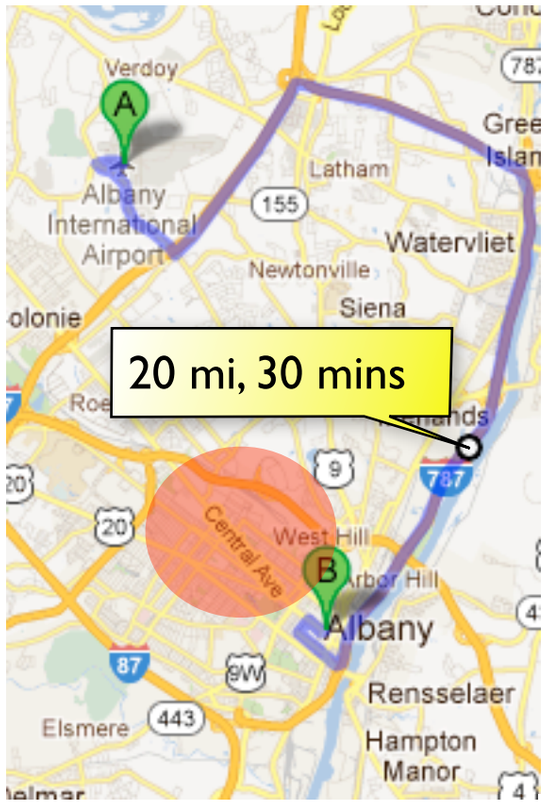

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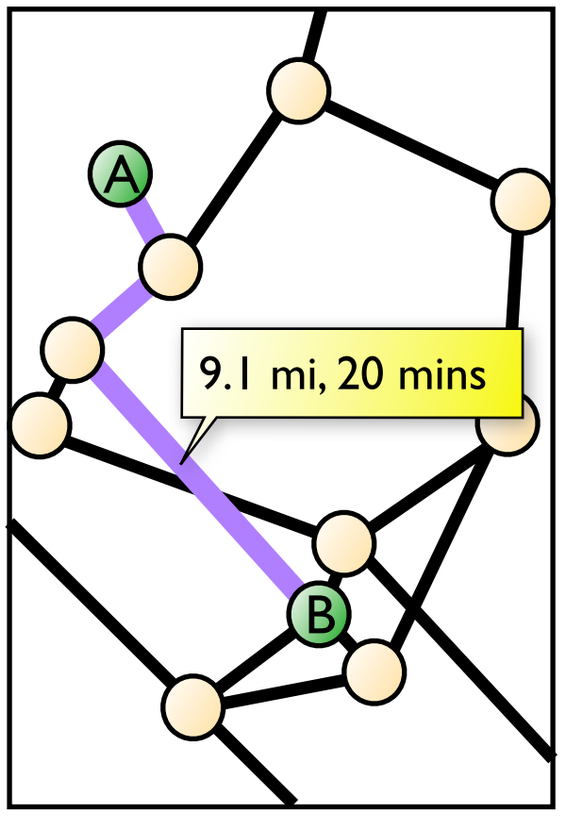

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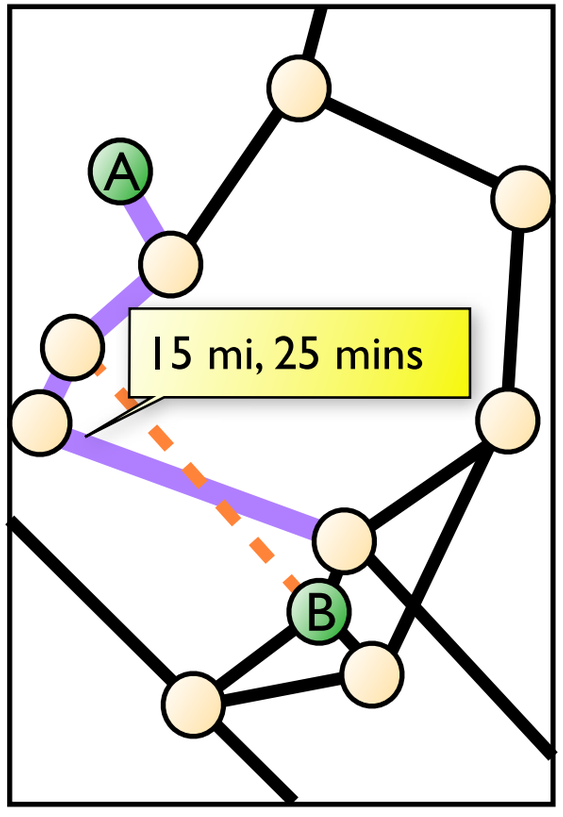

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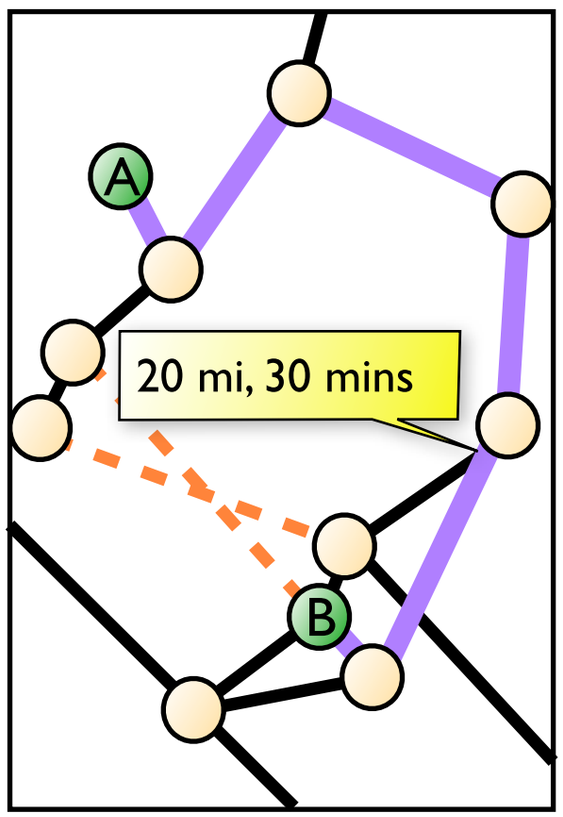

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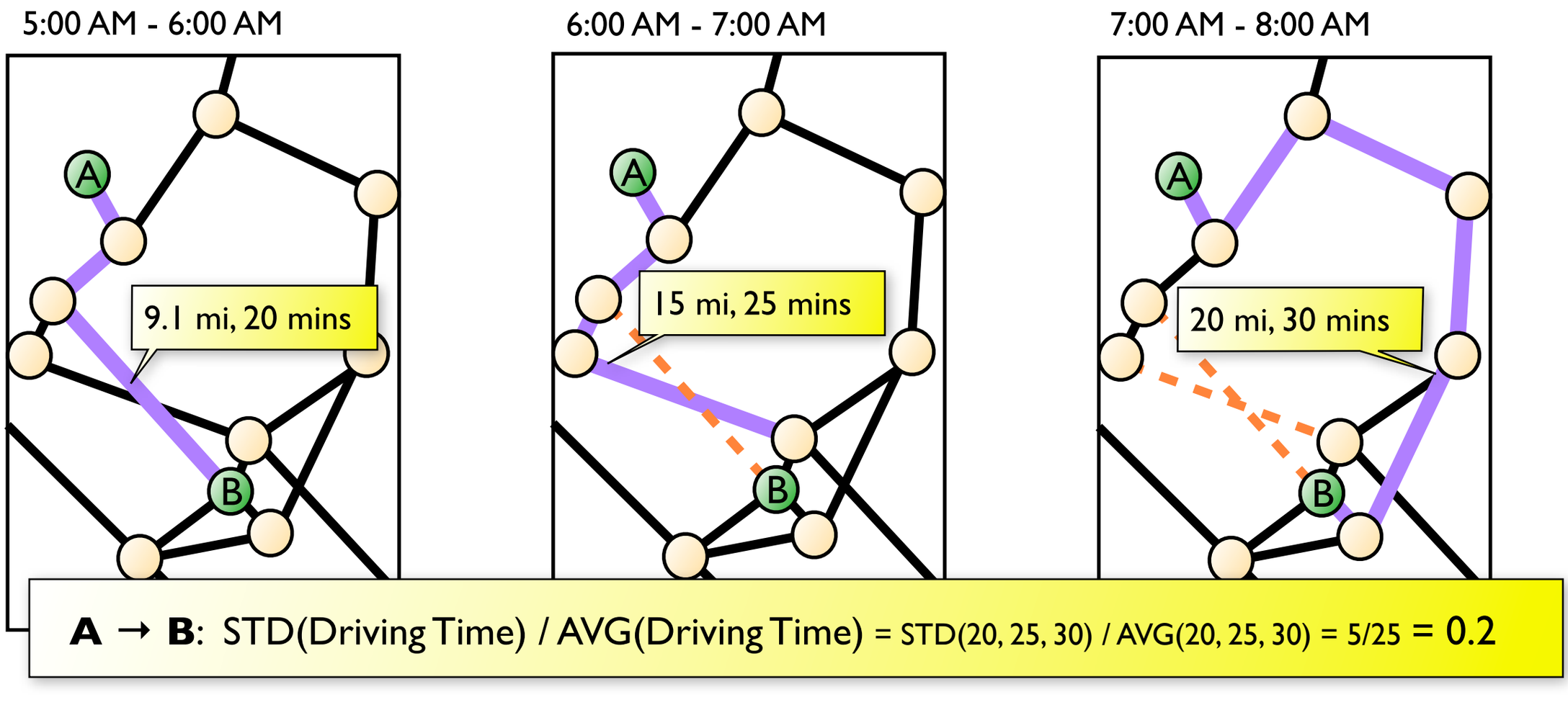

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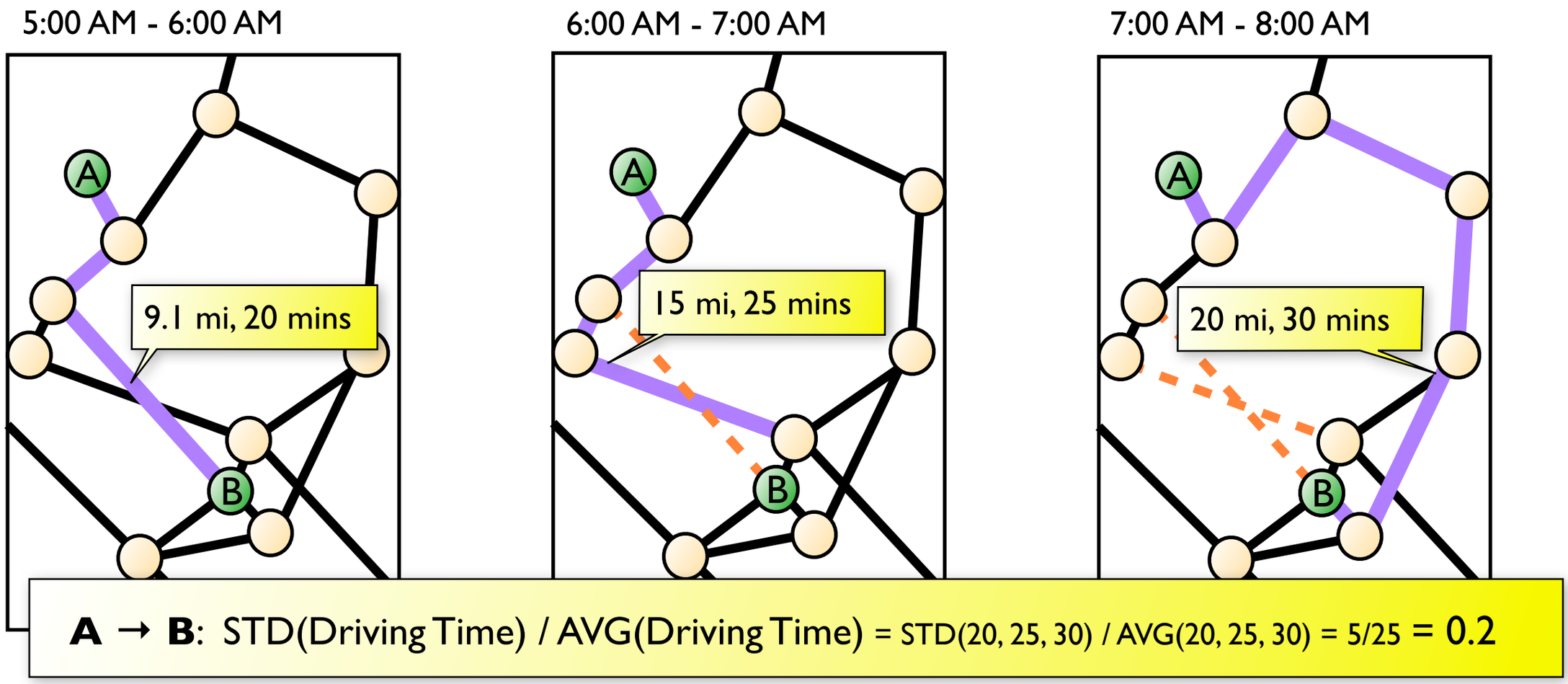

- Social and Political Studies / Marketing / National Security
- Epidemic Simulations and Analysis

Limitations of Existing Systems

	inconvenient	inefficient
RDBMSs	no SQL support for graphs	no built-in graph traversal capabilities
Graph Systems	coding for each type of computation	only one graph at a time

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Limitations of Existing Systems

Example: **shortest distance** in **Pregel**

```
class ShortestPathVertex
    : public Vertex<int, int, int> {
  void Compute(MessageIterator* msgs) {
    int mindist = IsSource(vertex_id()) ? 0 : INF;
    for (; !msgs->Done(); msgs->Next())
      mindist = min(mindist, msgs->Value());
    if (mindist < GetValue()) {
      *MutableValue() = mindist;
      OutEdgeIterator iter = GetOutEdgeIterator();
      for (; !iter.Done(); iter.Next())
        SendMessageTo(iter.Target(),
                      mindist + iter.GetValue());
    }
    VoteToHalt();
  }
};
```

```
class MinIntCombiner : public Combiner<int> {
  virtual void Combine(MessageIterator* msgs) {
    int mindist = INF;
    for (; !msgs->Done(); msgs->Next())
      mindist = min(mindist, msgs->Value());
    Output("combined_source", mindist);
  }
};
```

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- Goal
  - convenient and efficient queries on graphs using a server cluster
- Key Features
  - succinct graph query language
  - distributed, deduplicate storage of graphs
  - parallel query processing that shares computations across graphs

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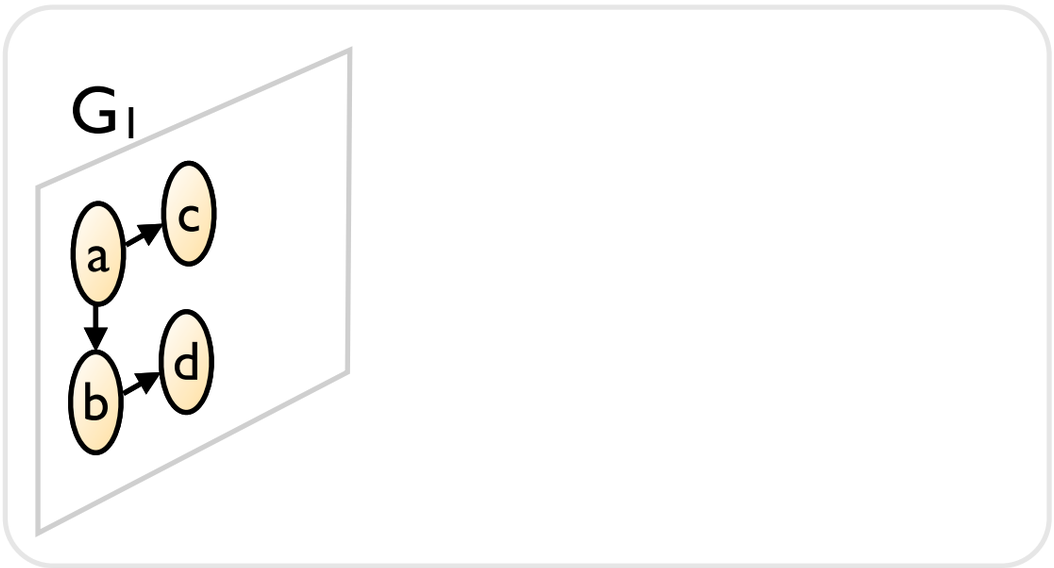

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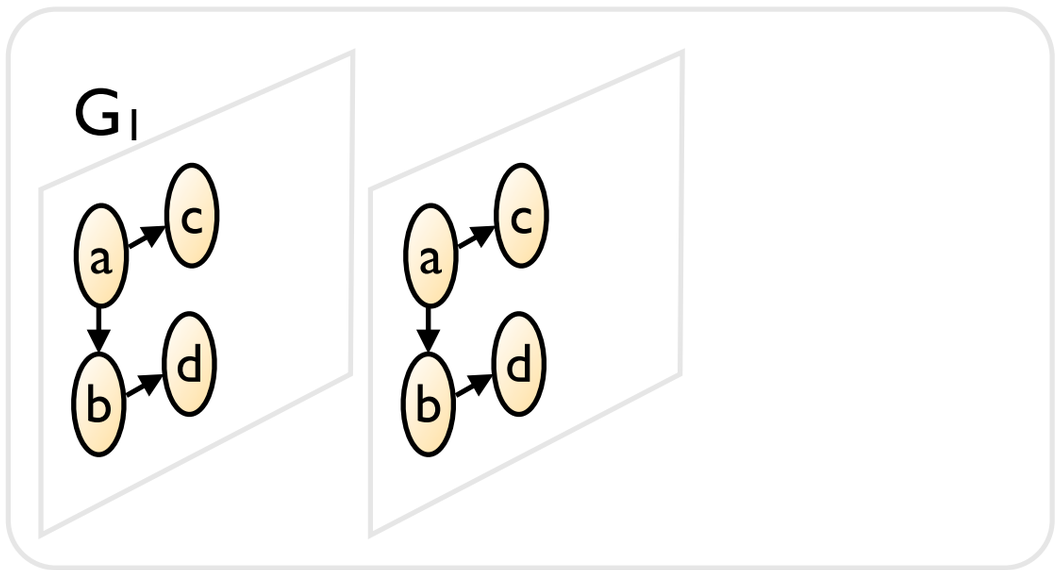

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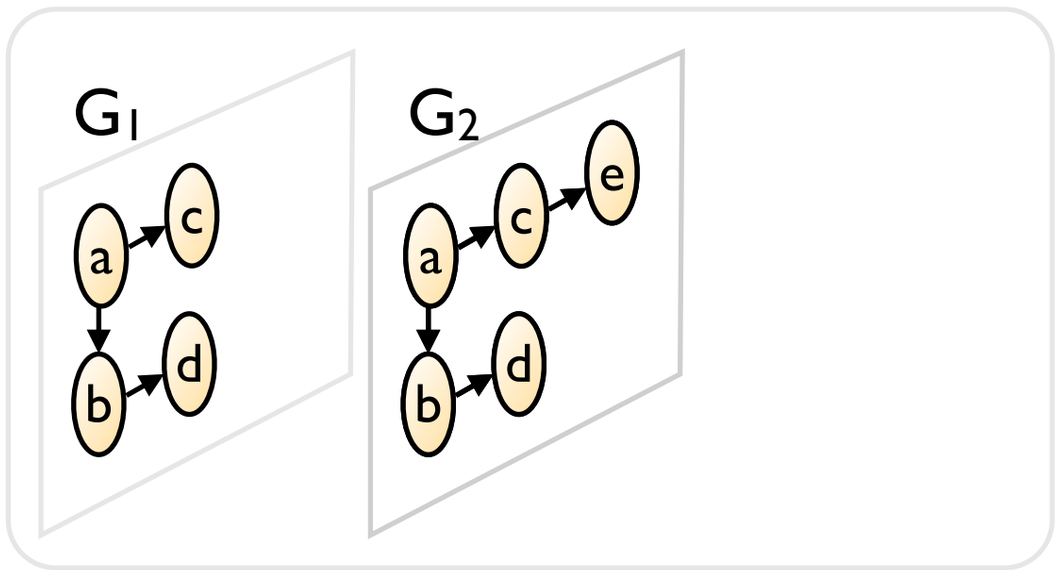

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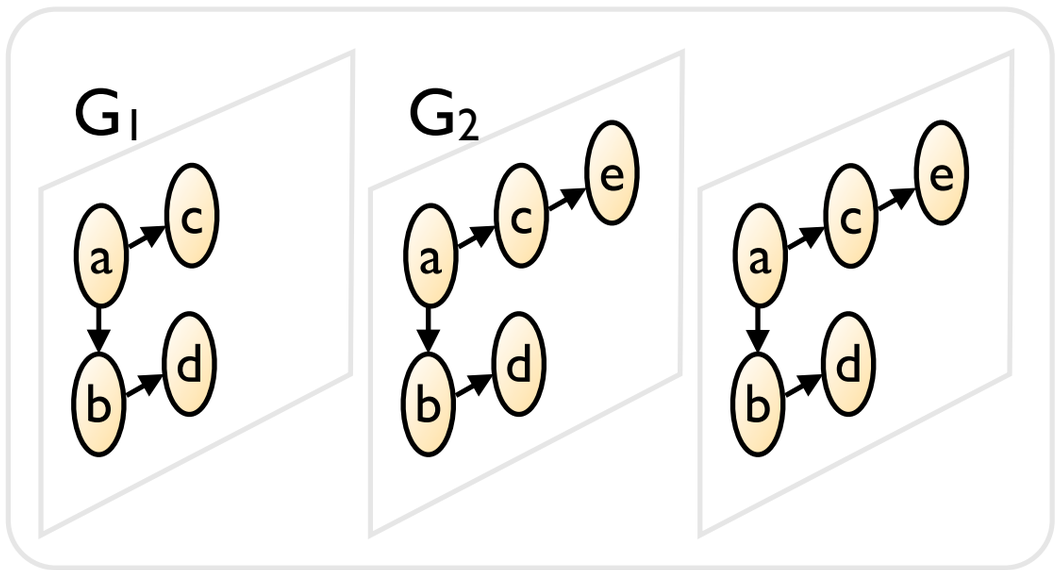

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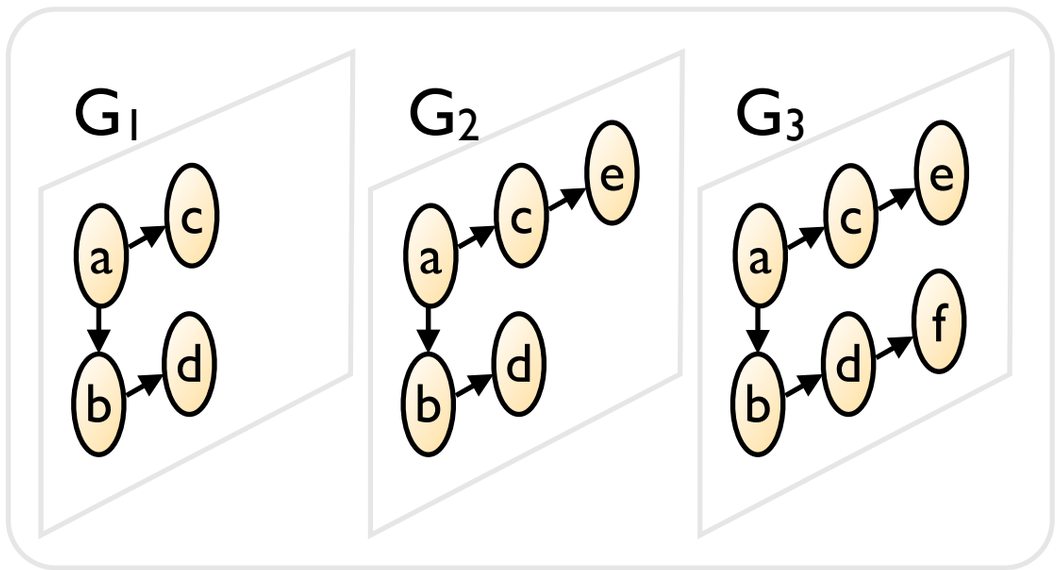

