Monarch: Gaining Command on Geo-Distributed Graph Analytics

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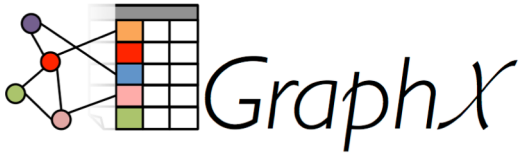
HotCloud, July 09, 2018

Graph Analytics Popular

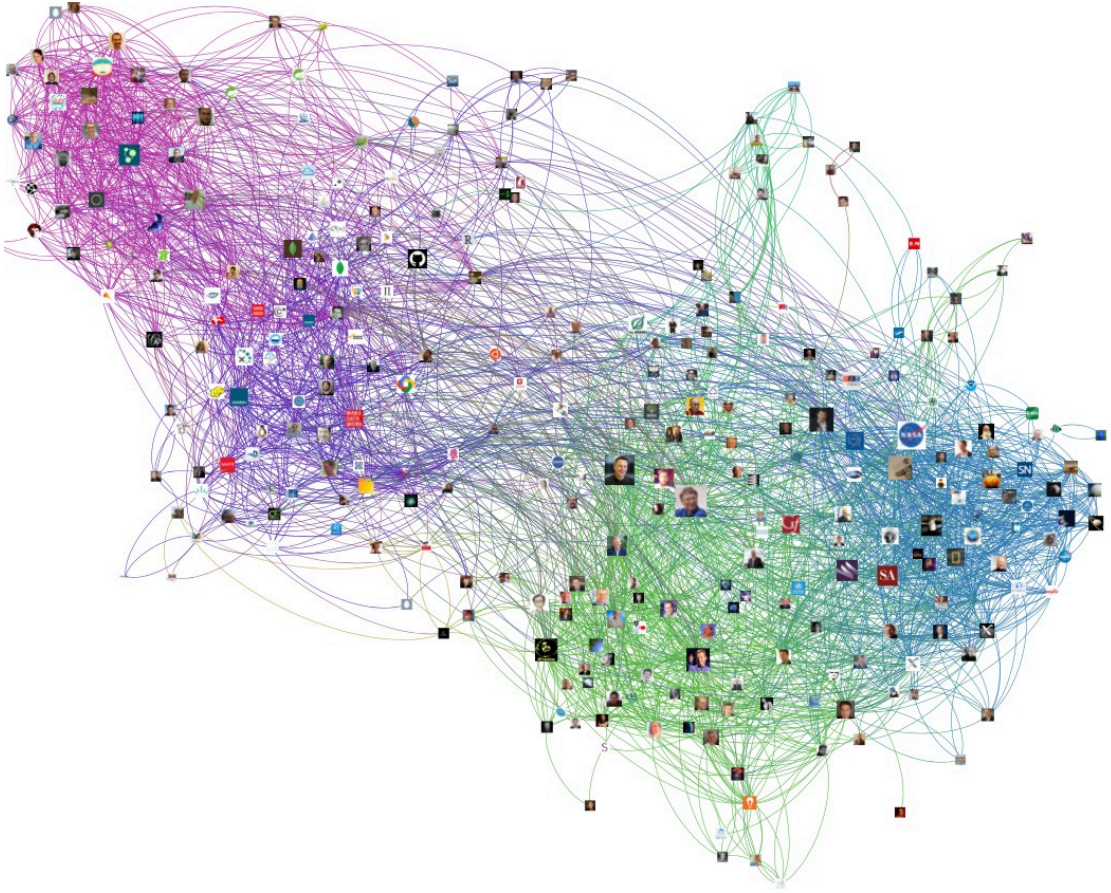


Graph Analytics Popular

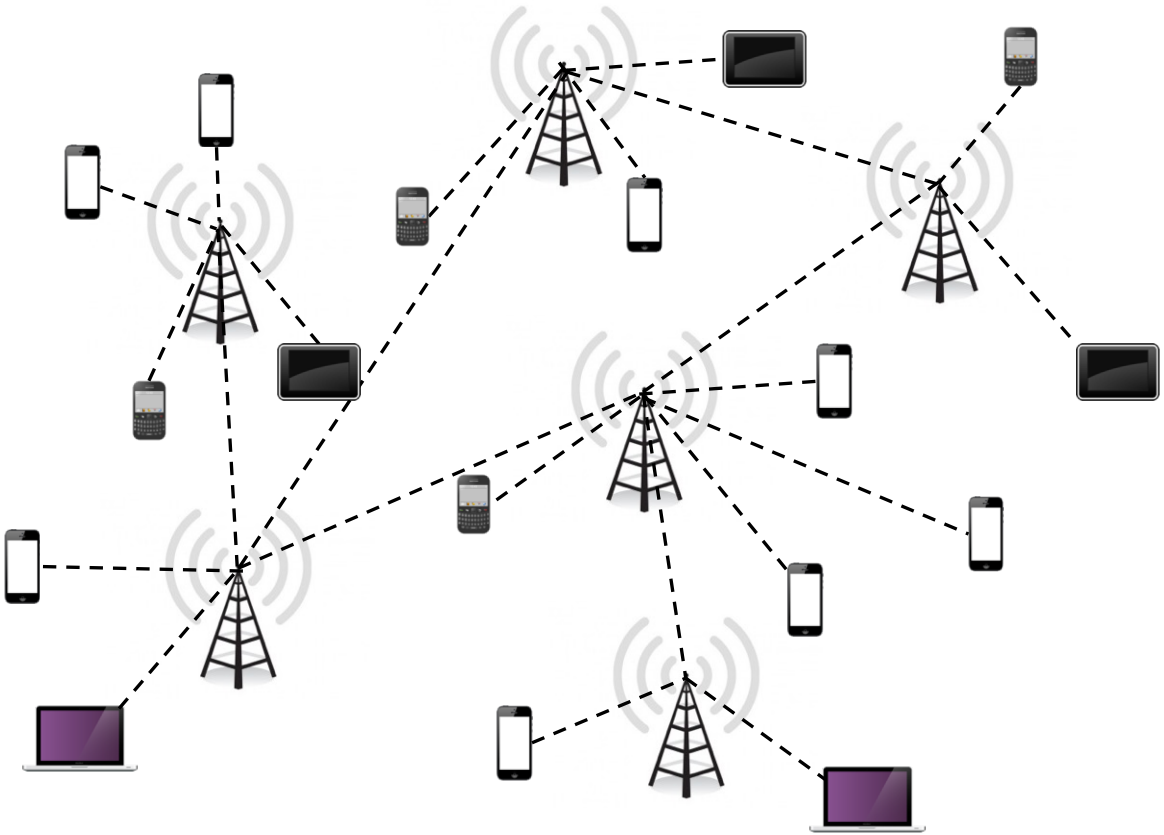
Assume graph is aggregated to a single DC