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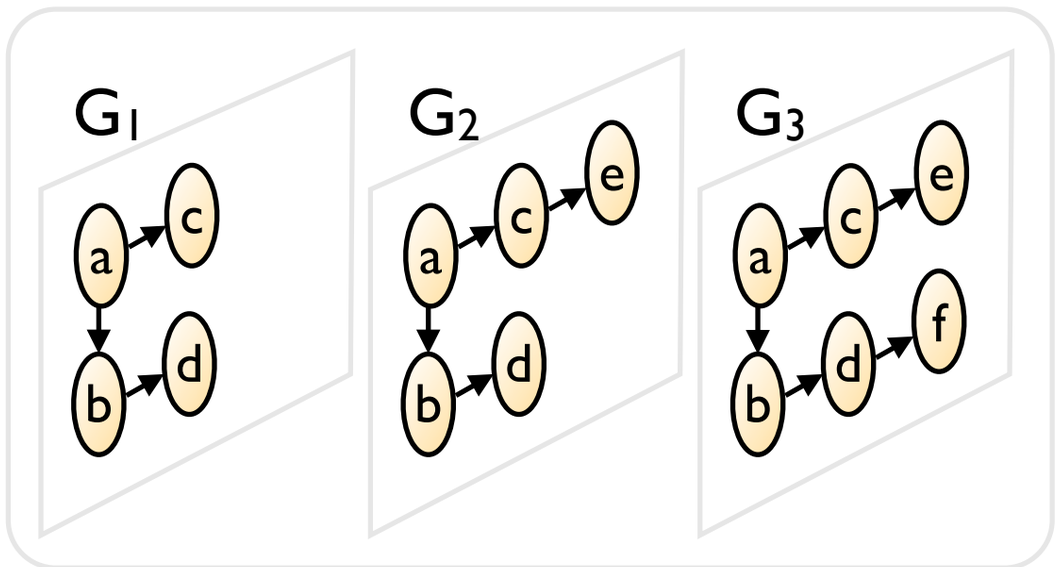

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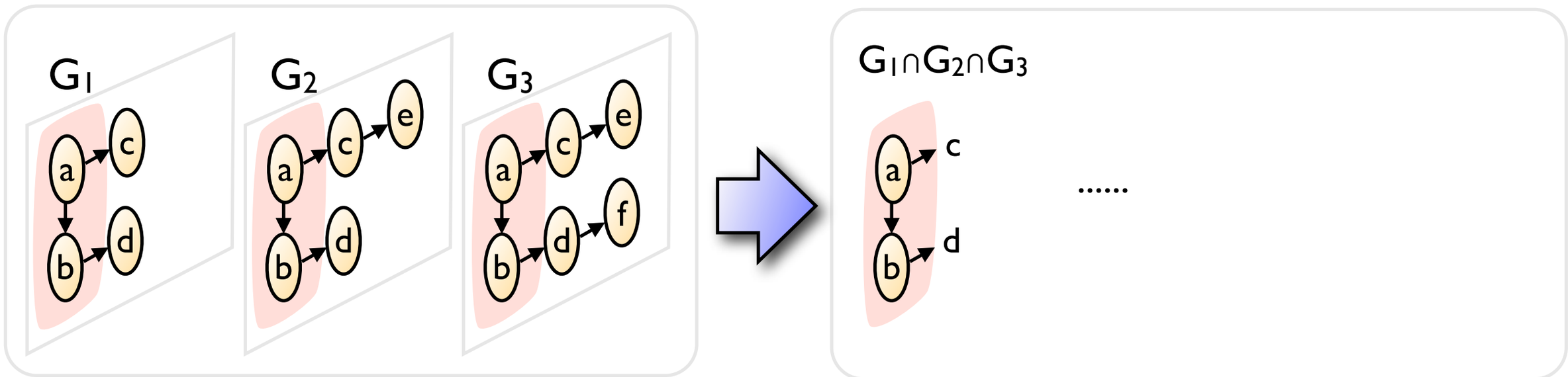

Distribution of Graph Data

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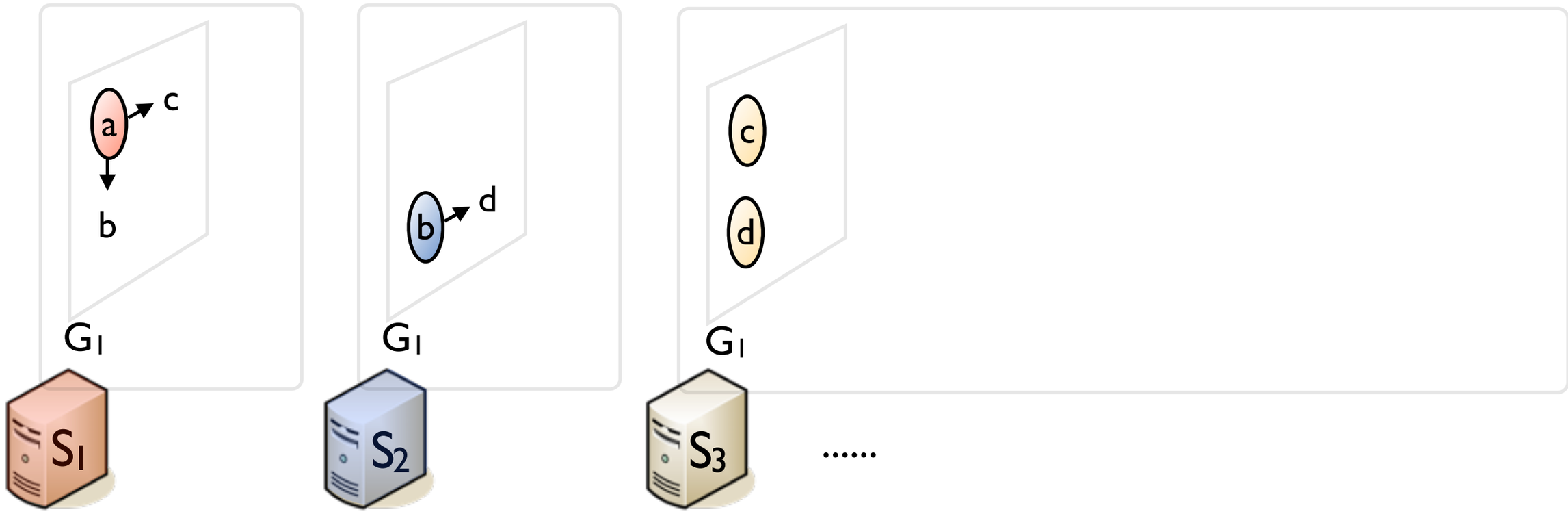

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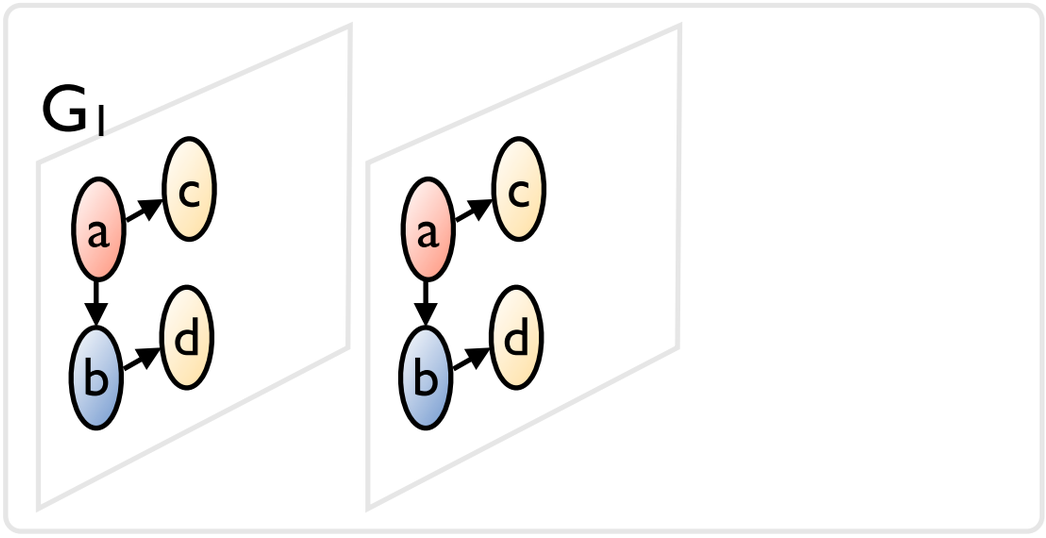

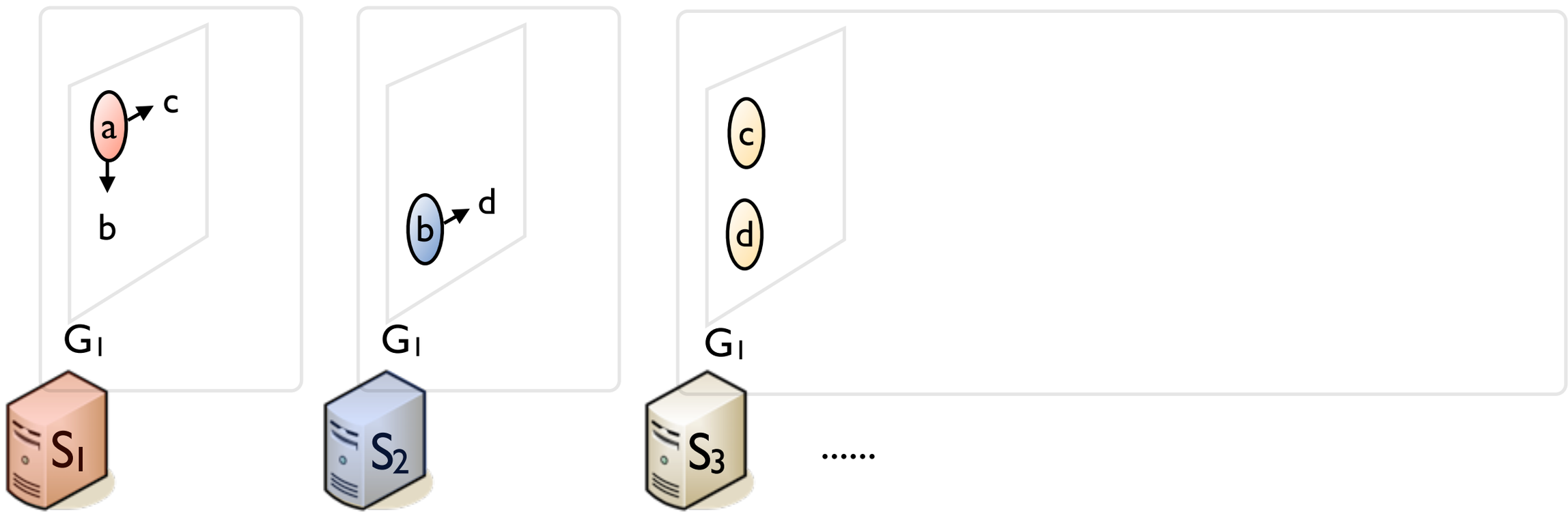

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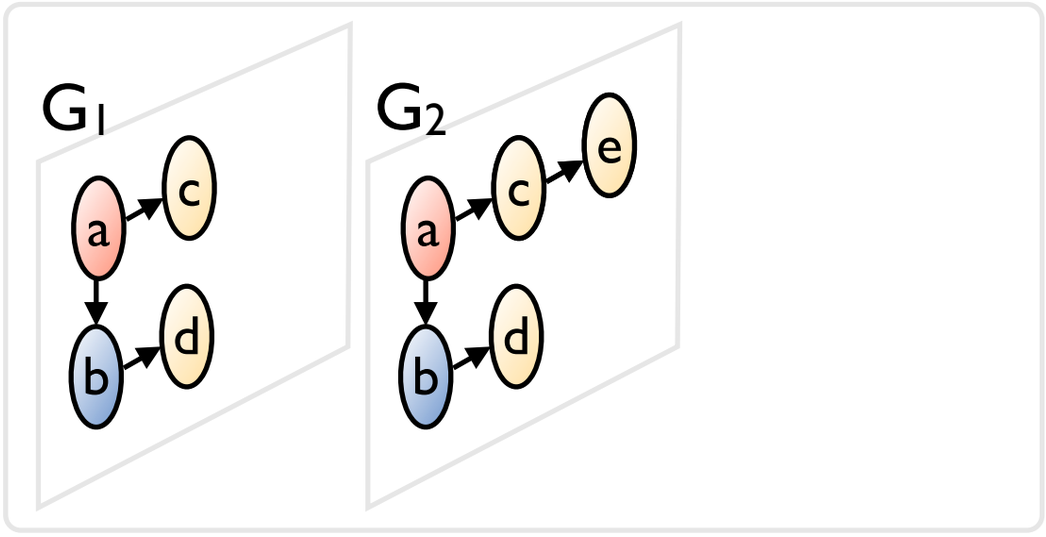

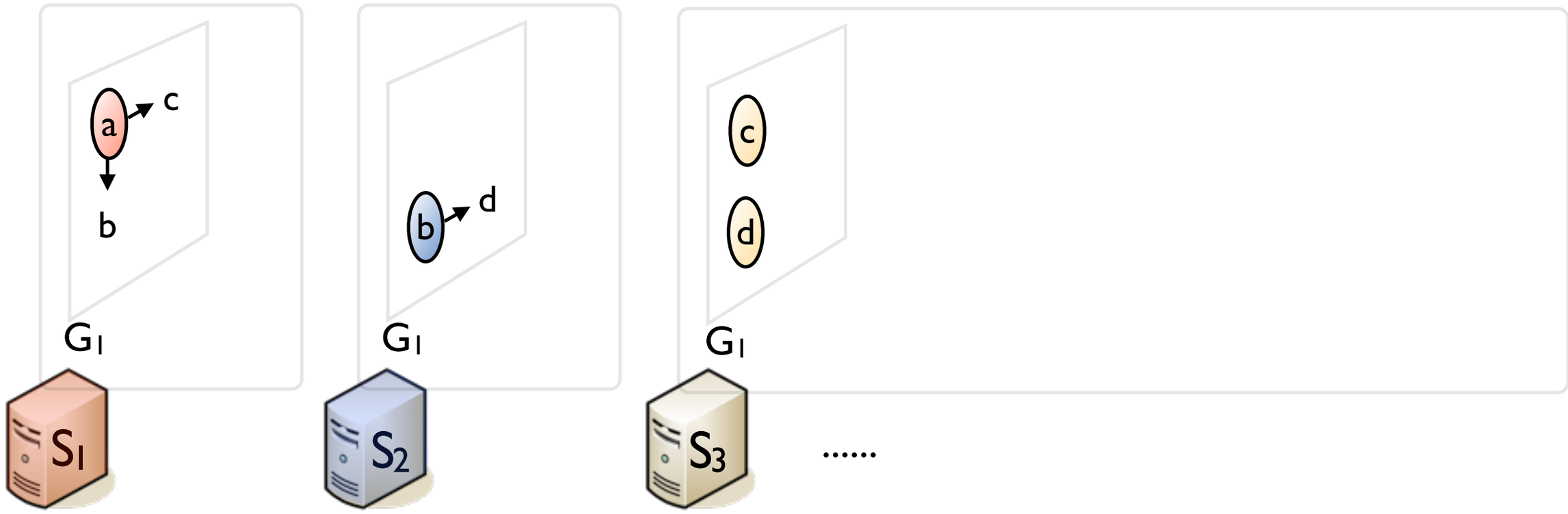

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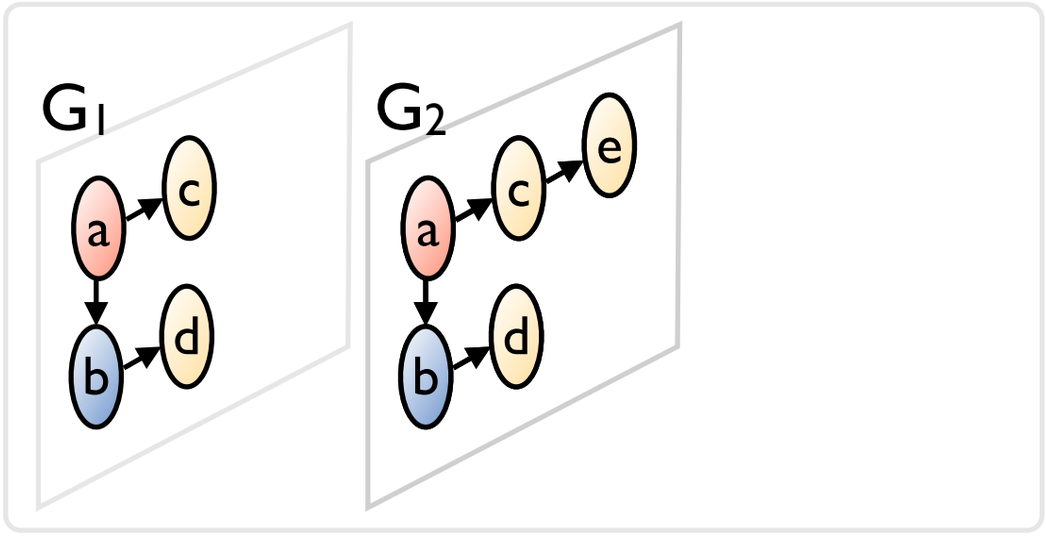

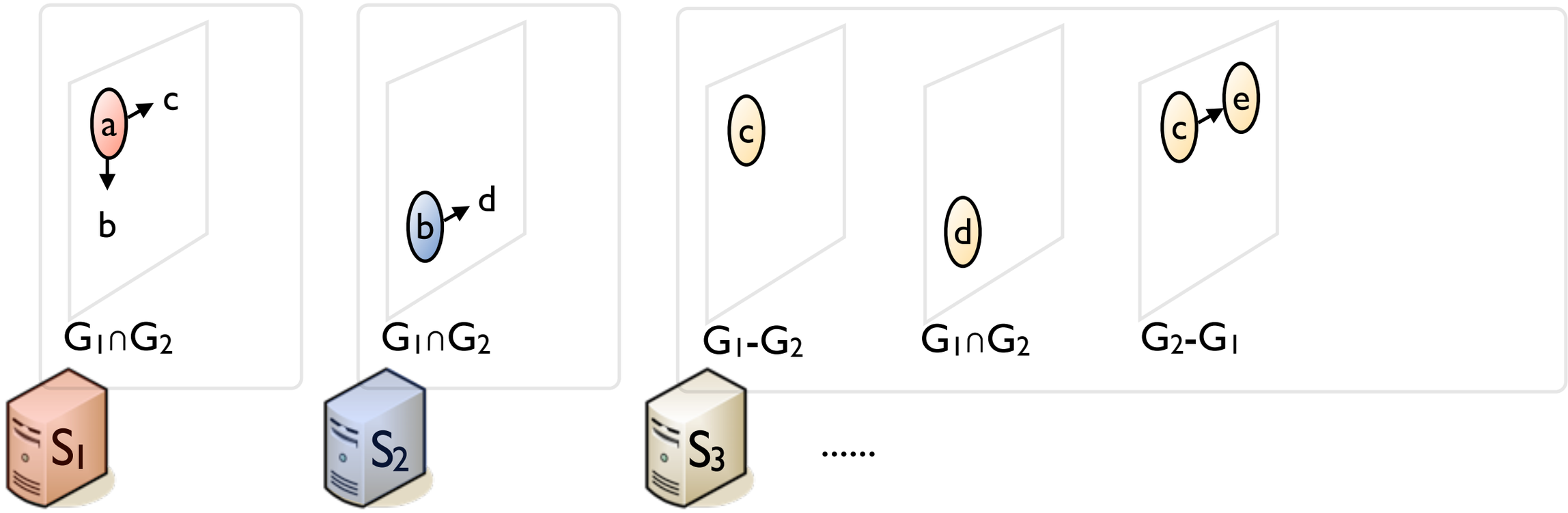

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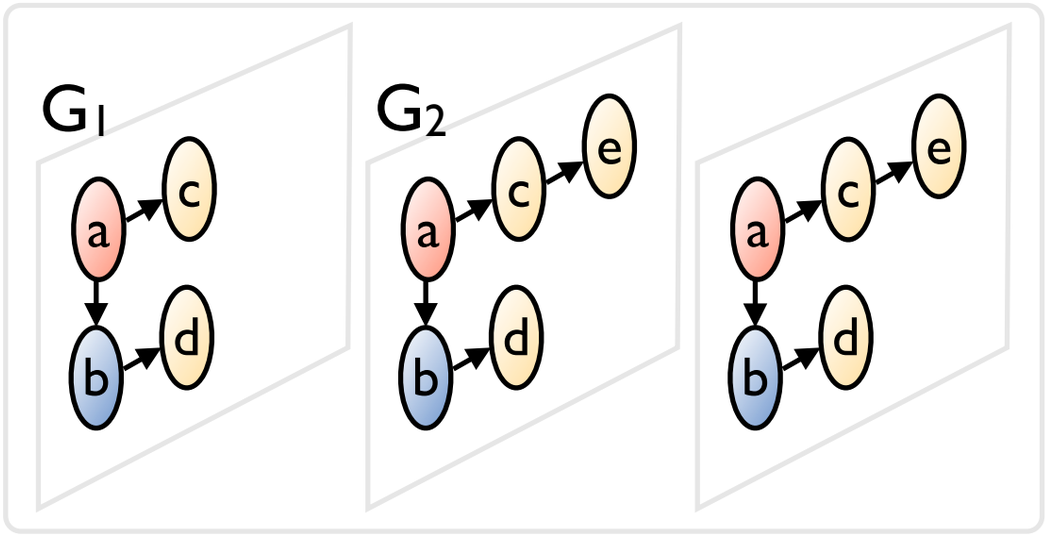