GTRAPH

Social Networks



Cellular Network Analytics



Financial Network Analytics

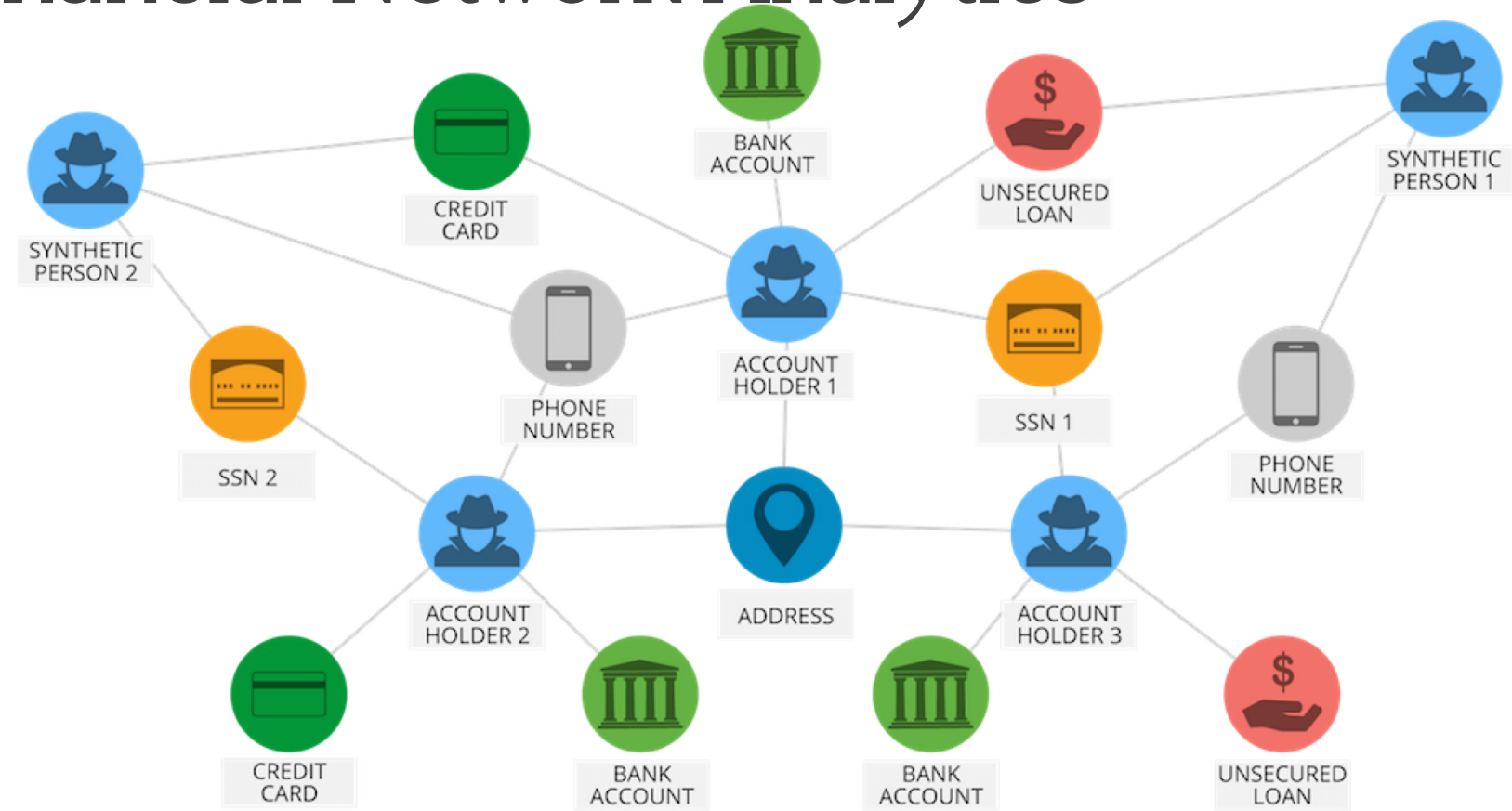
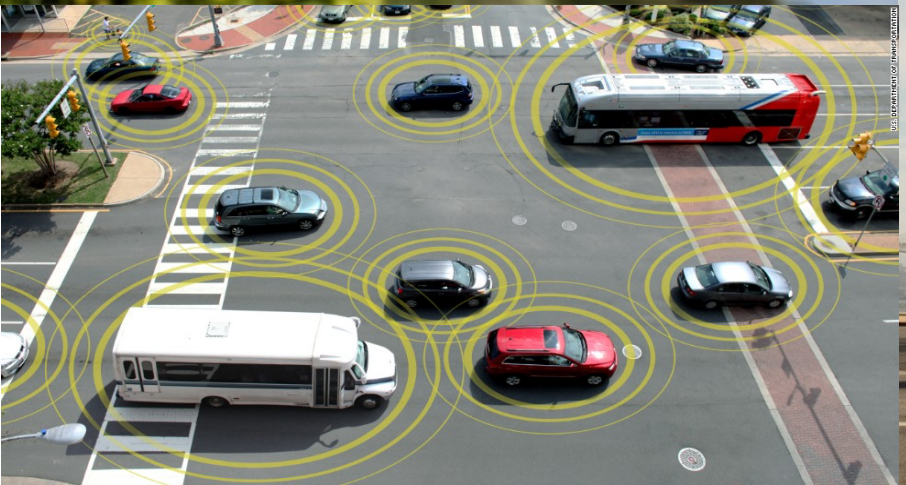
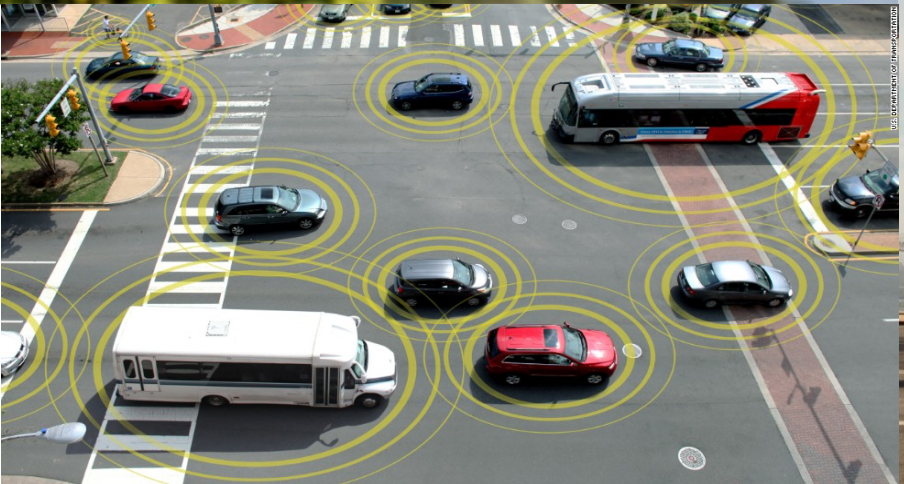