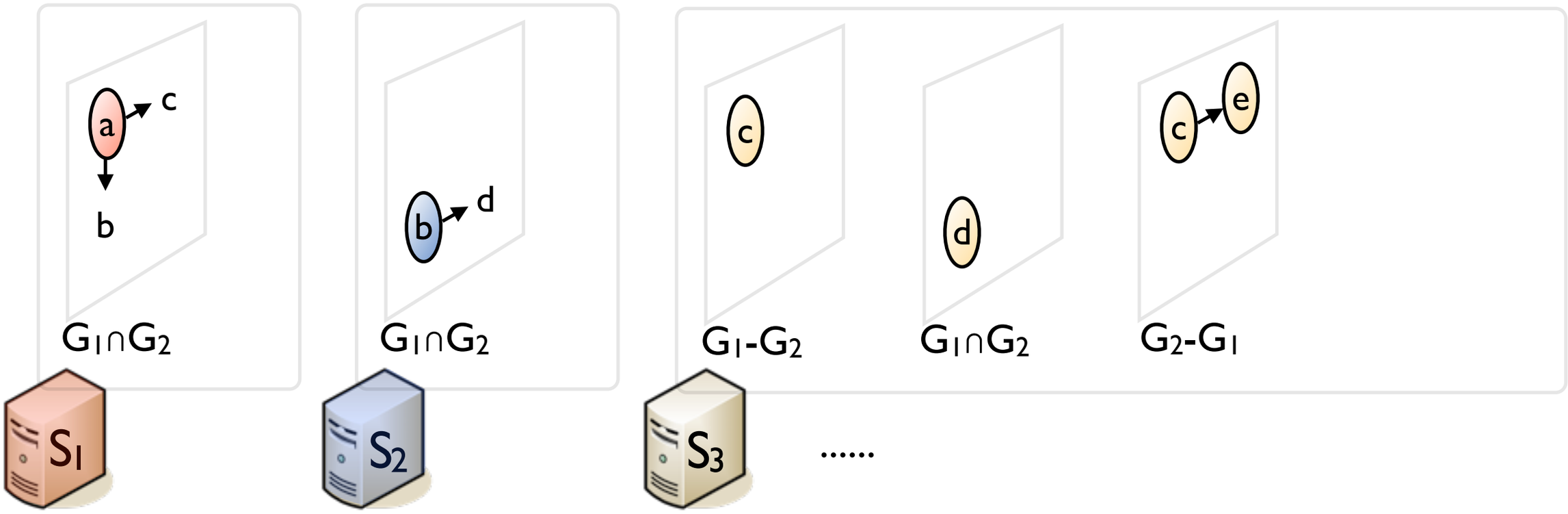

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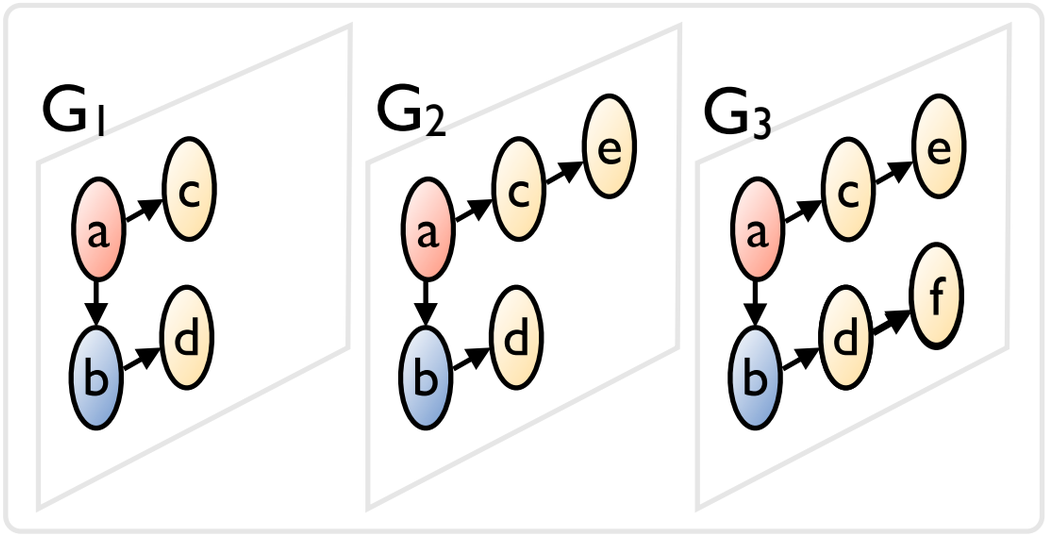

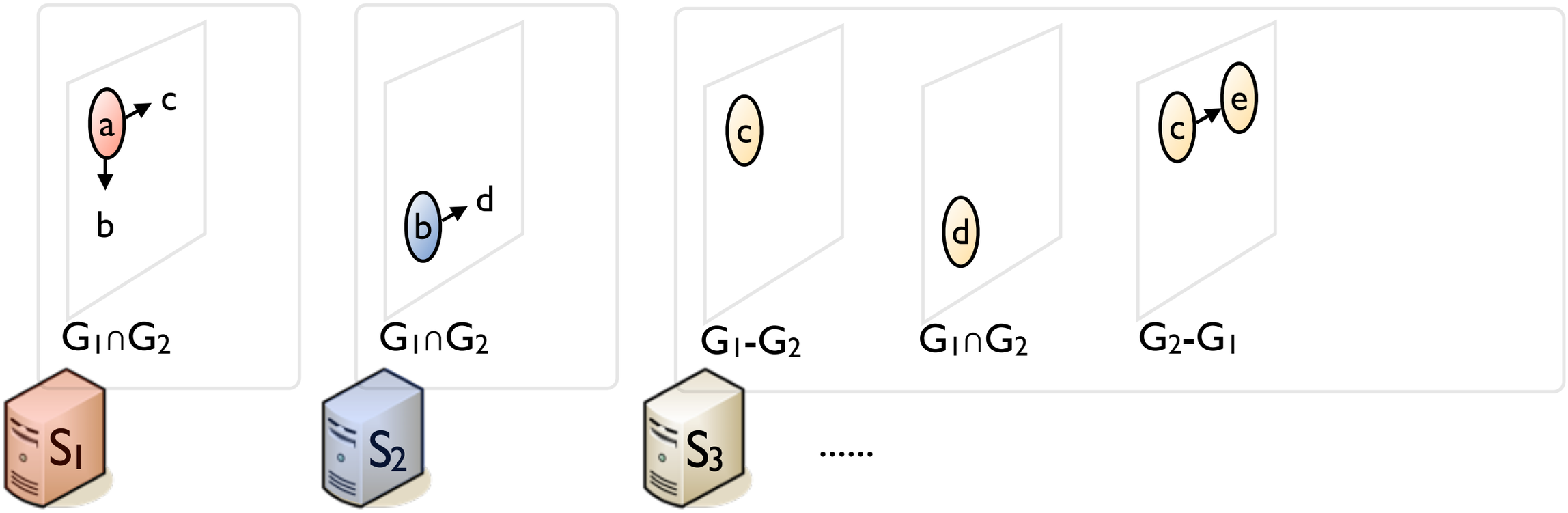

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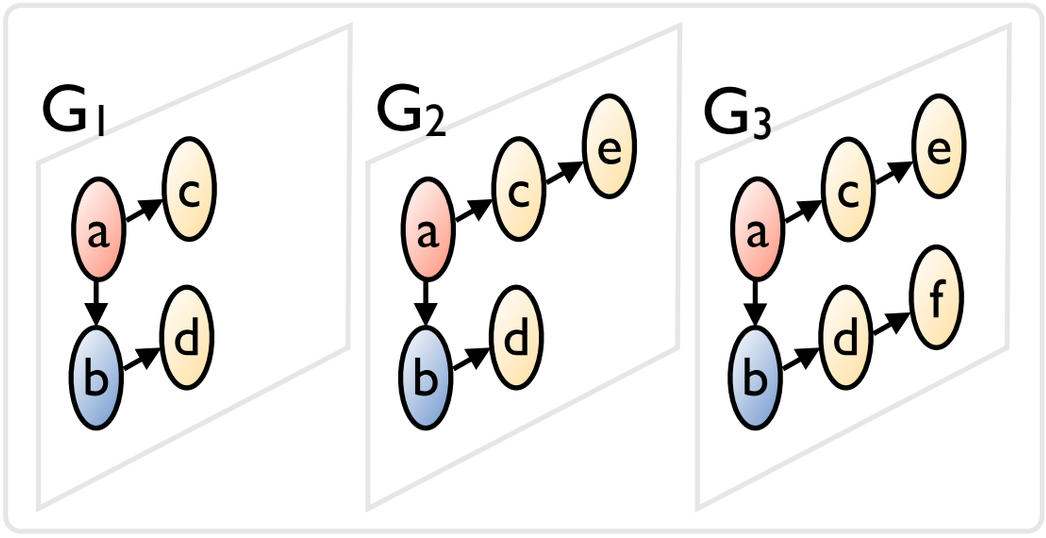
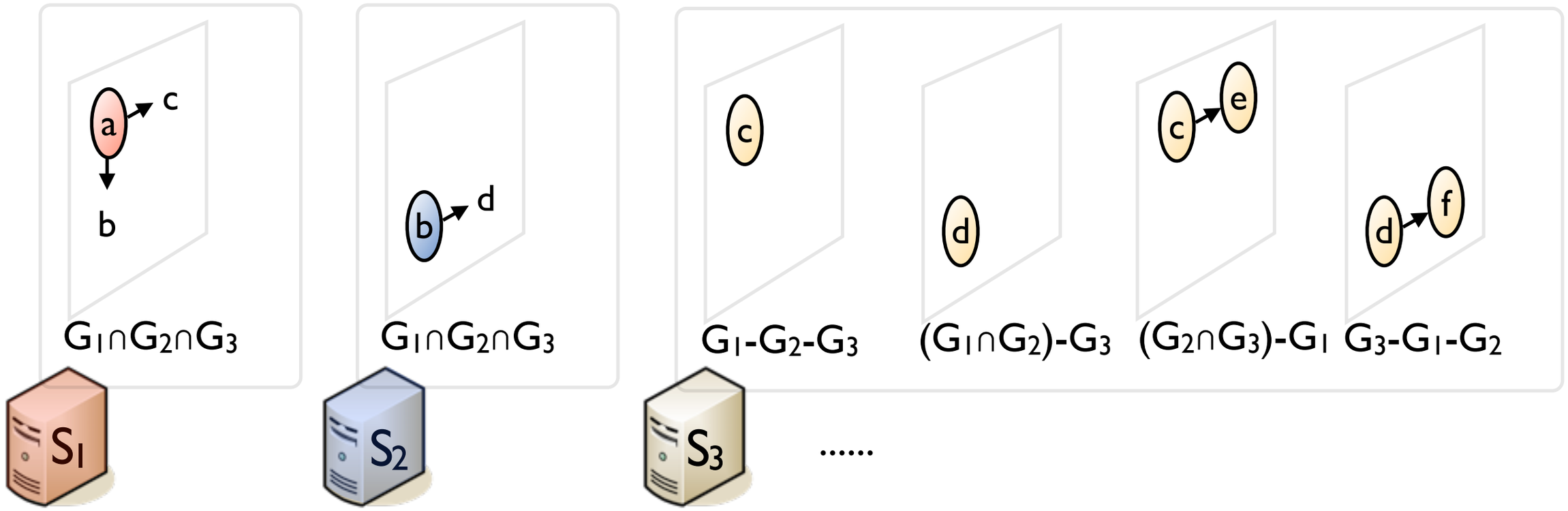
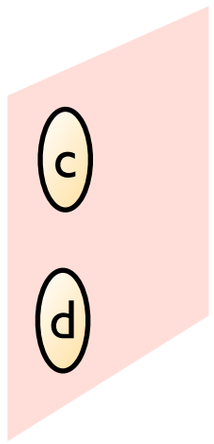


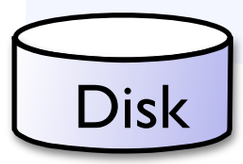


Storage of Graphs (on server)



G_1

Memory



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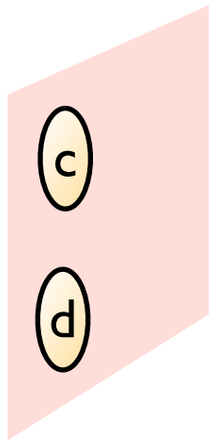

G_1

[1] attributes of vertex c

[2] attributes of vertex d

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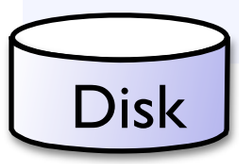

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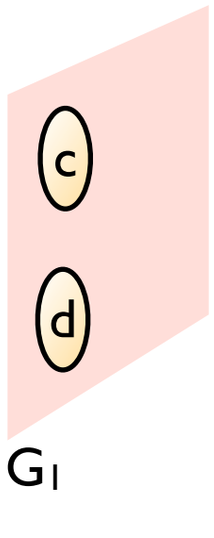

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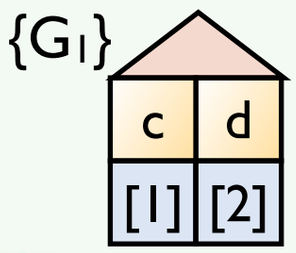

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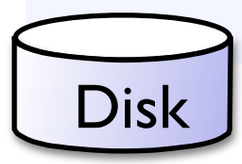

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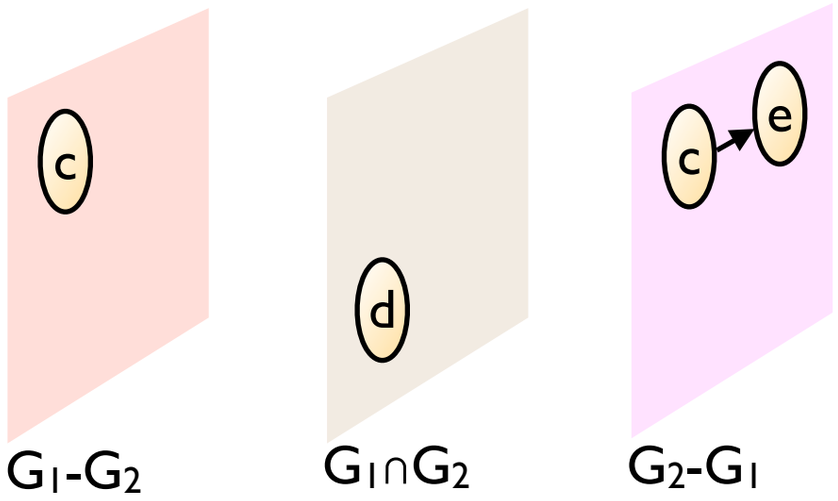

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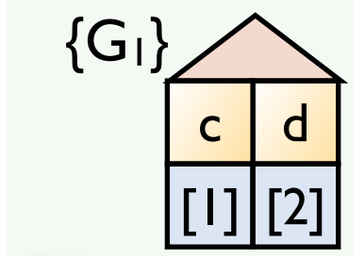

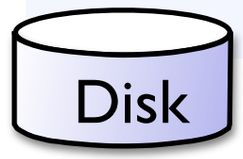

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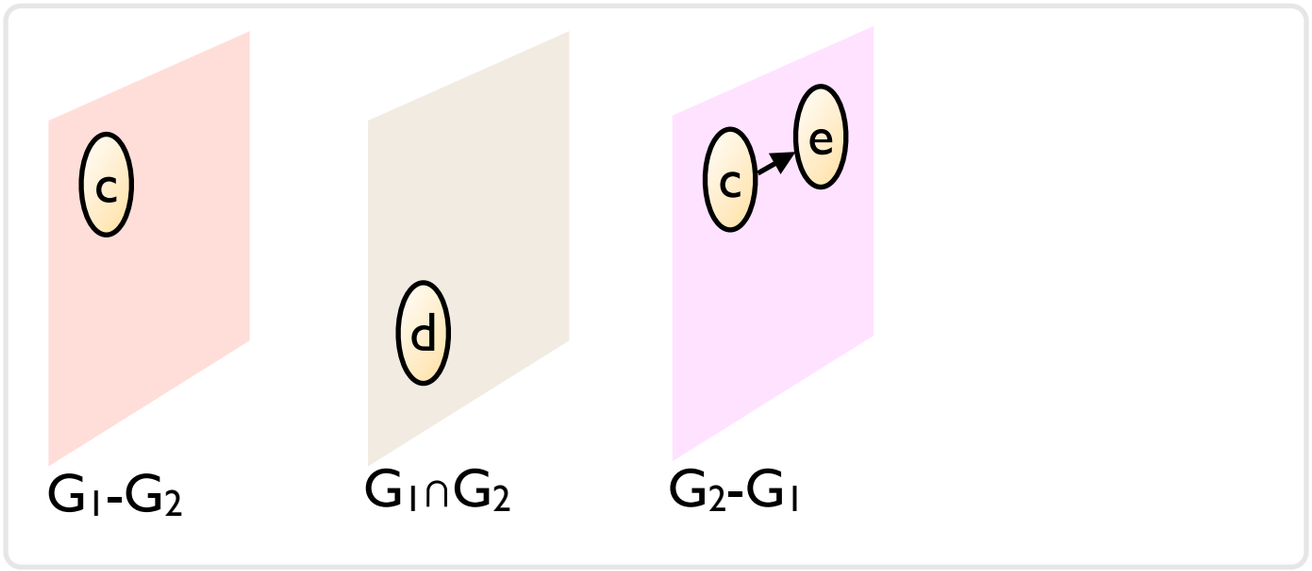

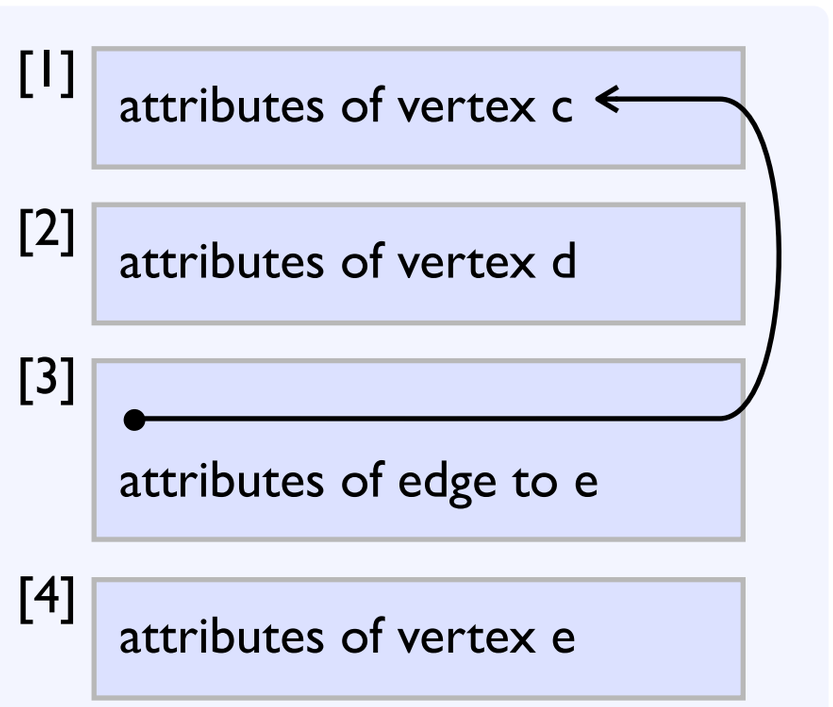

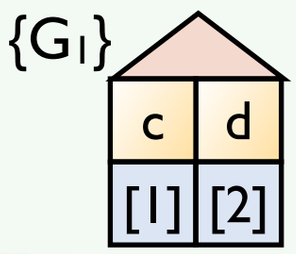

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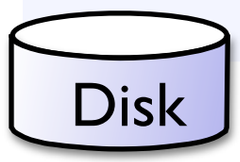

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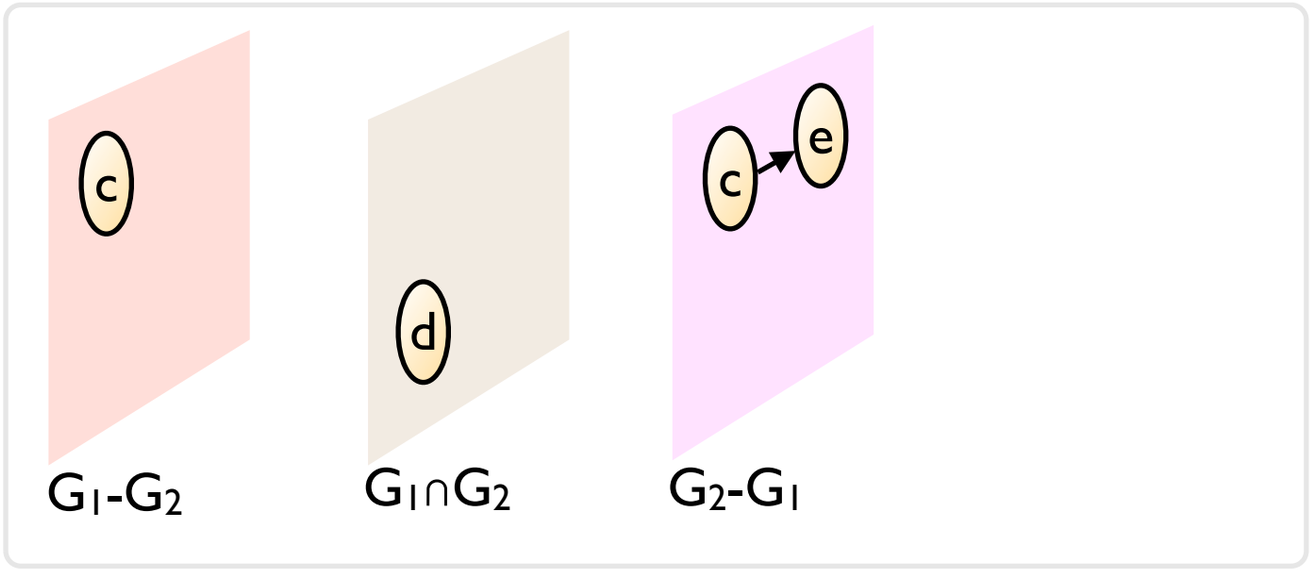
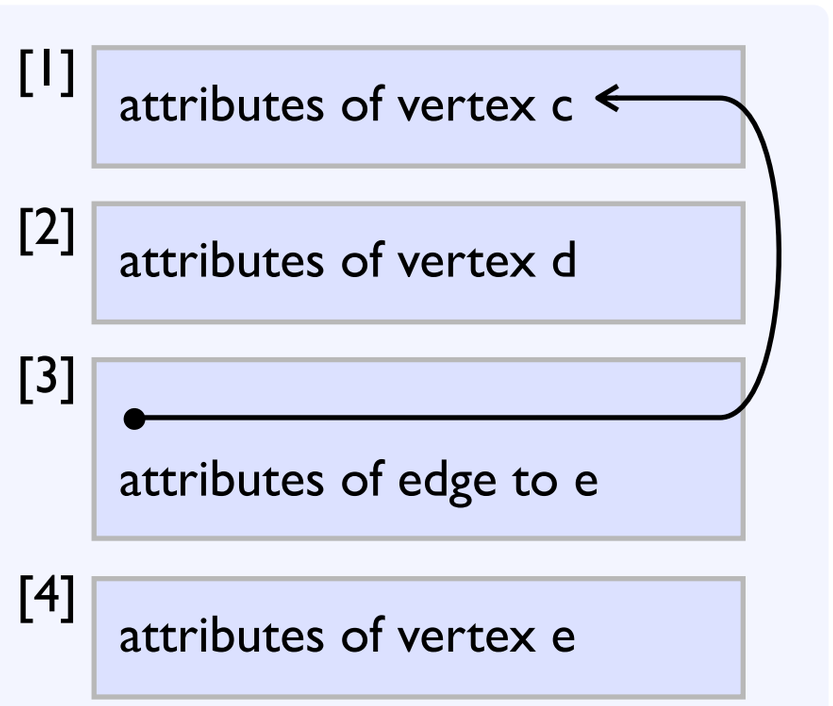
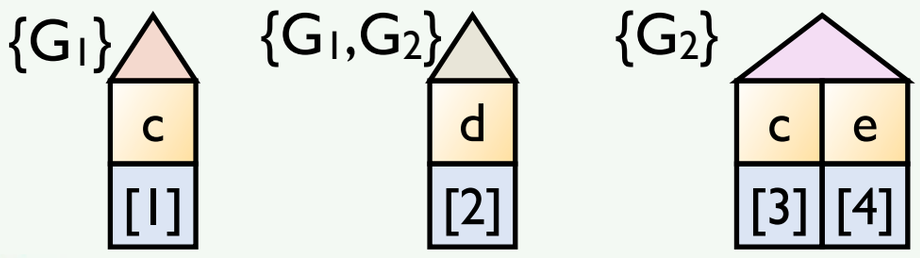
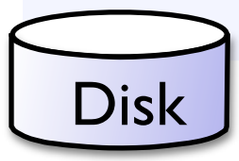