Image courtesy: Neo4J



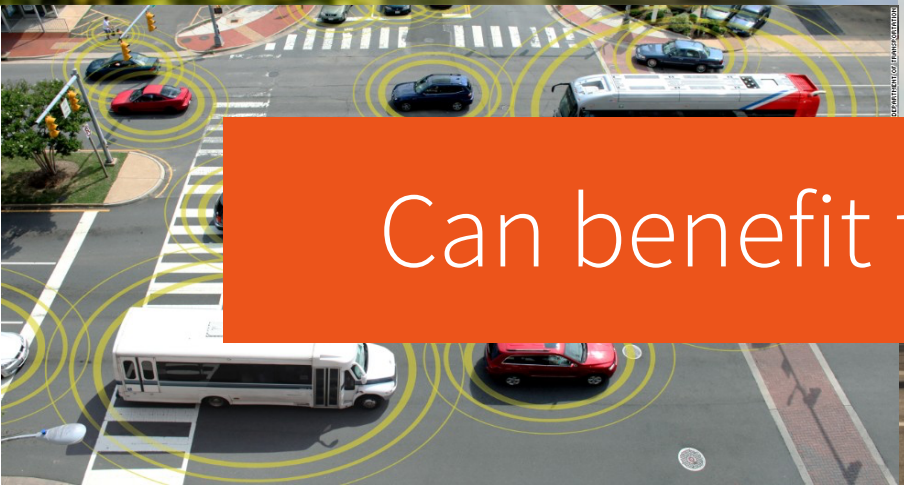
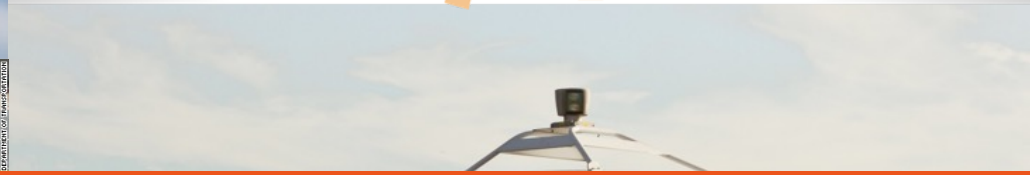