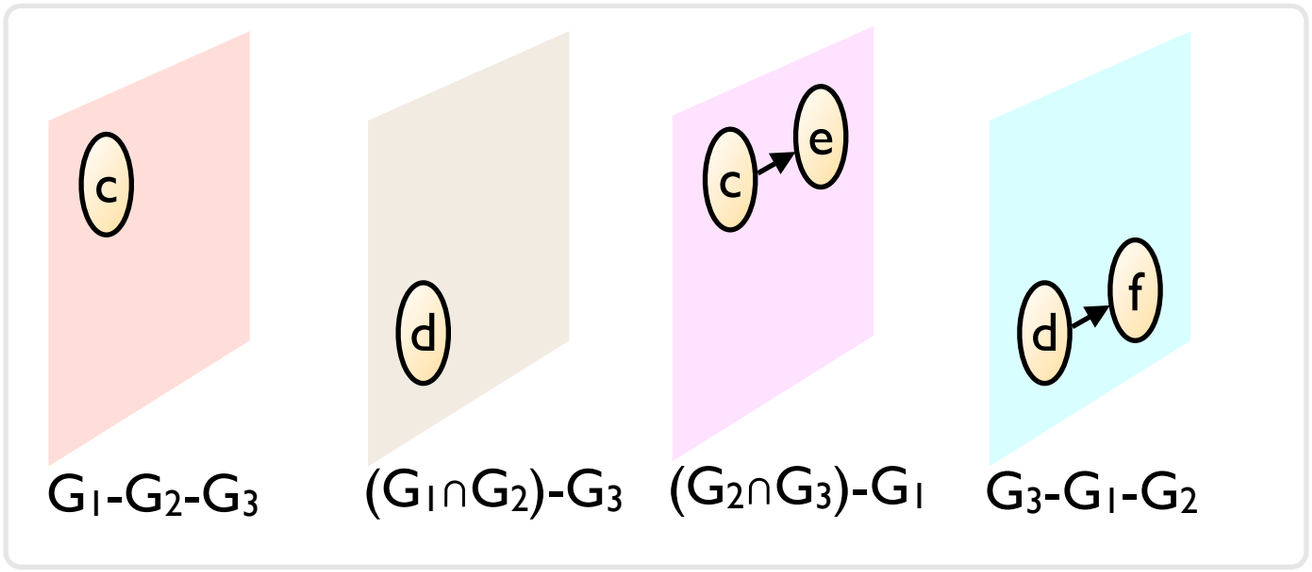


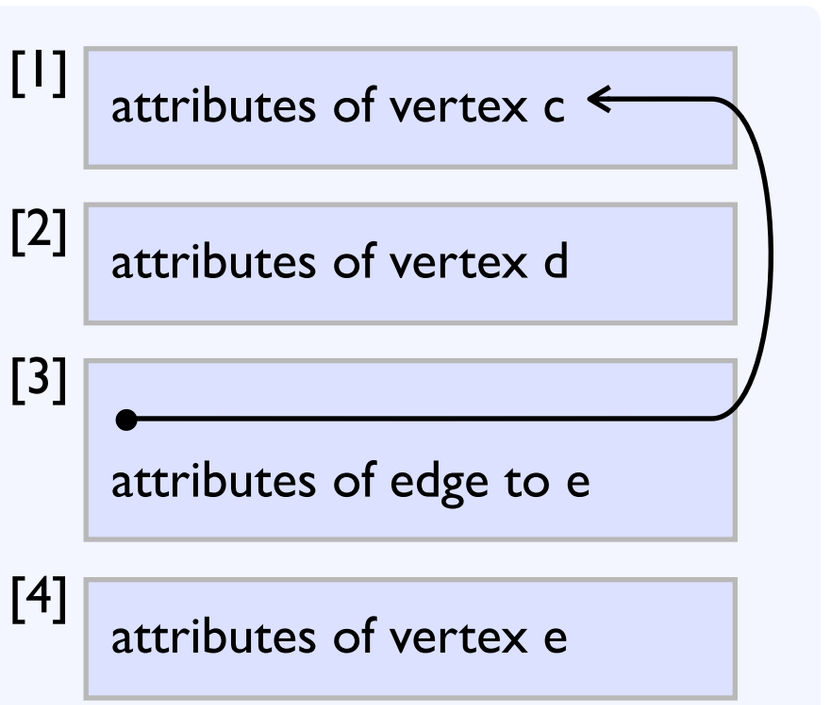
Memory

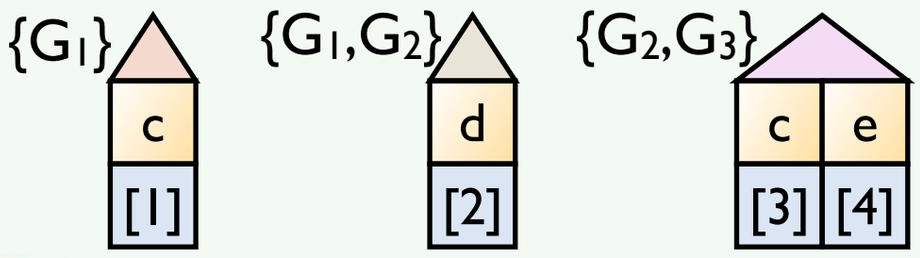


Disk

Storage of Graphs (on server)







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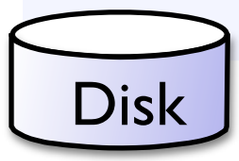

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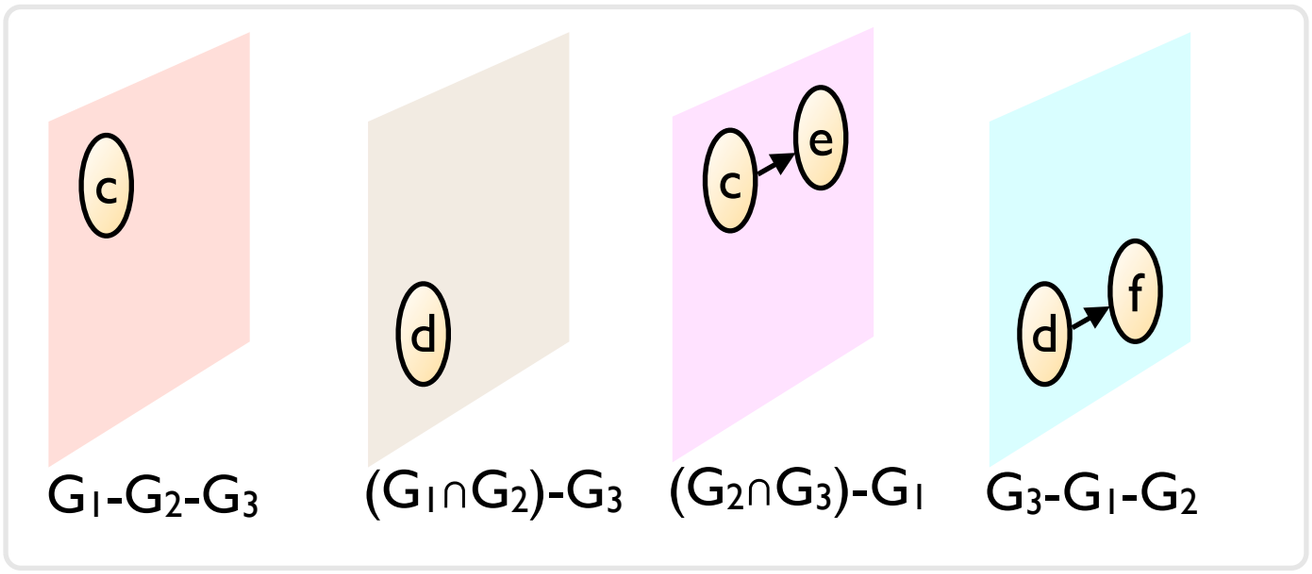

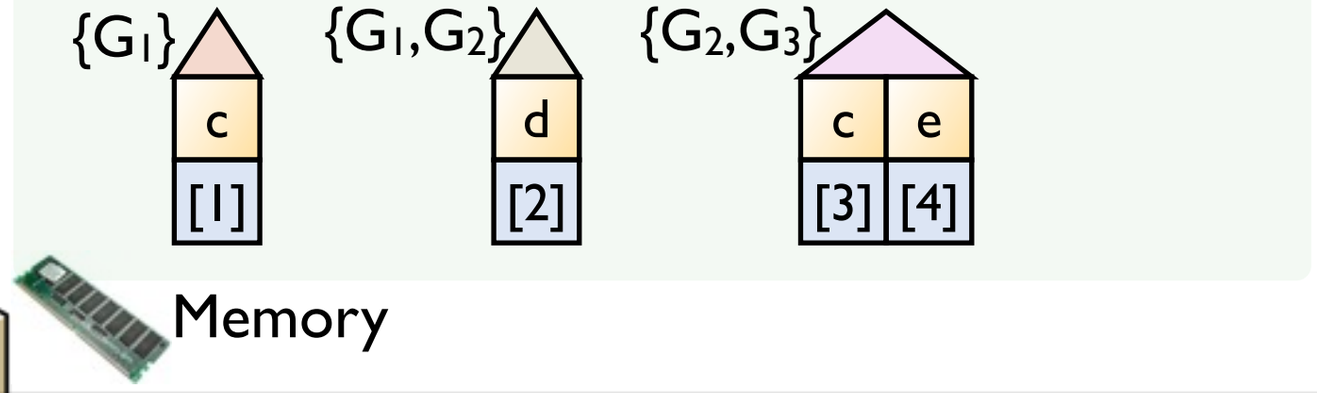

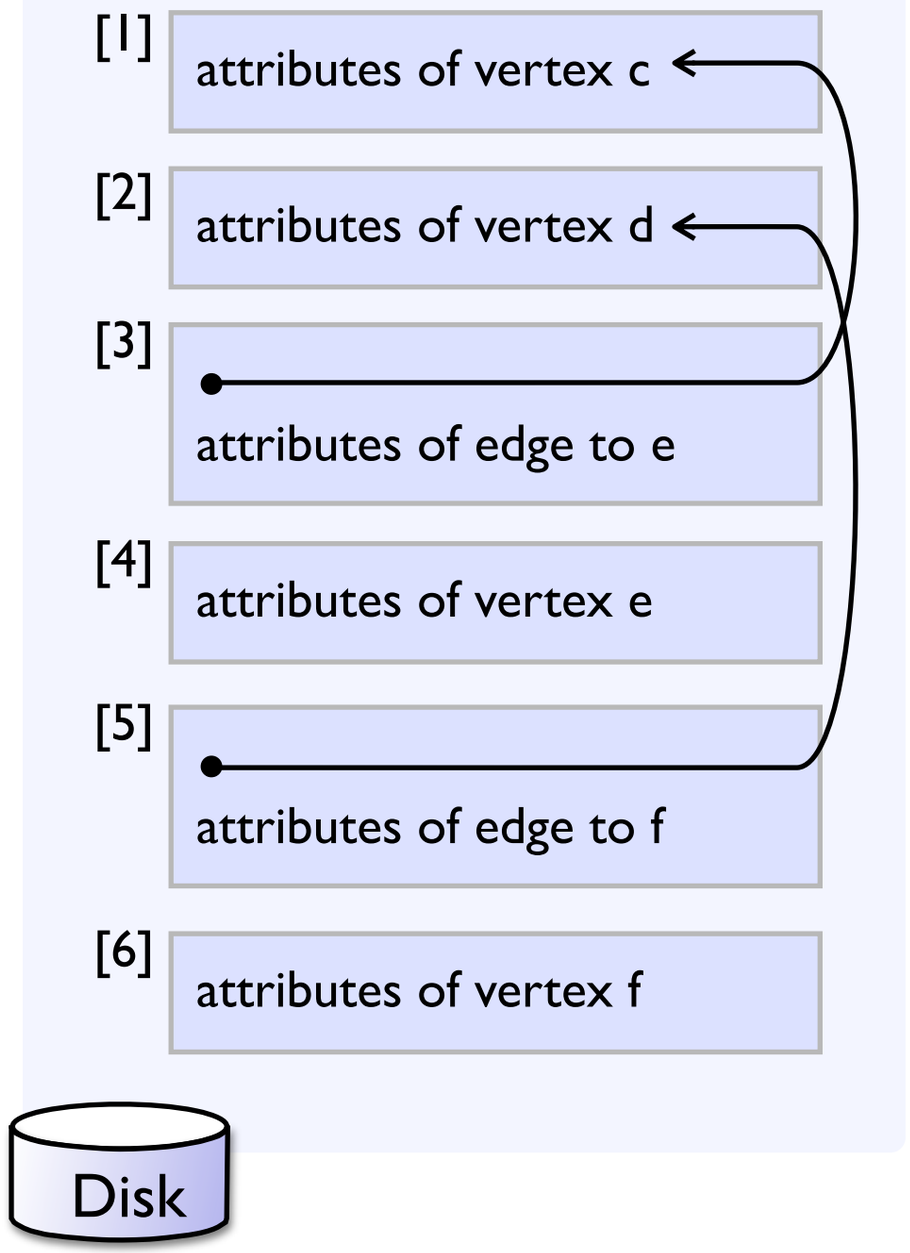

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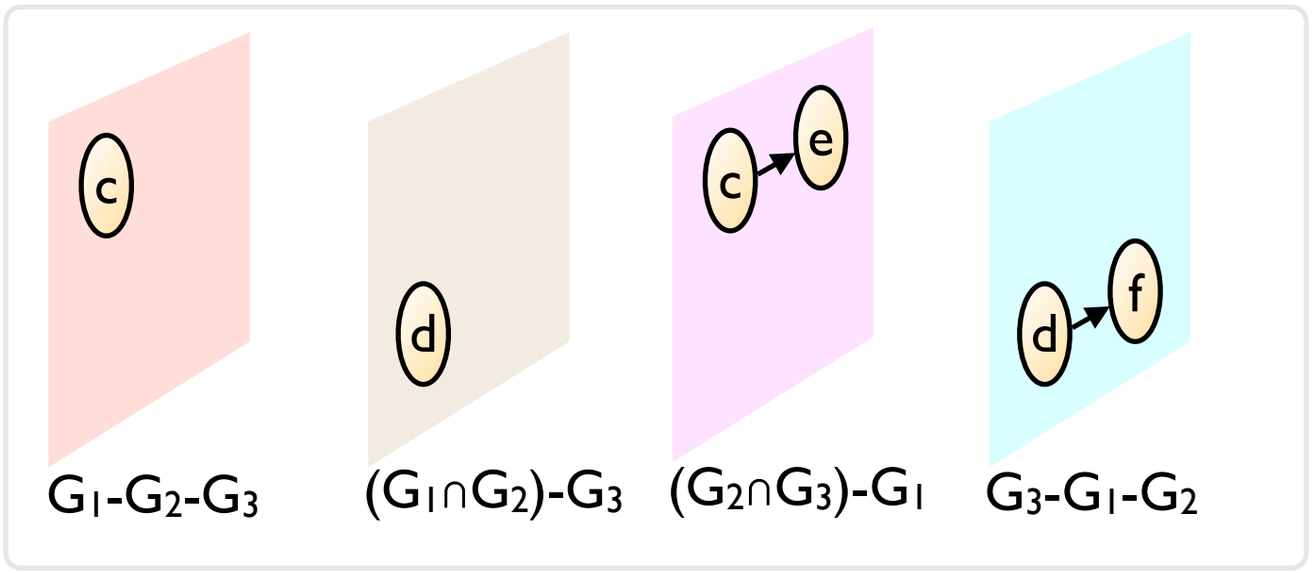

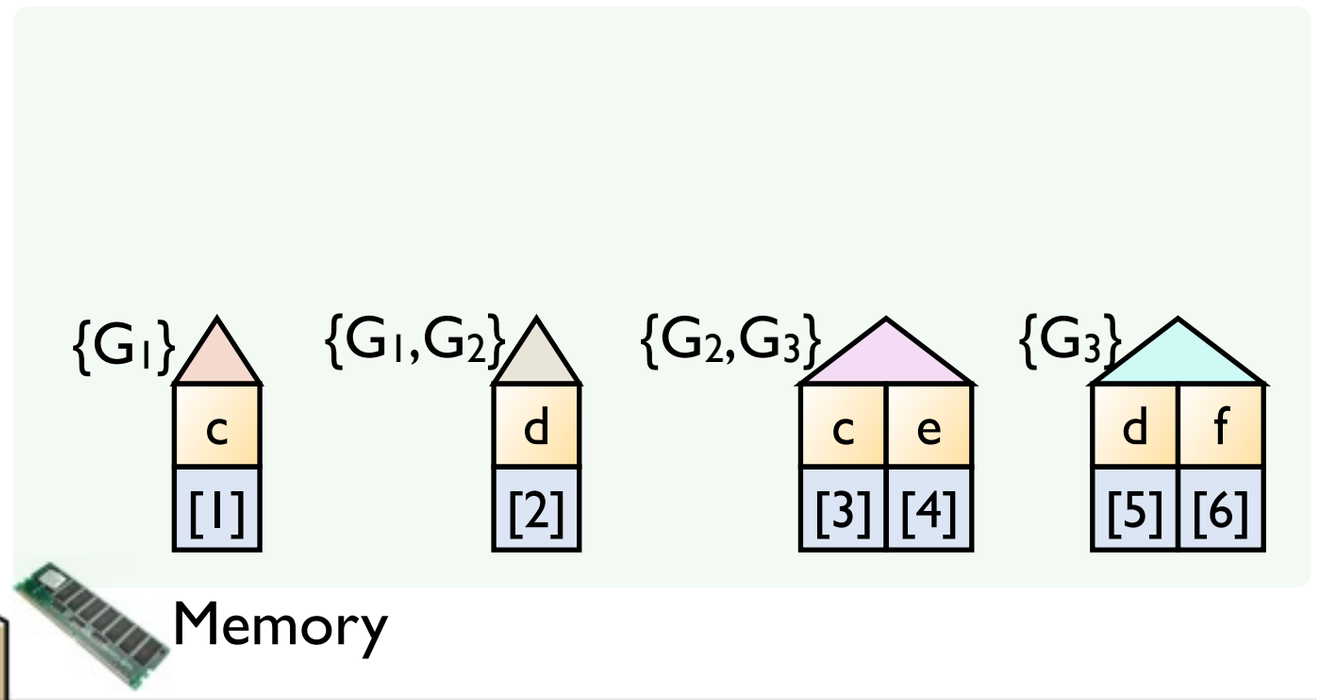

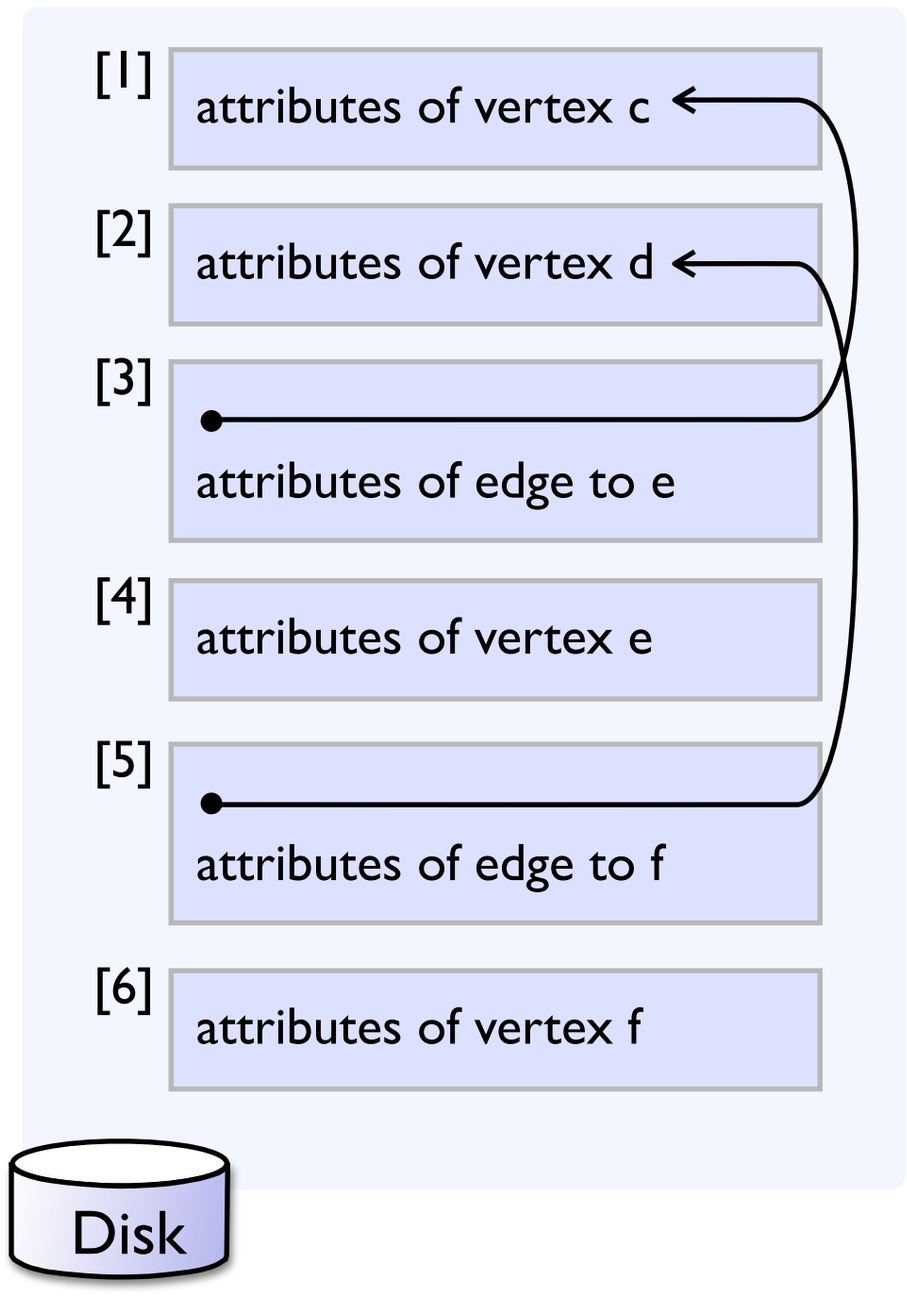

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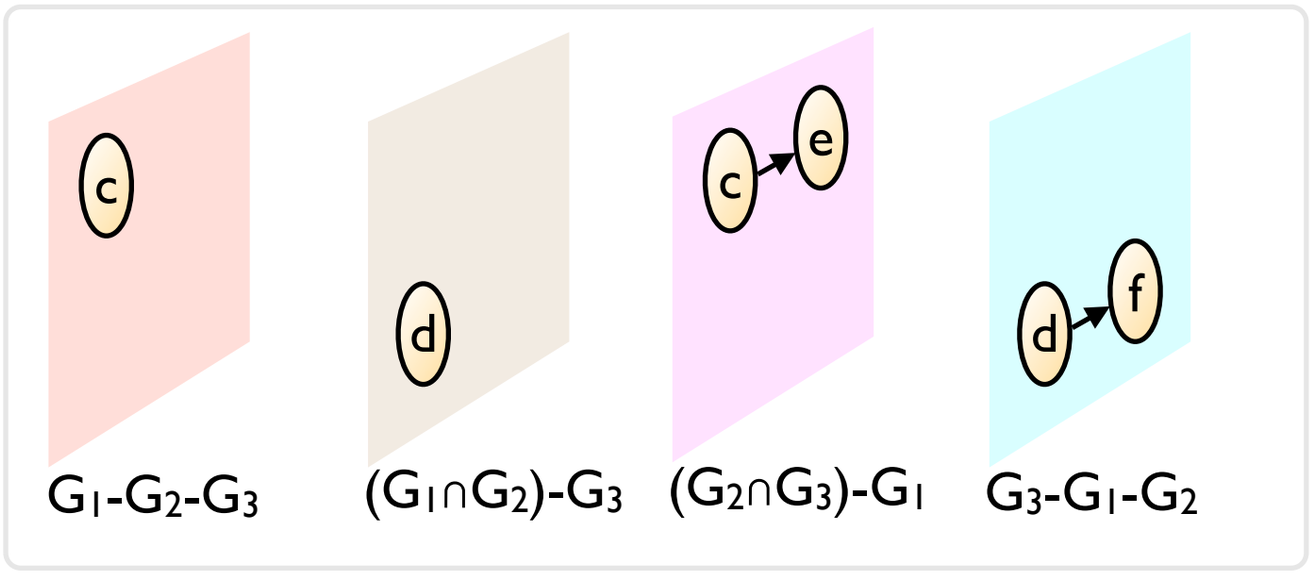
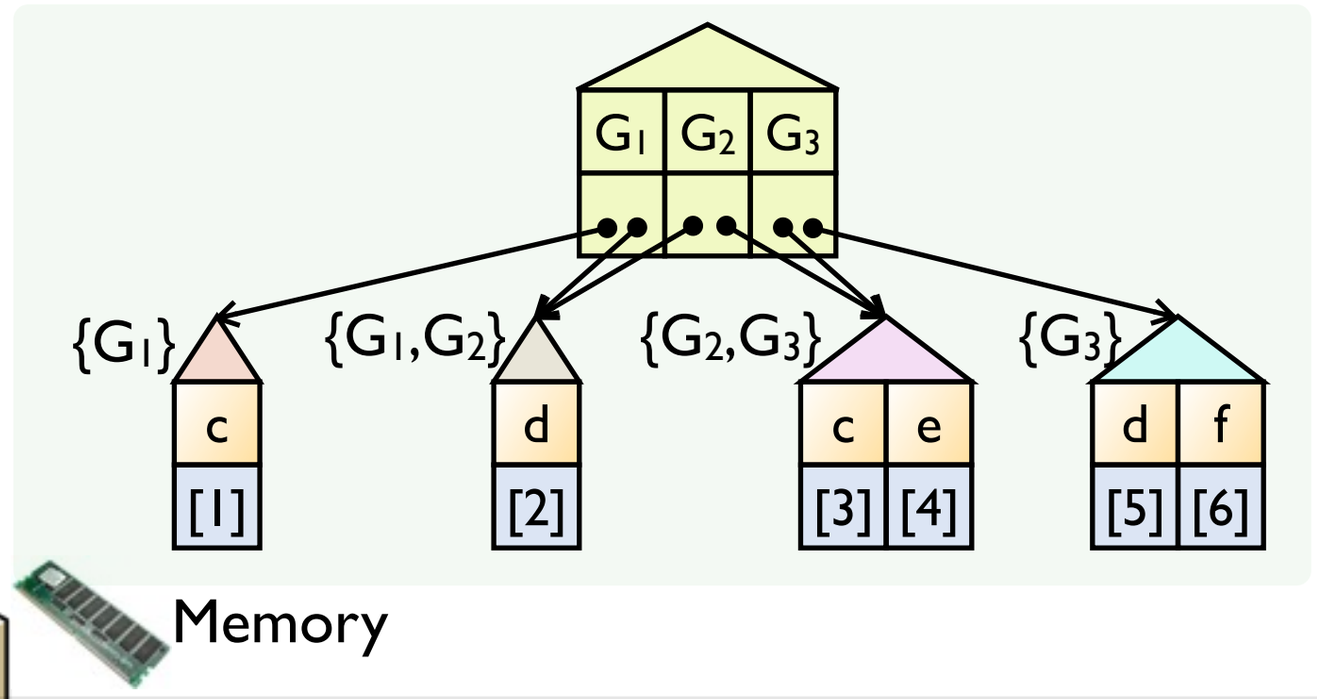
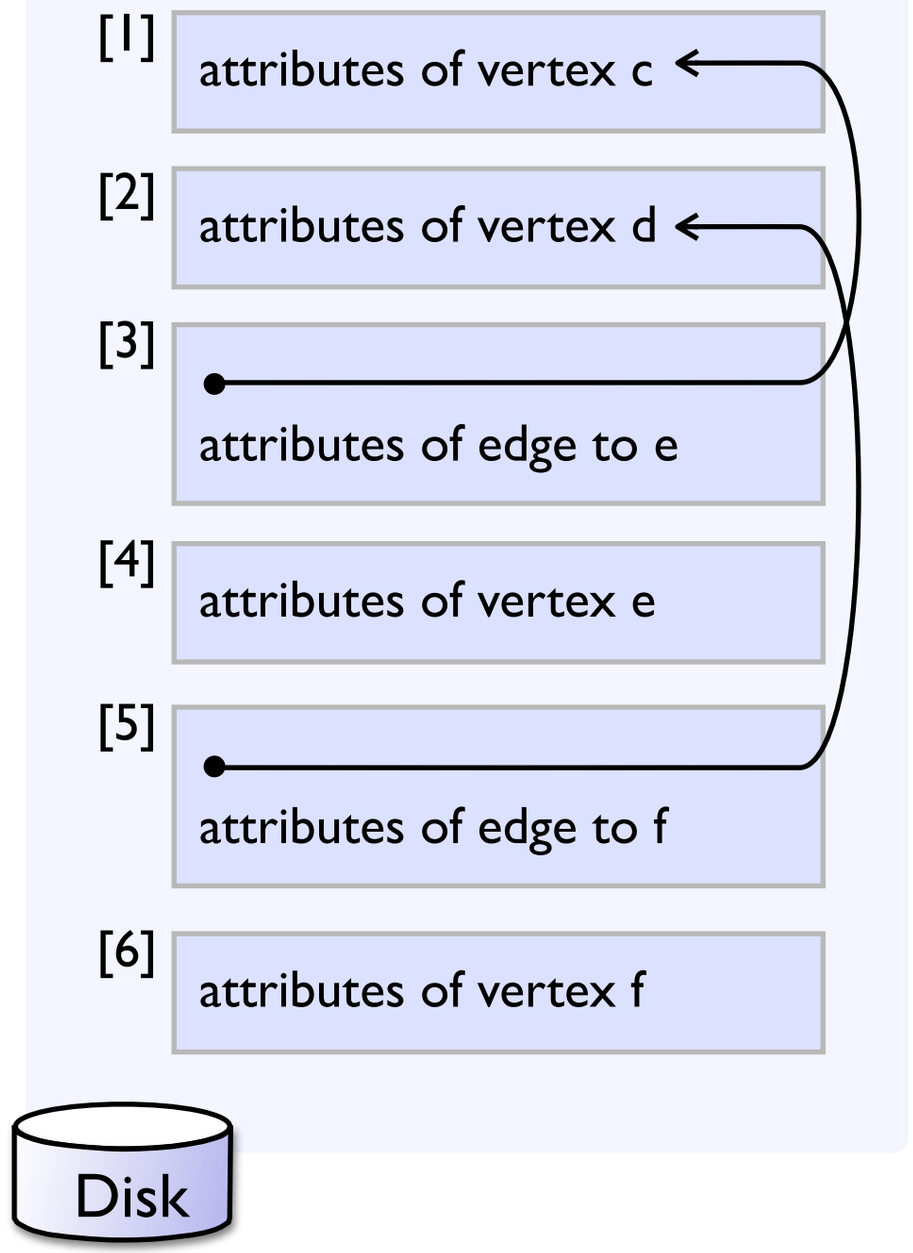
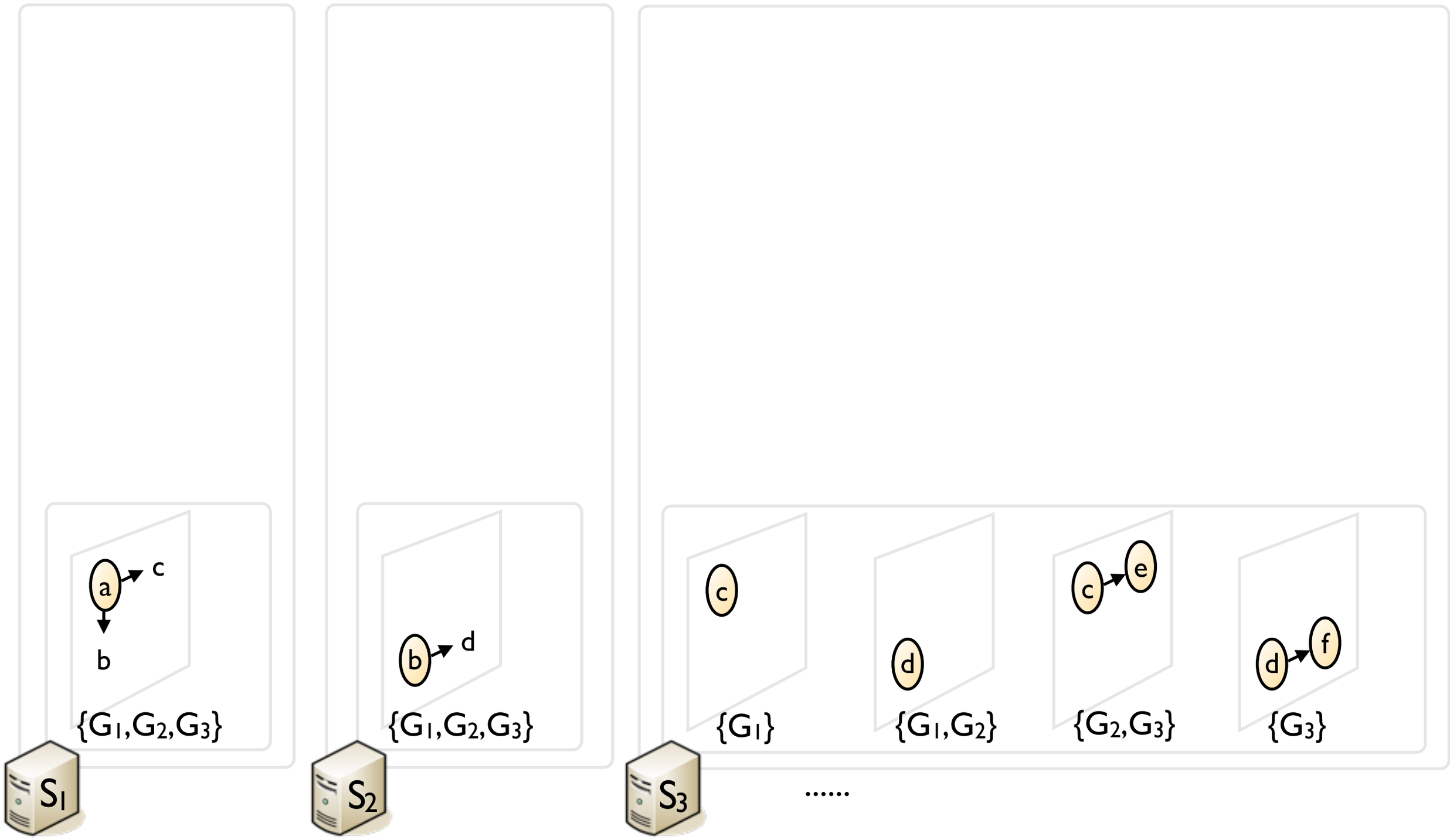






Example: average degree of each graph in $\{G_1, G_2\}$

Graph Query Execution



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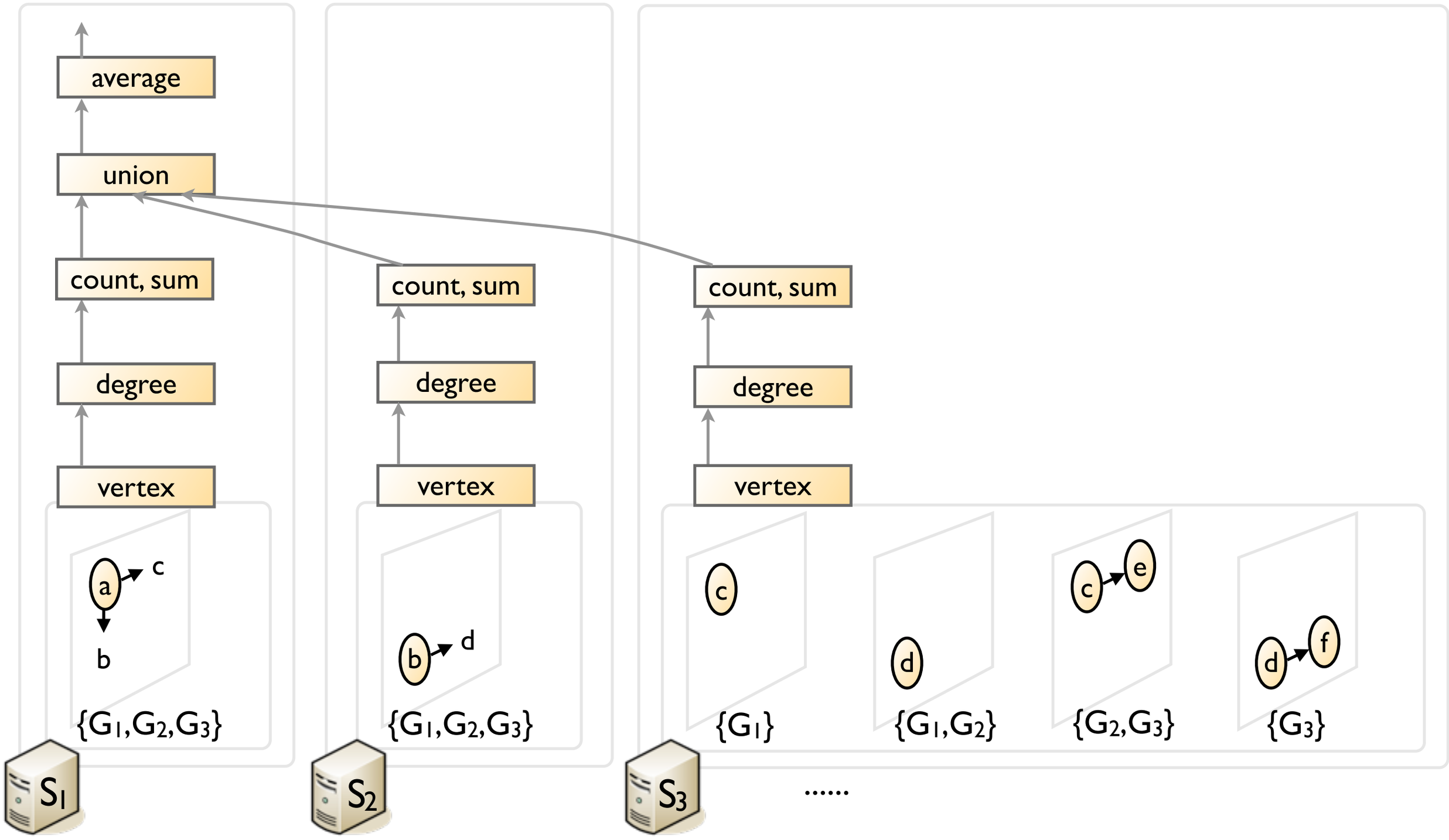

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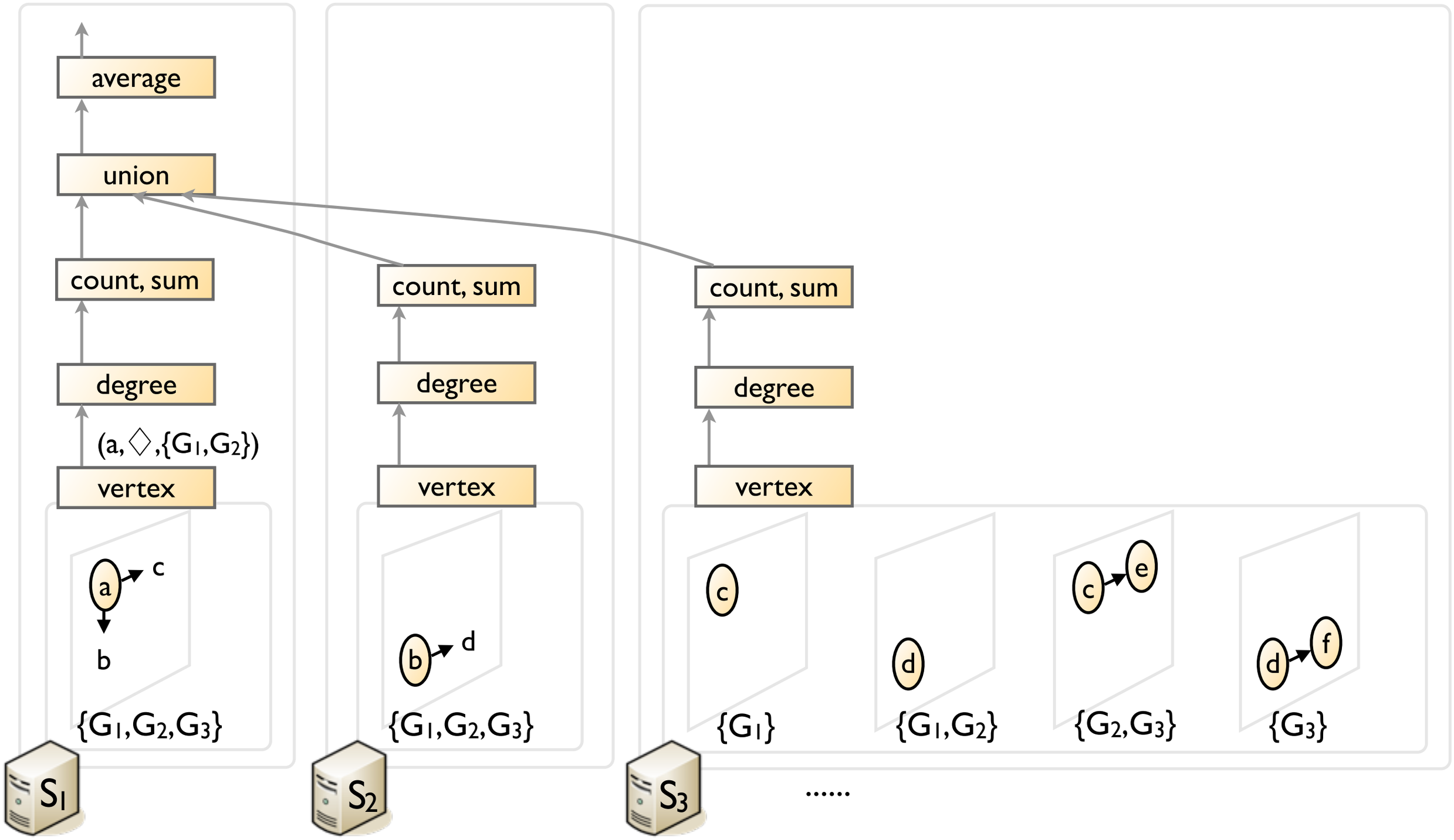

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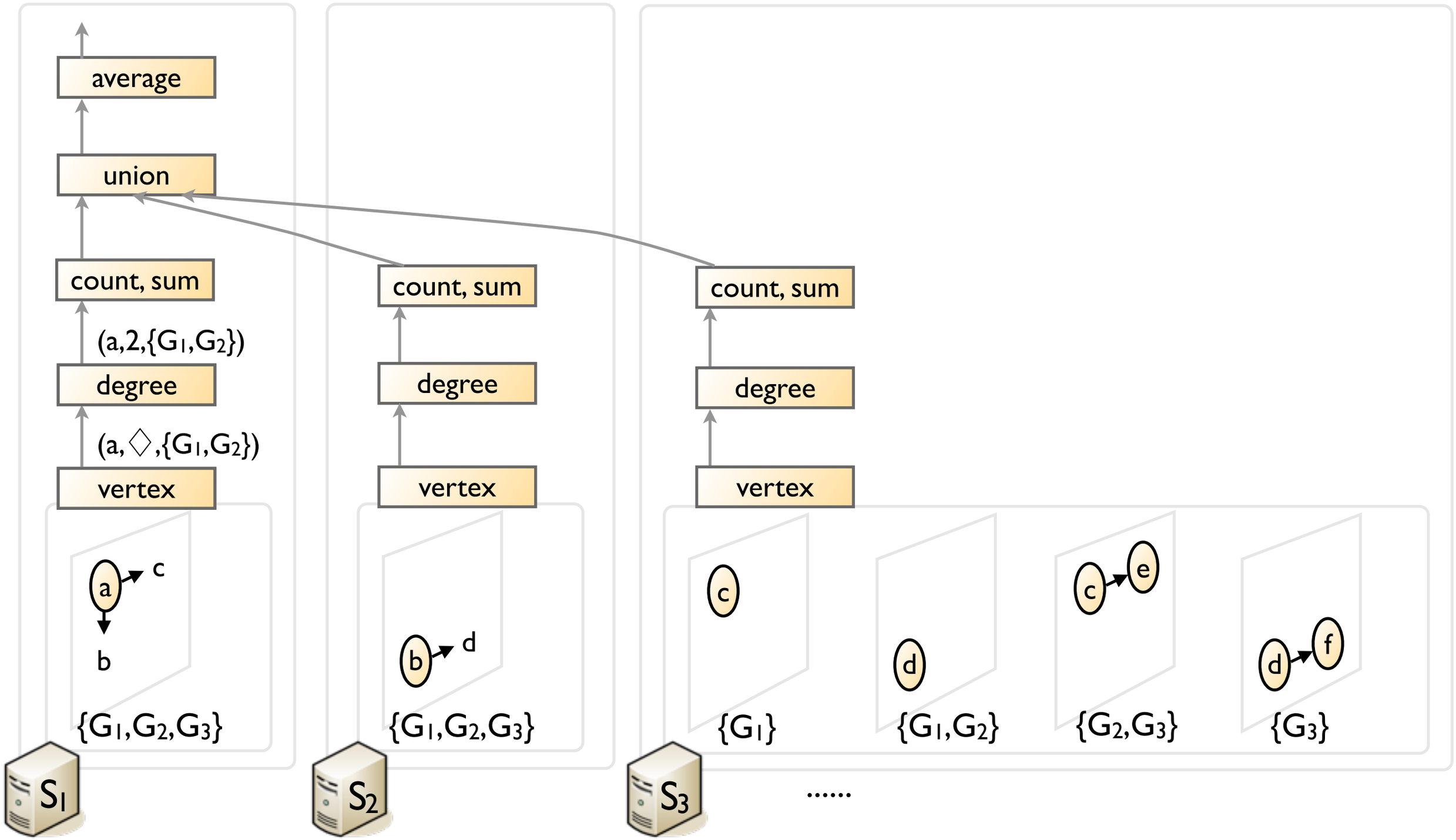