Google
self-driving car

Generate data in a *geo-distributed* fashion




Generate data in a *geo-distributed* fashion

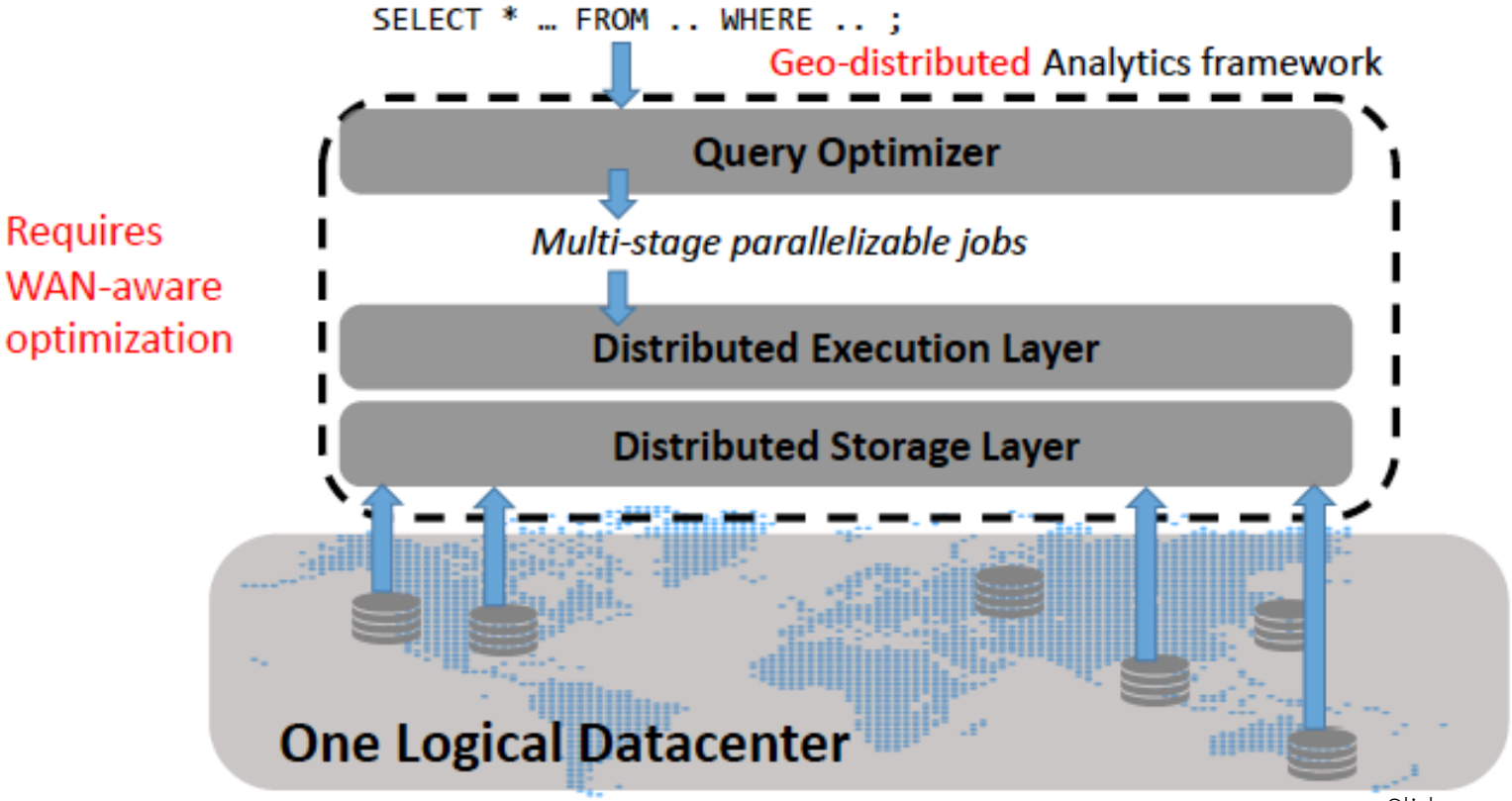


Can benefit from *timely* analysis

How do we perform efficient *geo-distributed* graph analytics?

Geo-Distributed Analytics (GDA)



Slide courtesy: Clarinet authors

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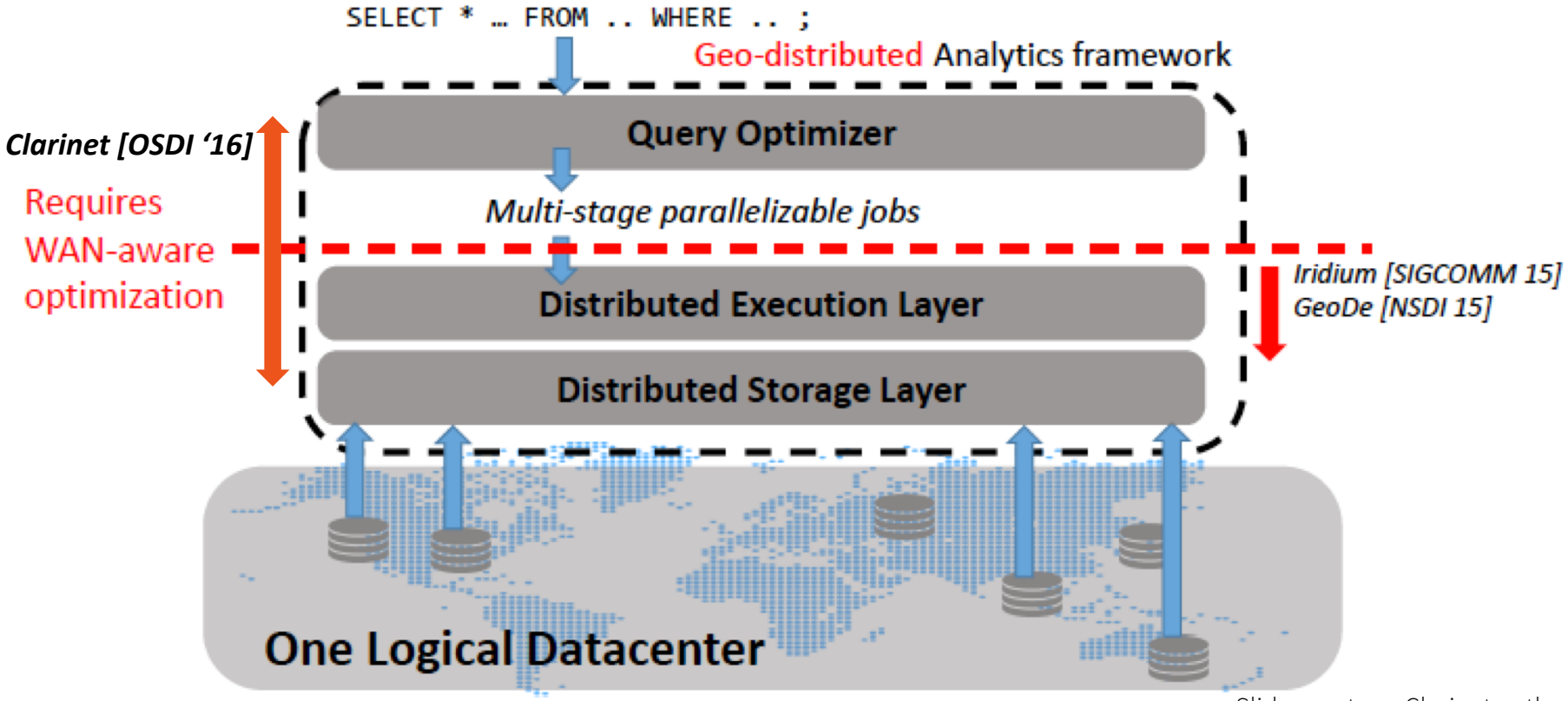

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Geo-Distributed Analytics on Graphs

Can we use the same idea on graphs?