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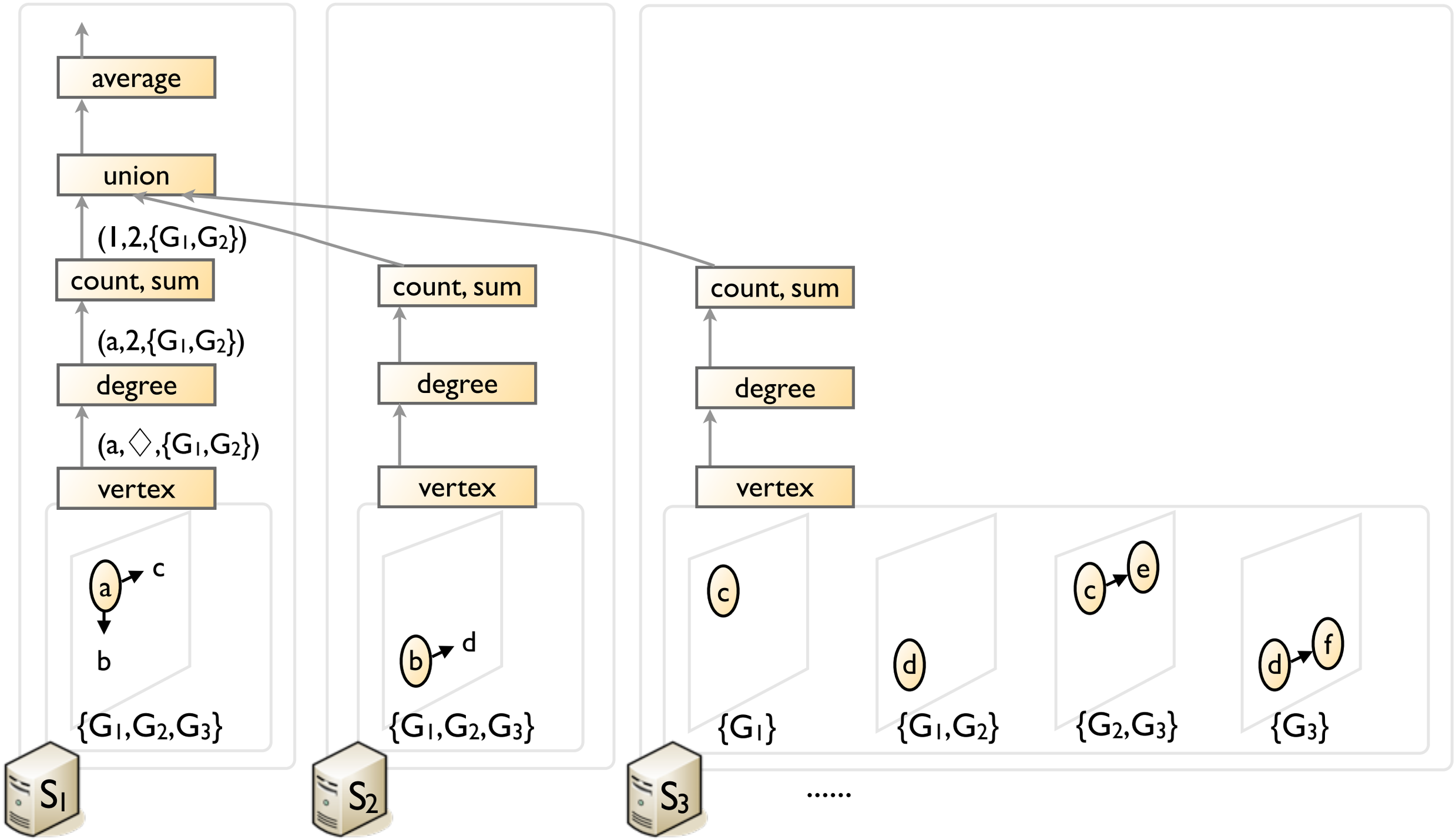

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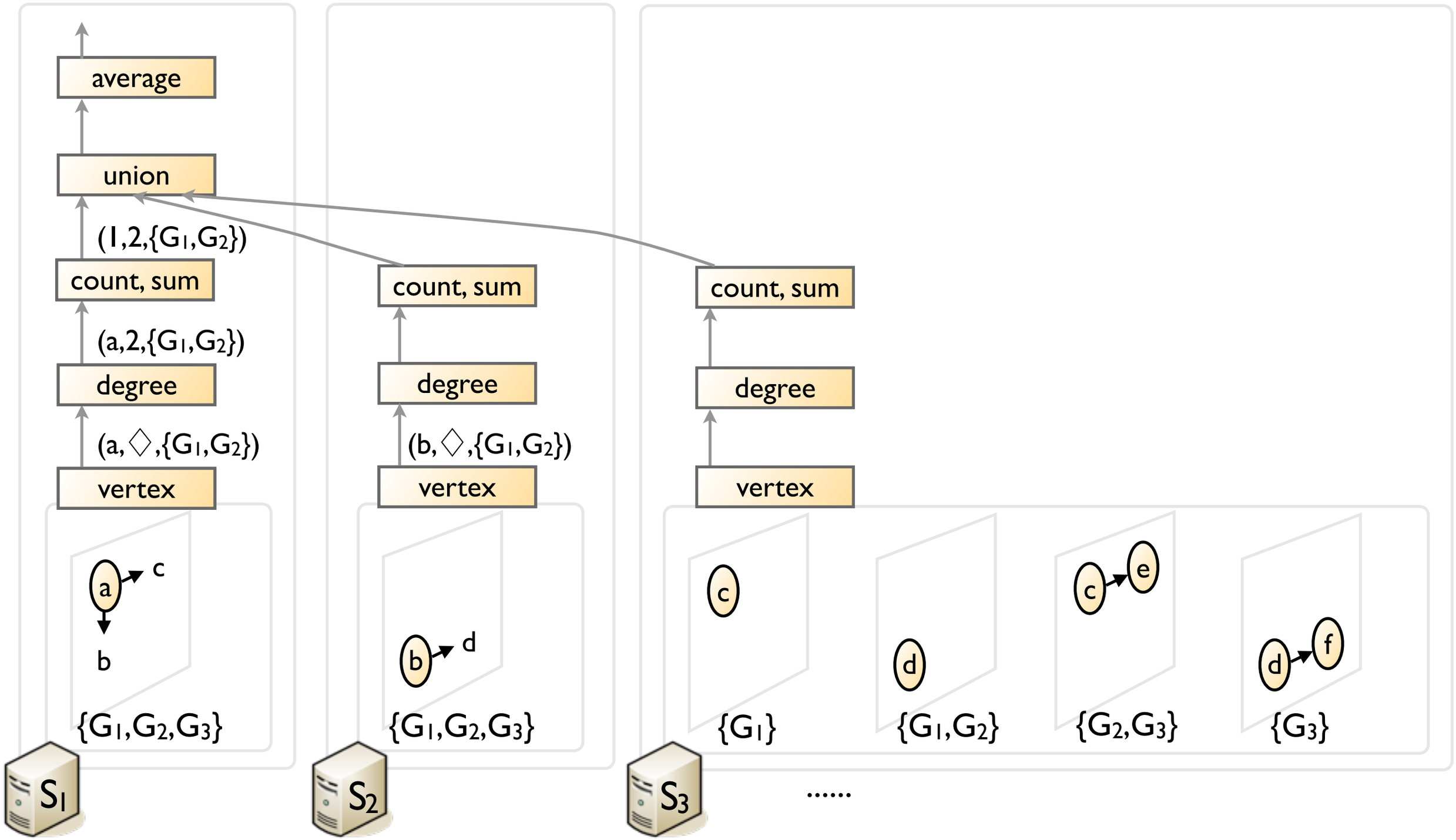

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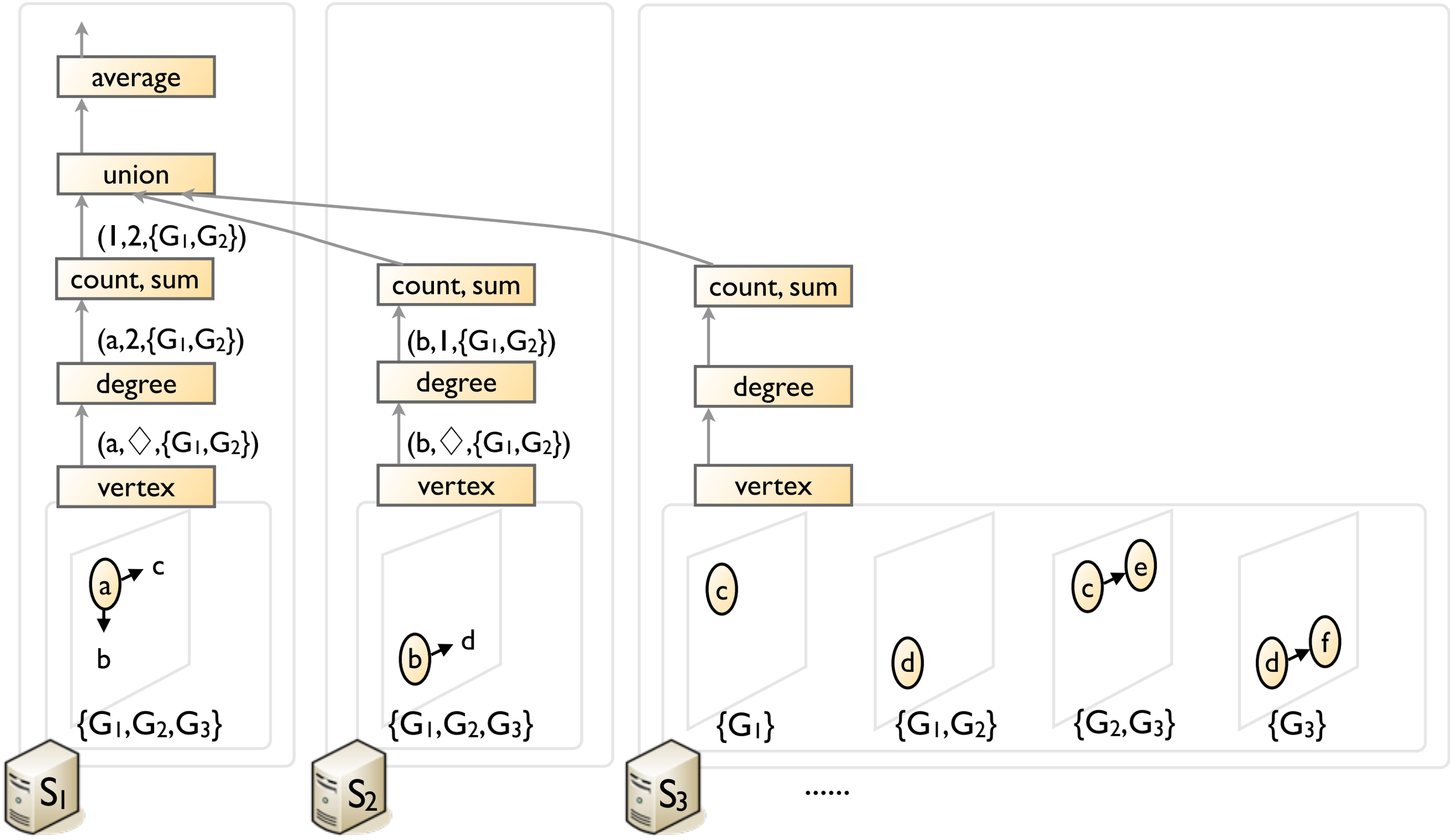

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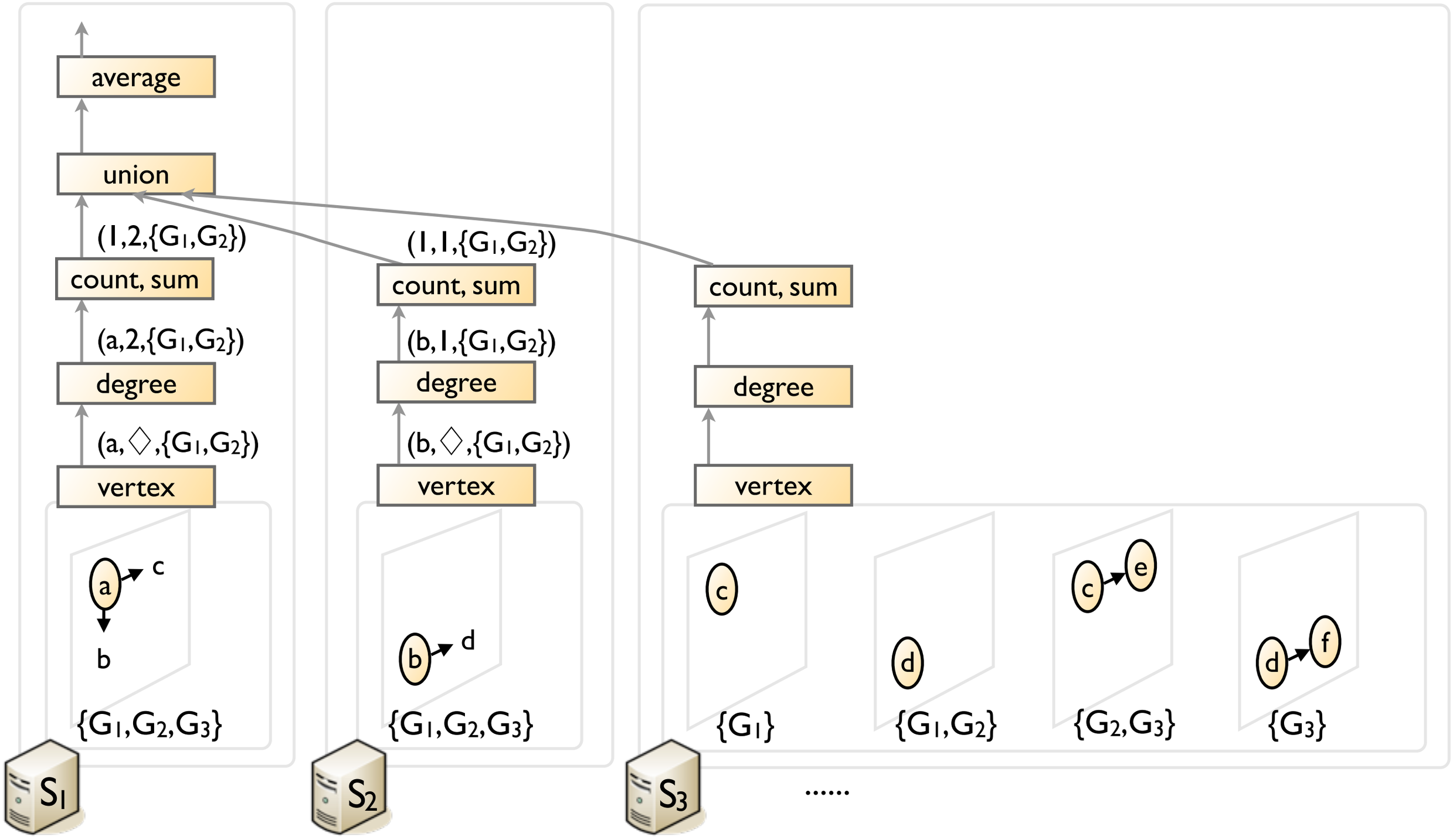

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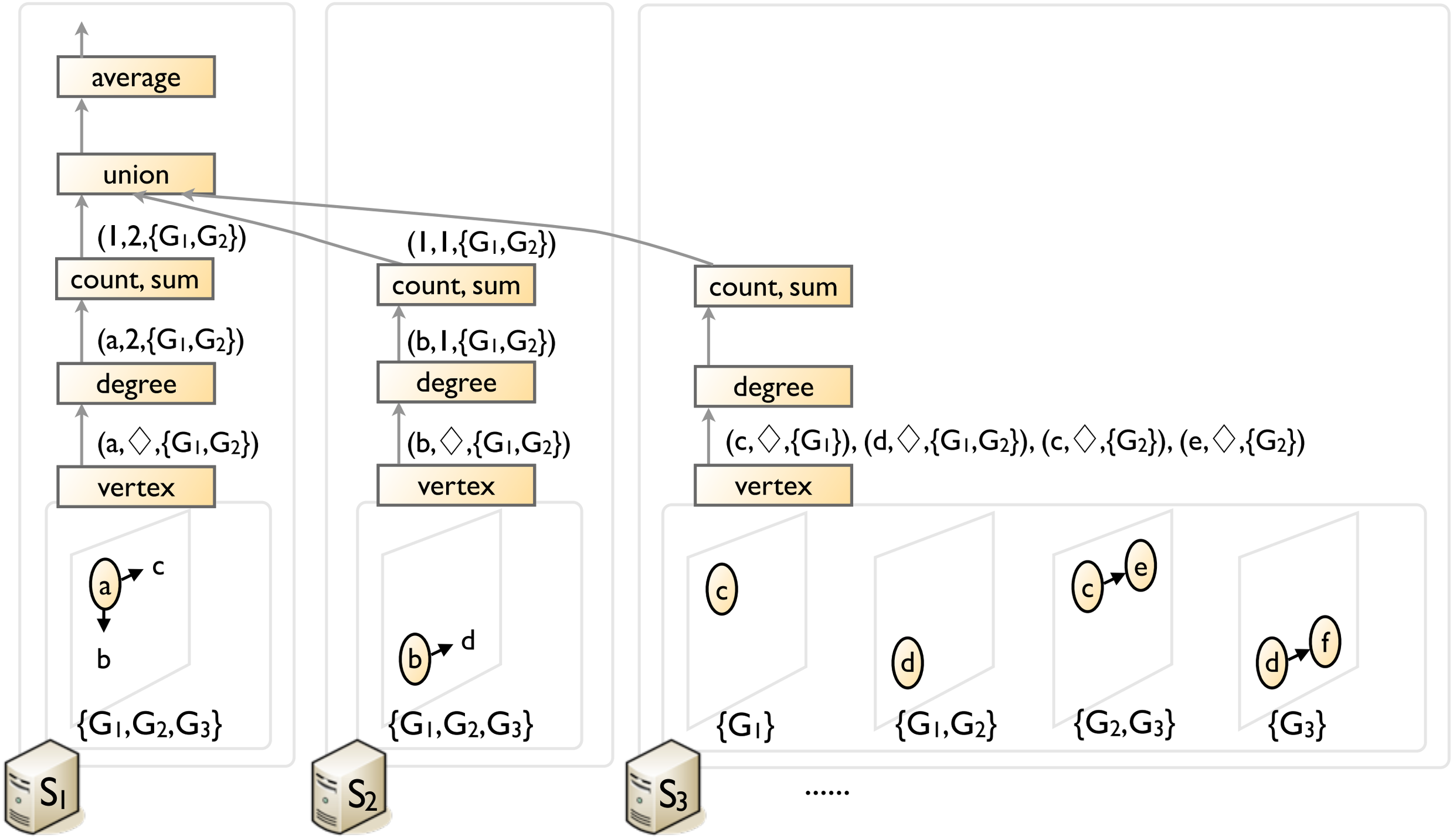

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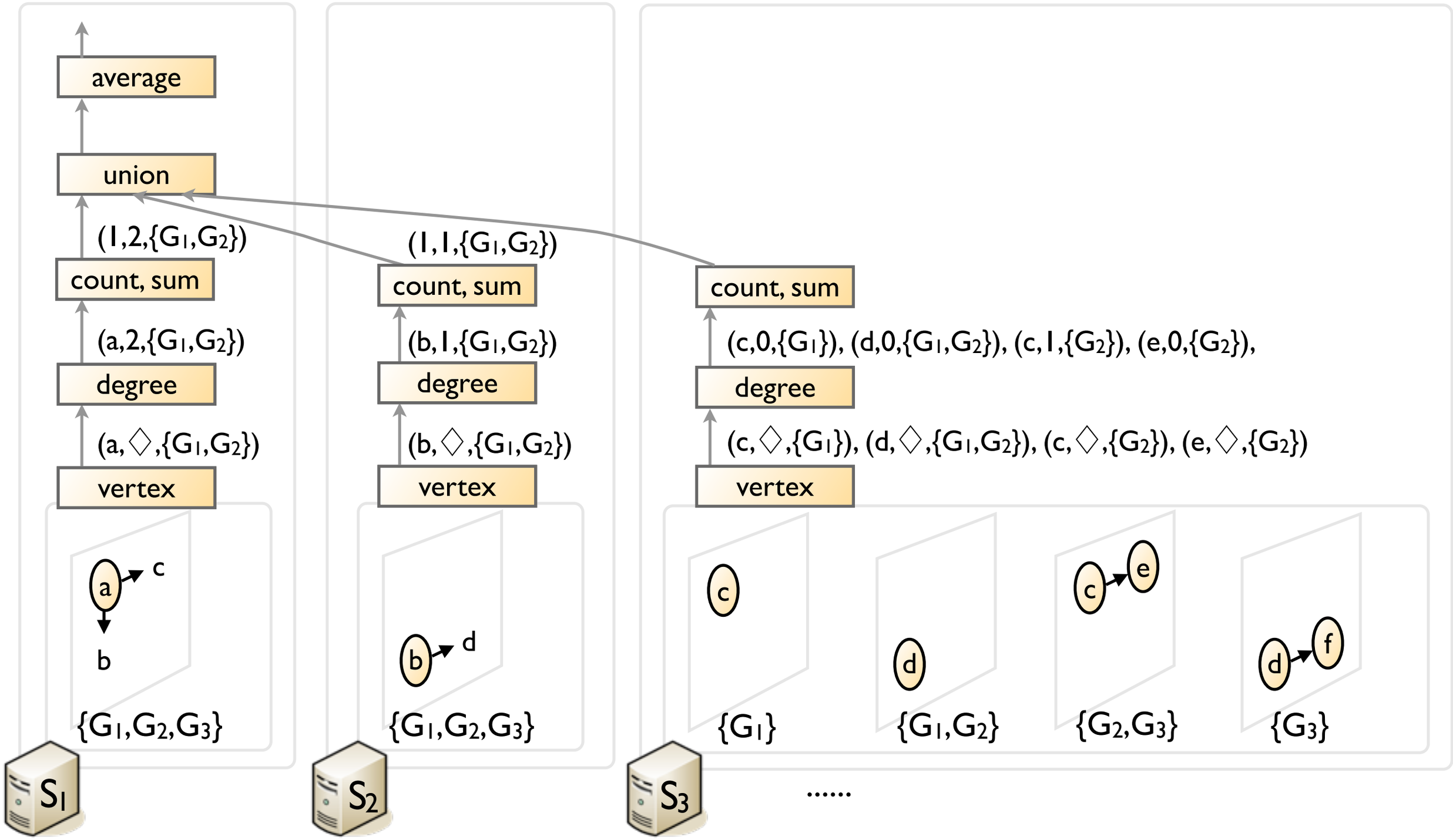