- GDA focuses on simple task placement/queries
  - Graph analytics iterative in nature
- Flexibility over data placement and join sites
  - Graph partitioning difficult
- Estimating intermediate data
  - Difficult in graph algorithms

Geo-Distributed Analytics on Graphs

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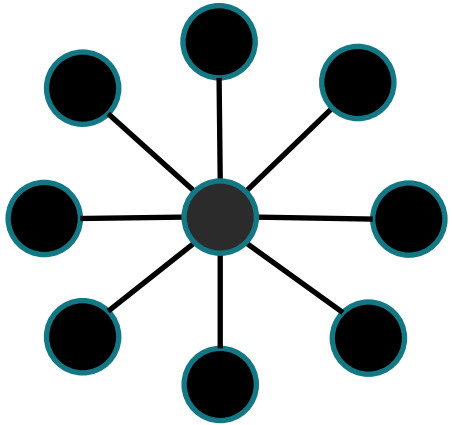
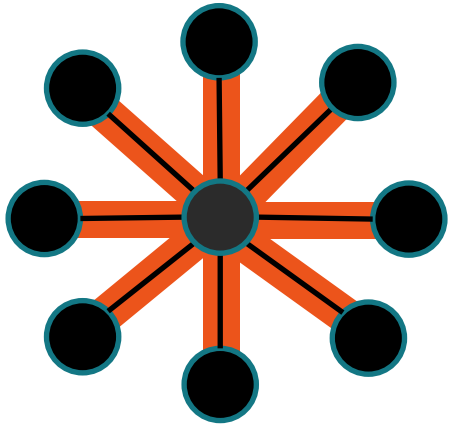
Key: Optimizing iterative graph-parallel processing

Graph Parallel Processing



Graph Parallel Processing

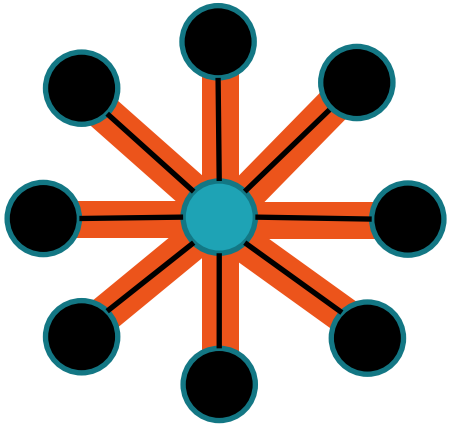
Gather: Accumulate information from neighborhood



Graph Parallel Processing

Gather: Accumulate information from neighborhood

Apply: Apply the accumulated value

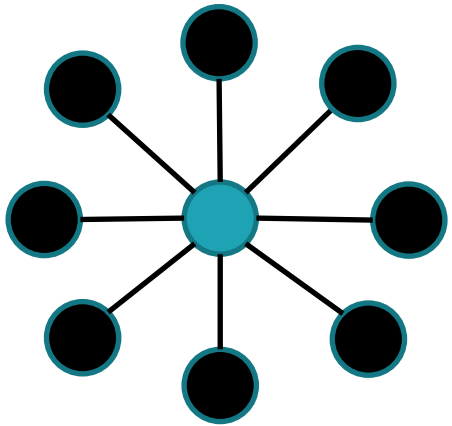


Graph Parallel Processing

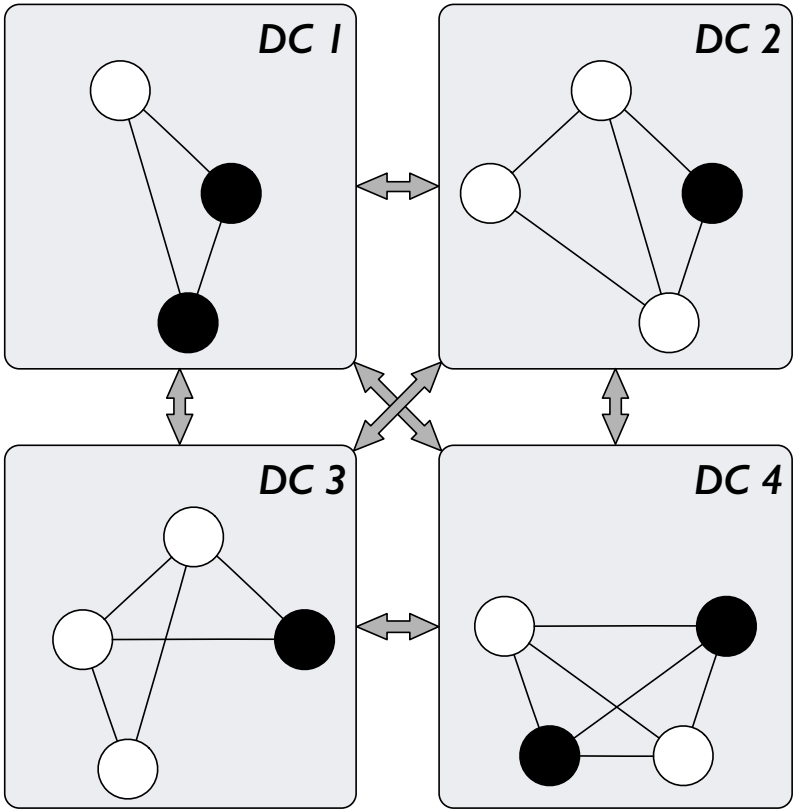
Gather: Accumulate information from neighborhood

Apply: Apply the accumulated value

Scatter: Update adjacent edges & vertices with new value



Our Proposal: Monarch



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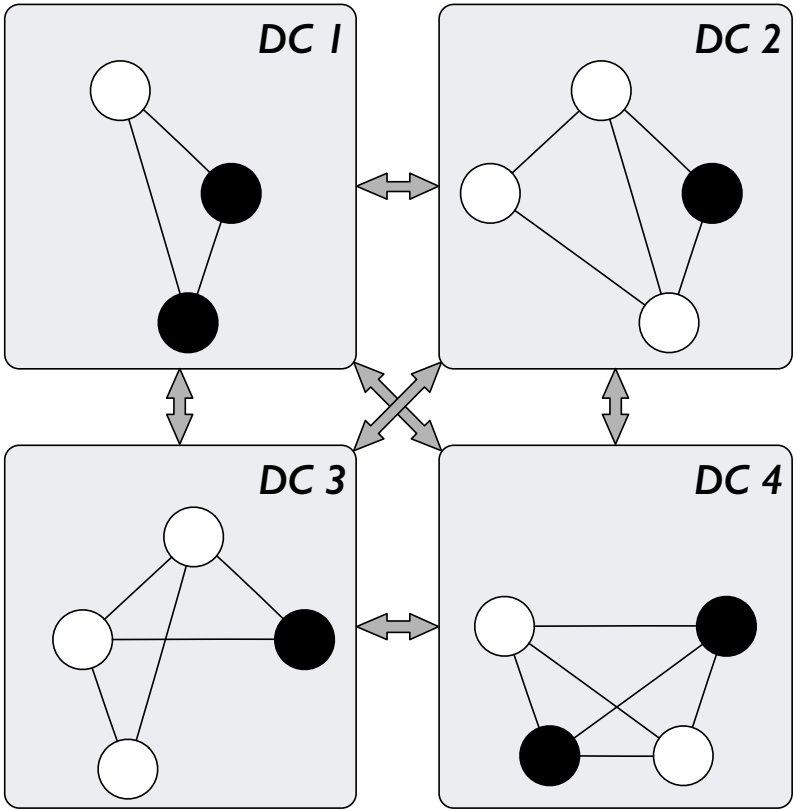
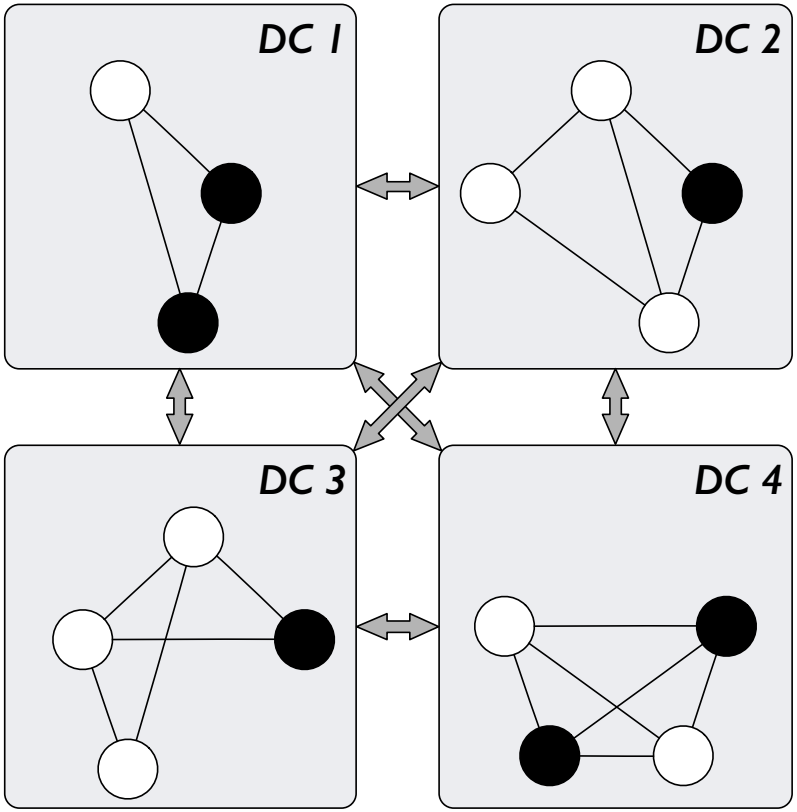