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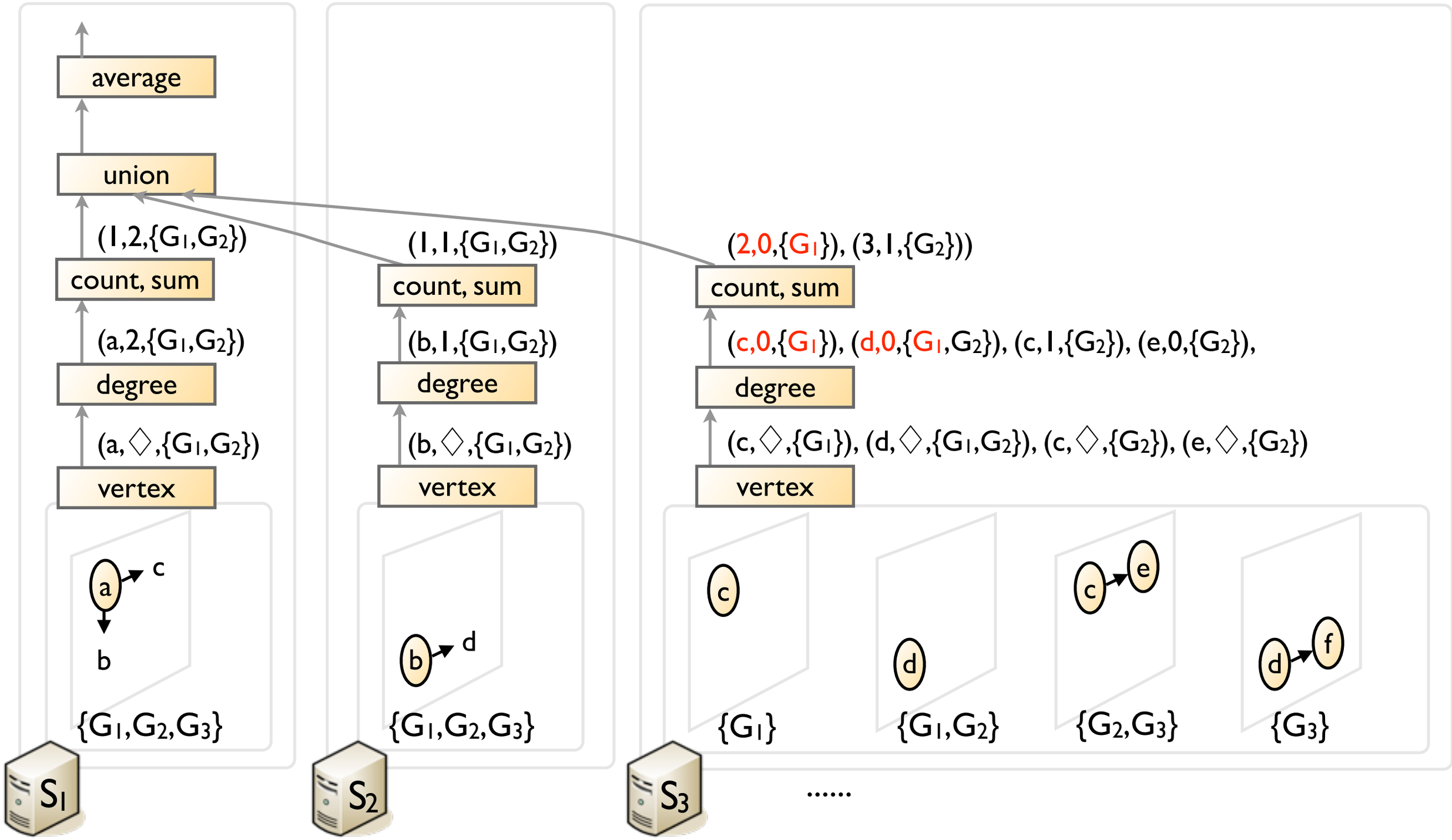
Graph Query Execution



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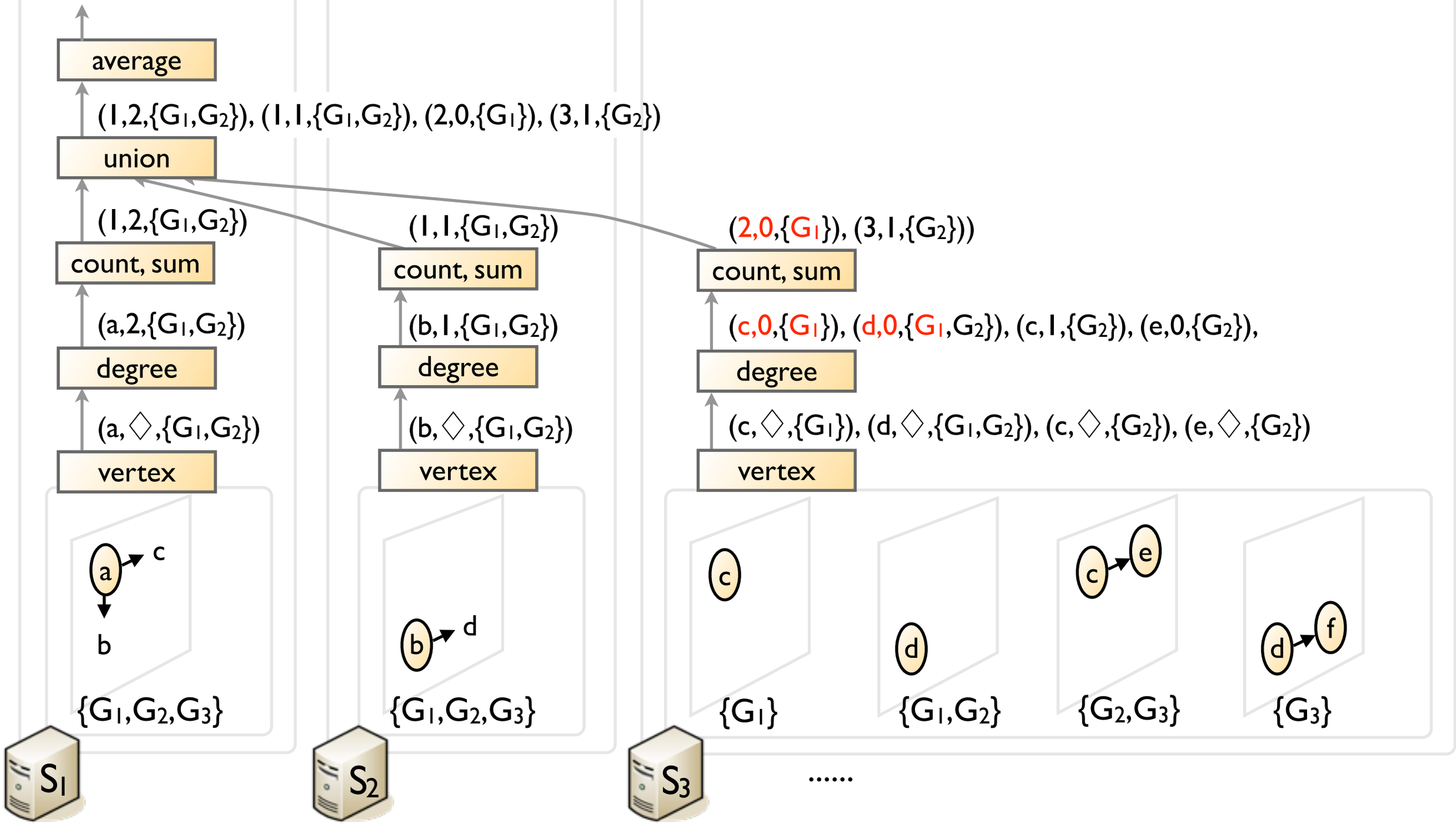

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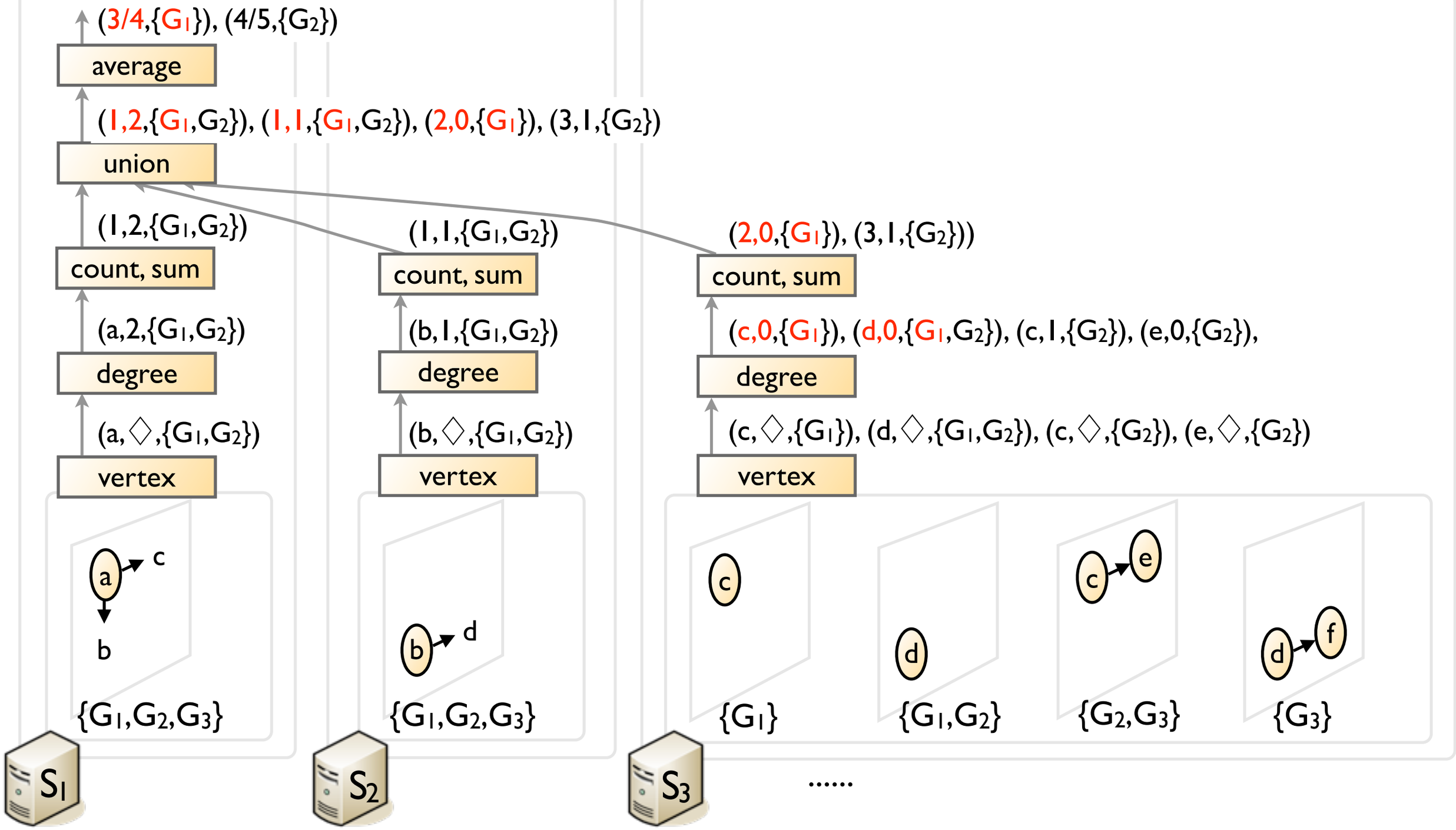

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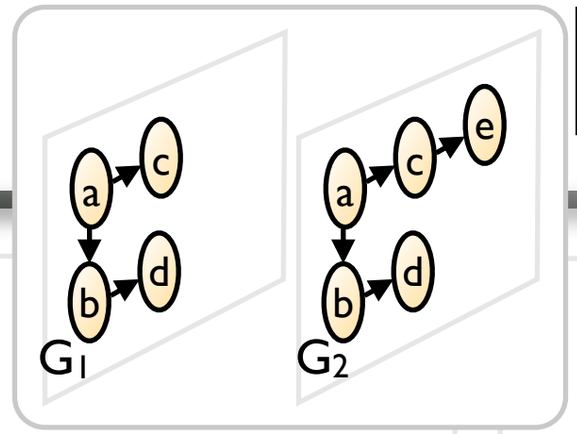


($3/4$,{G_1}), ($4/5$,{G_2})

average

($1,2$,{G_1,G_2}), ($1,1$,{G_1,G_2}), ($2,0$,{G_1}), ($3,1$,{G_2})

union

($1,2$,{G_1,G_2})

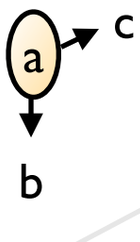
count, sum

($a,2$,{G_1,G_2})

degree

(a,◇,{G_1,G_2})

vertex



{G_1,G_2,G_3}

S_1

($1,1$,{G_1,G_2})

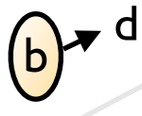
count, sum

($b,1$,{G_1,G_2})

degree

(b,◇,{G_1,G_2})

vertex



{G_1,G_2,G_3}

S_2

($2,0$,{G_1}), ($3,1$,{G_2}))

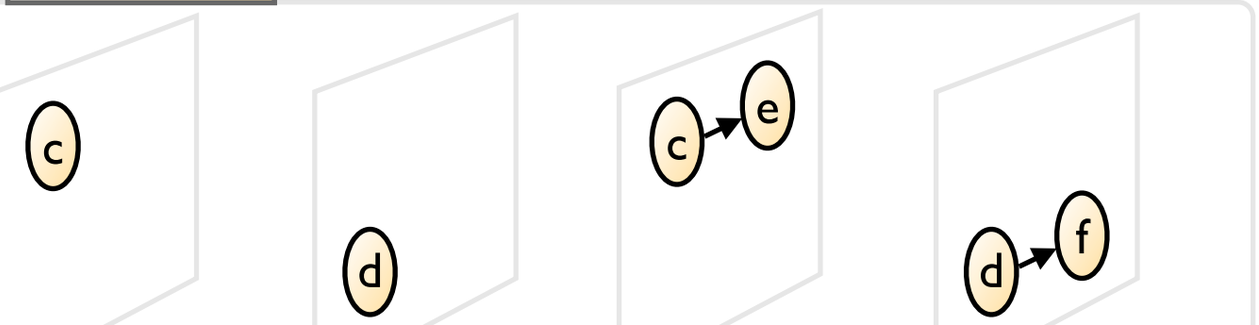
count, sum

($c,0$,{G_1}), ($d,0$,{G_1,G_2}), ($c,1$,{G_2}), ($e,0$,{G_2}),

degree

(c,◇,{G_1}), (d,◇,{G_1,G_2}), (c,◇,{G_2}), (e,◇,{G_2})

vertex



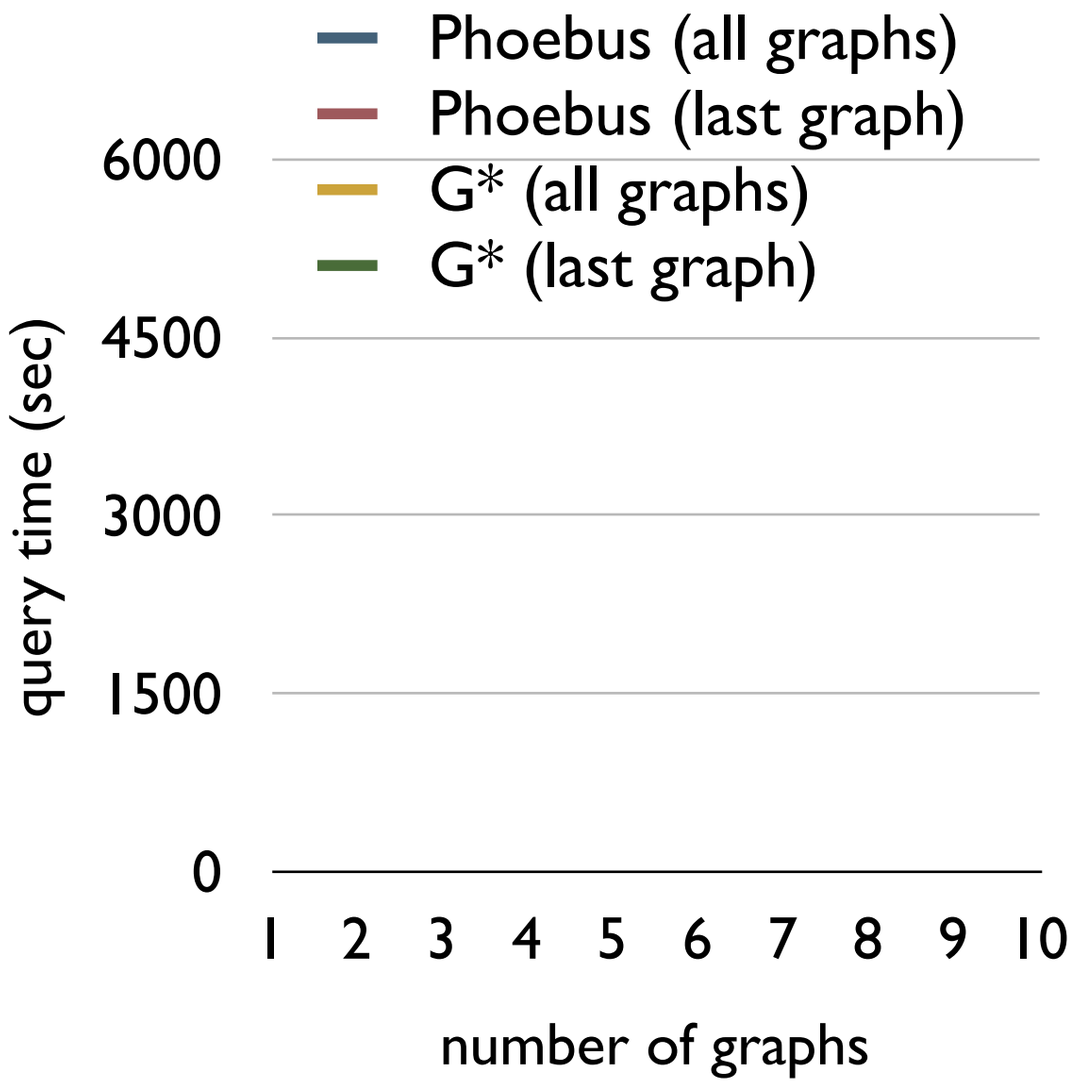
{G_1} {G_1,G_2} {G_2,G_3} {G_3}

S_3

.....

G* vs Phoebus (an open-source version of Pregel)

- Data
  - 10 complete binary trees
  - i'th tree = (i-1)'th tree
    +
    new 25K vertices (and edges)
- Query
  - single-source shortest paths



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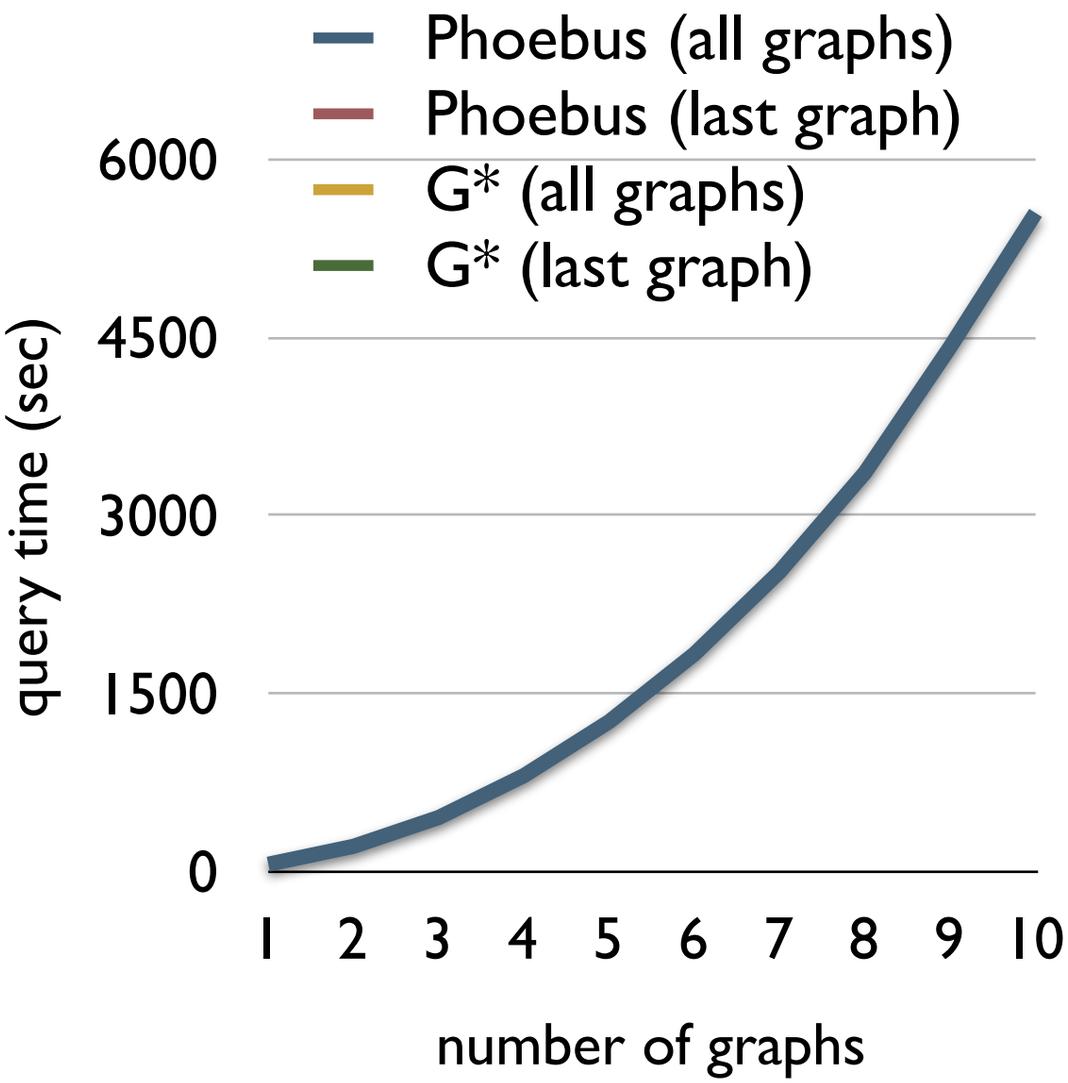

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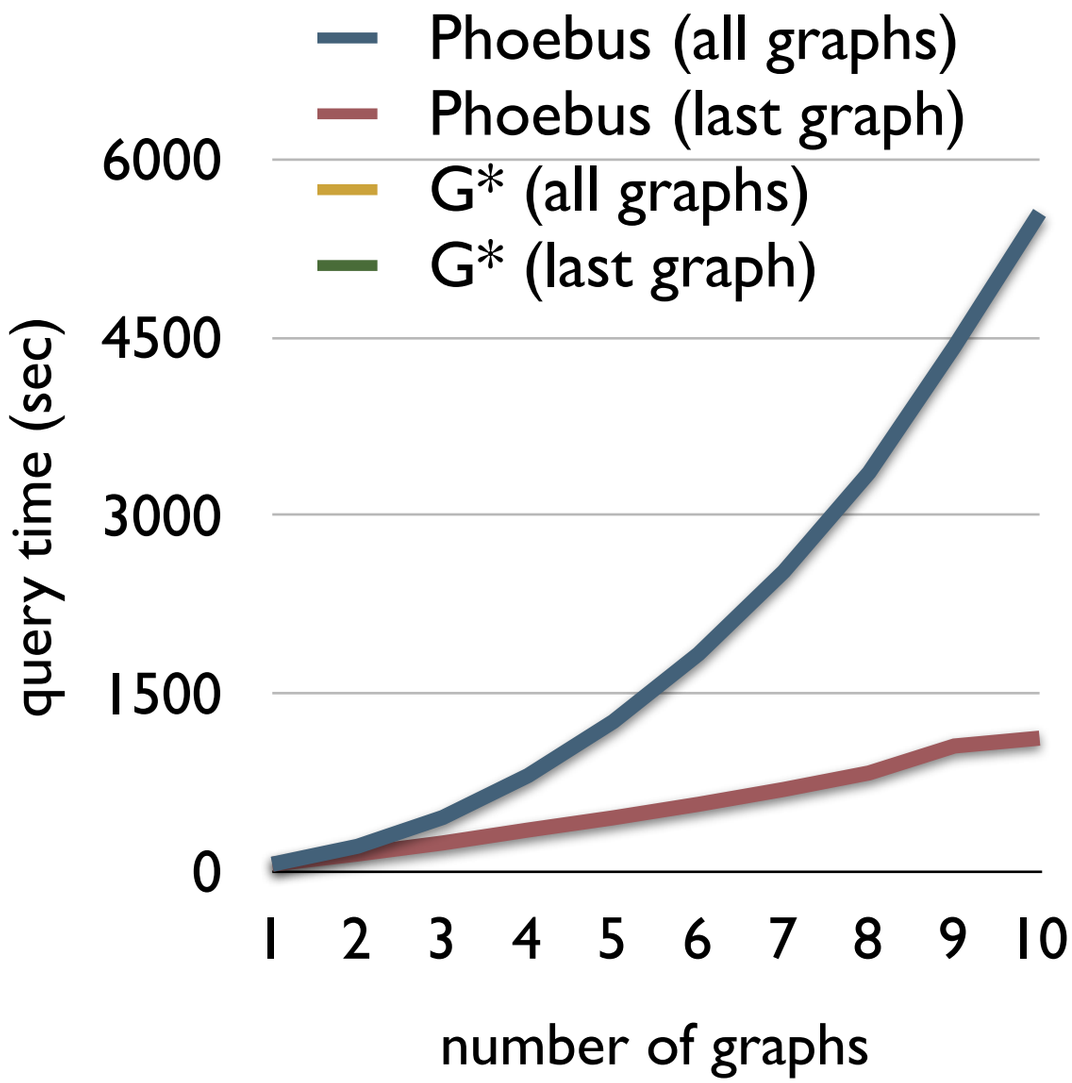

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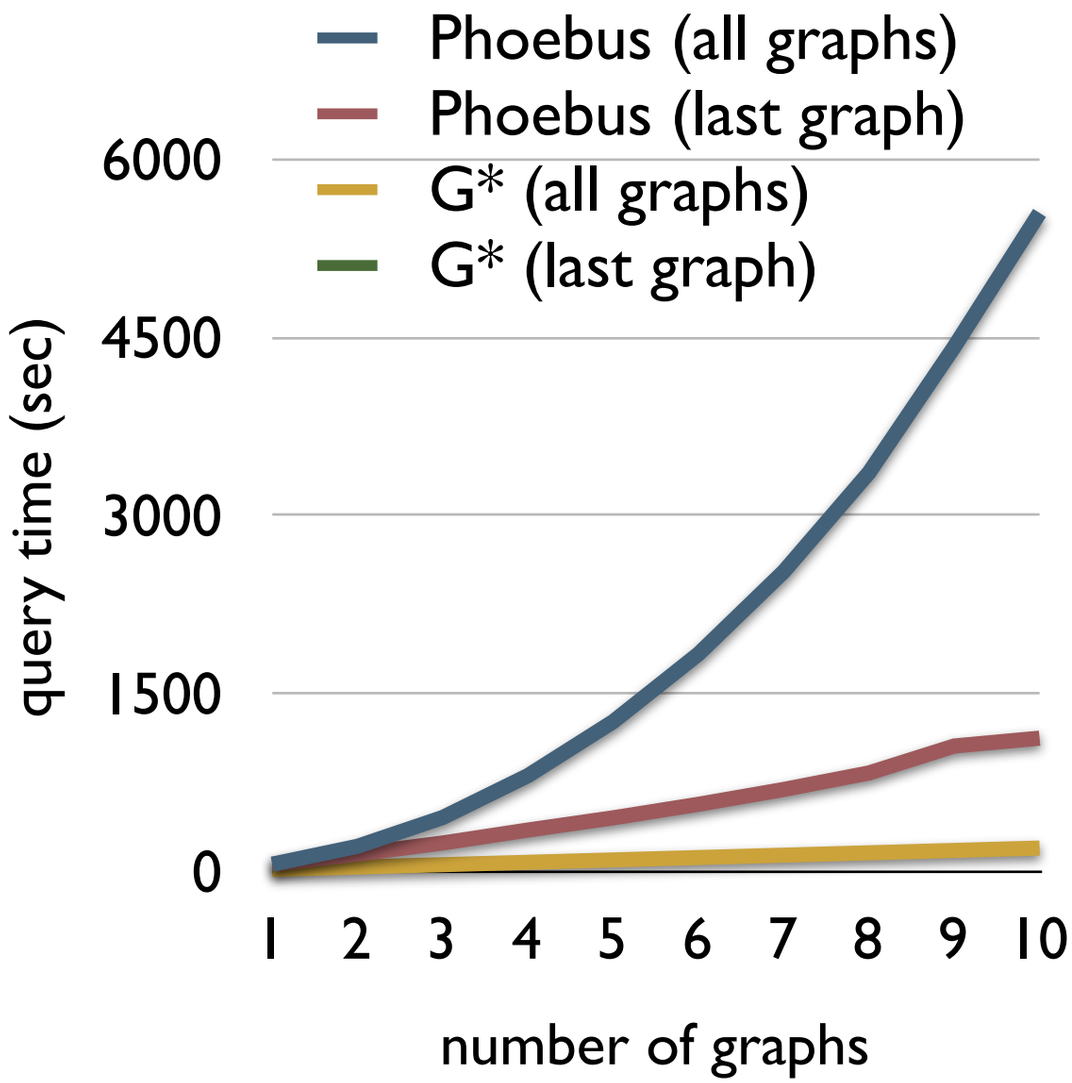

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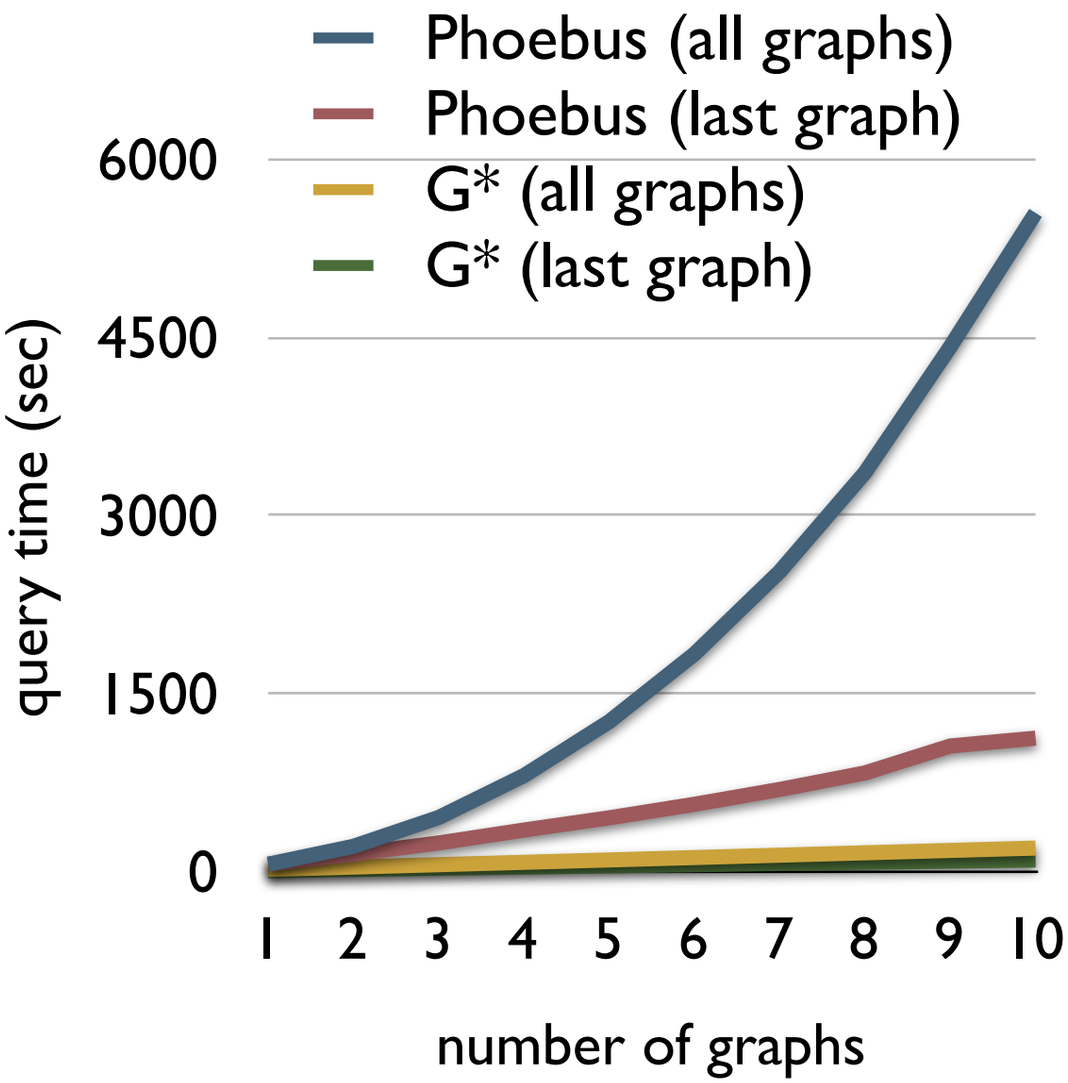
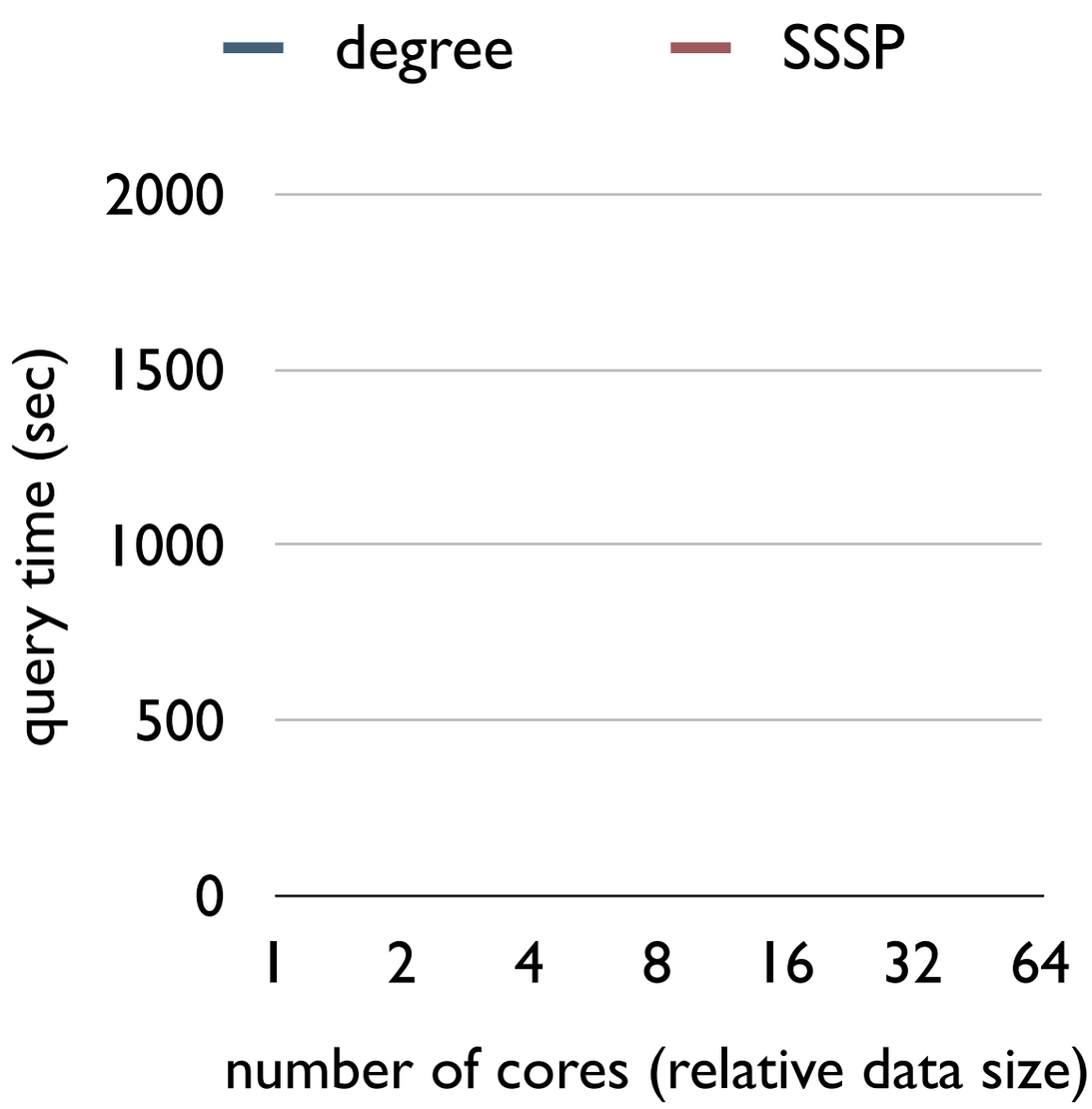


Scale-up Test

- Platform
  - 64 core server cluster
- Data
  - 1 complete binary tree
  - 1 billion vertices (edges)
  - 64 million vertices / server
- Queries
  - vertex degree
  - single-source shortest paths



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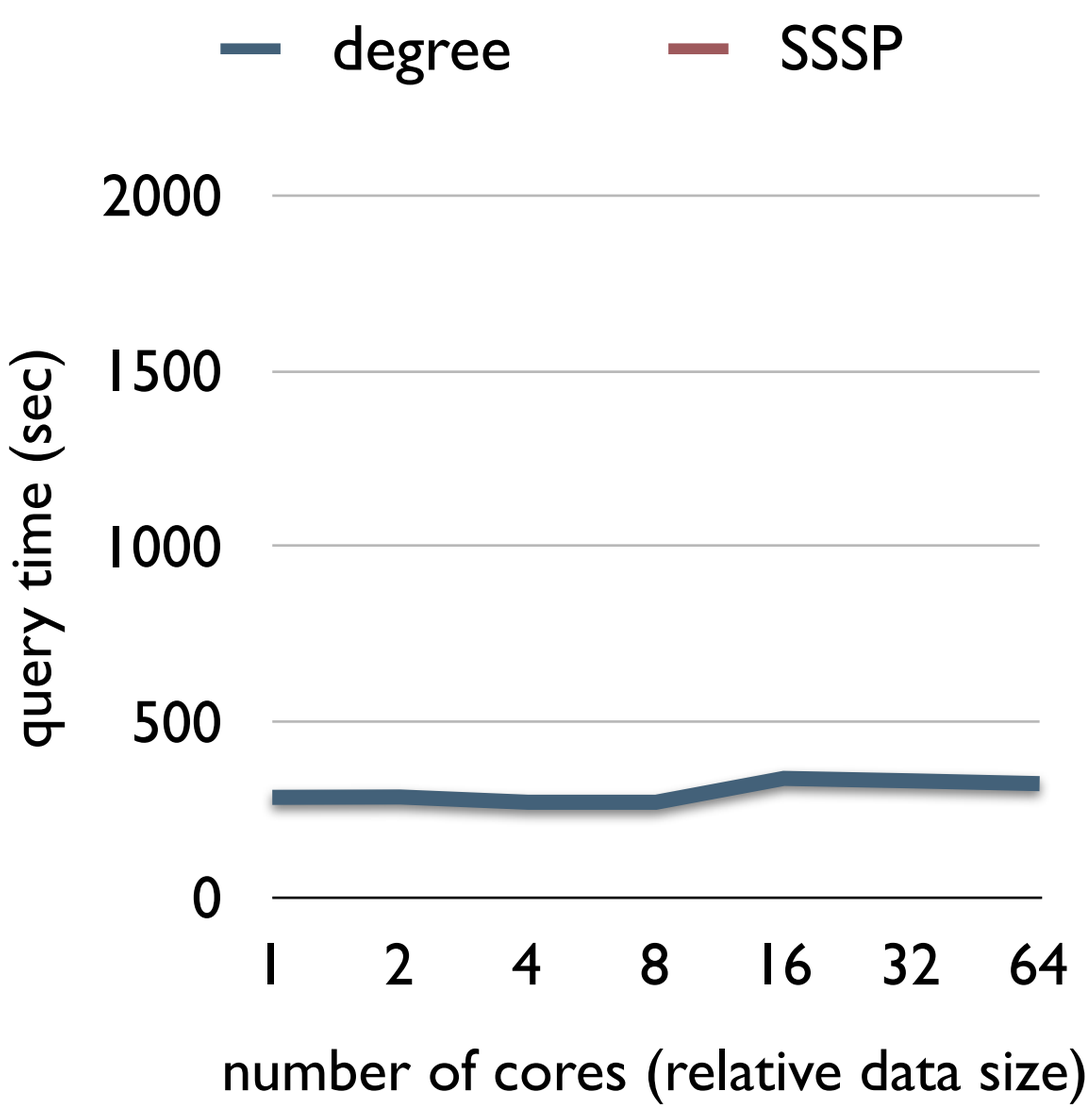

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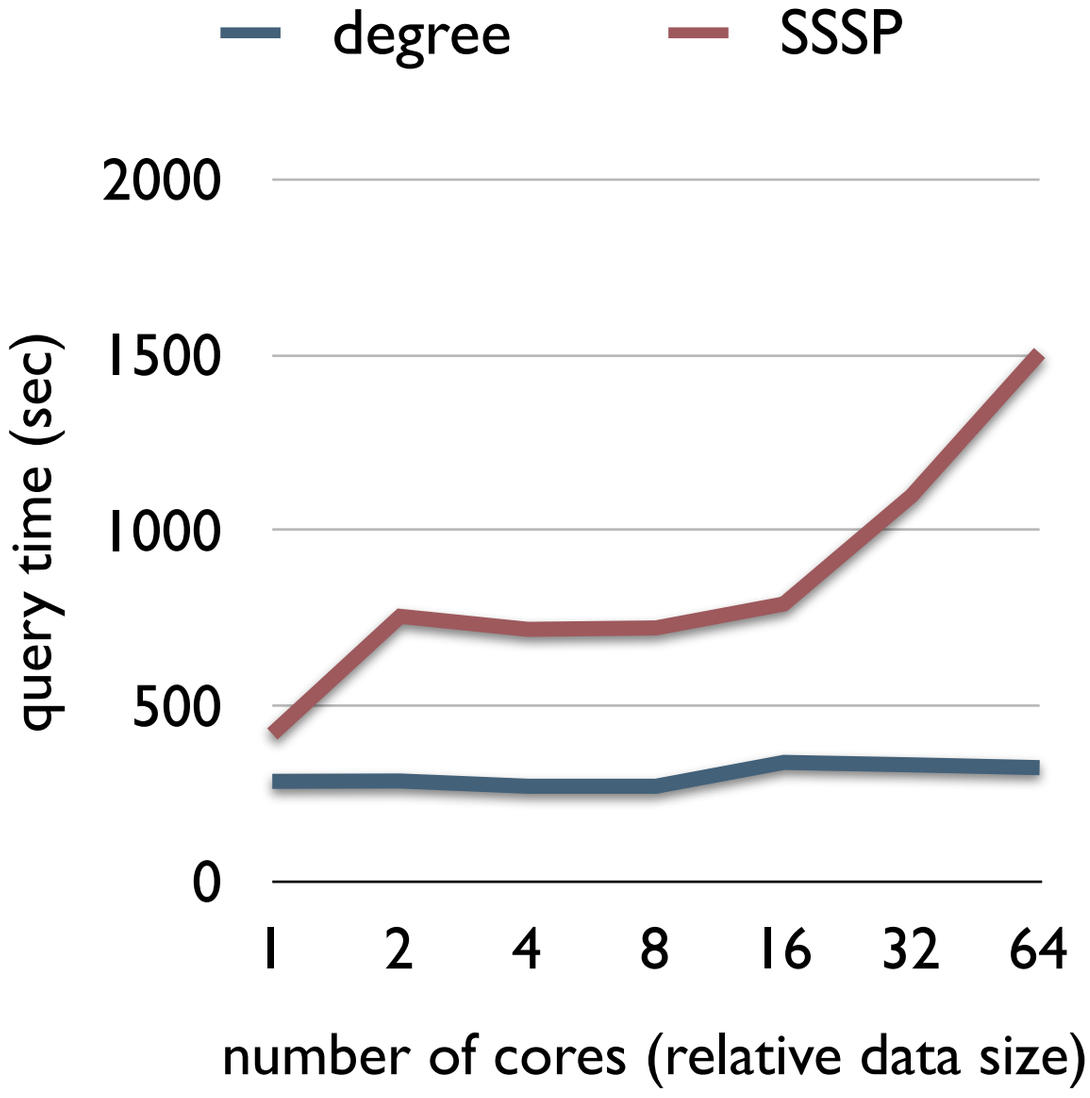

Conclusion

- Convenient and efficient queries on graphs
  - distributed, deduplicate storage of graphs
  - parallel query processing that share computations across graphs
- Supported by NSF CAREER award IIS-1149372
- 30K lines of Java code
- 1st code release in August 2012
- Future work
  - disk optimization / graph distribution / query optimization / high availability

Thank you!