Sparsification

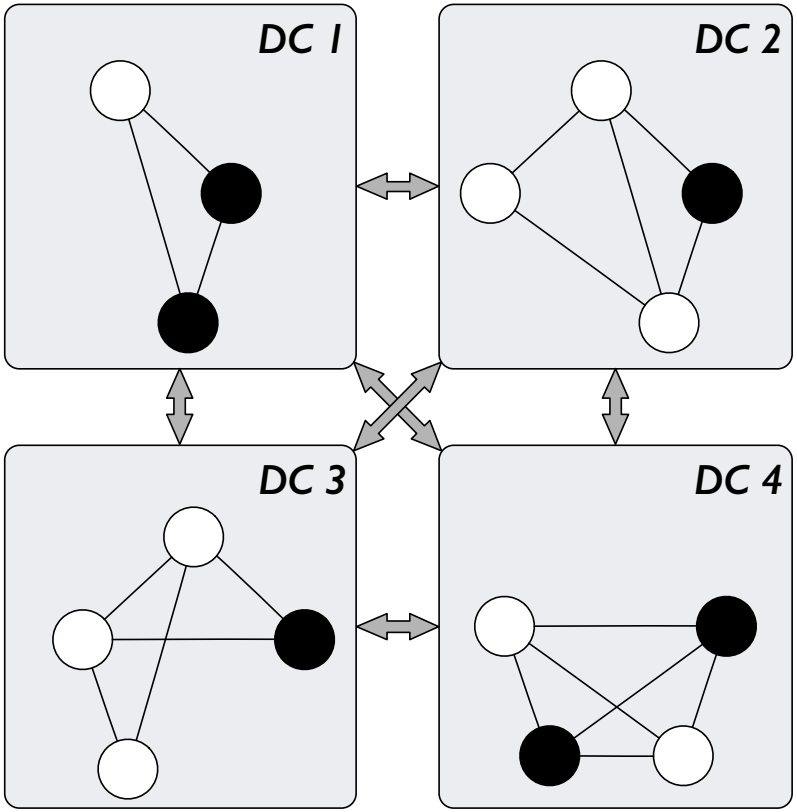
Our Proposal: Monarch



Sparsification

Execution Model

Our Proposal: Monarch



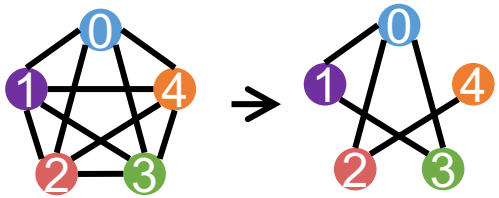
Sparsification

Execution Model

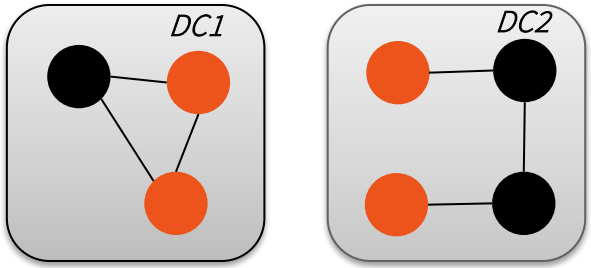
WAN Awareness

Graph Sparsification

- Sparsification extensively studied in graph theory
  - **Idea:** approximate the graph using a sparse, much smaller graph
  - Drop edges/vertices



- Sparsify without accuracy loss
  - Only worry about reducing cross-DC entities
  - Leverage graph-parallel model and algorithm properties



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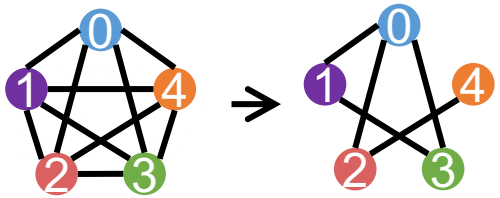

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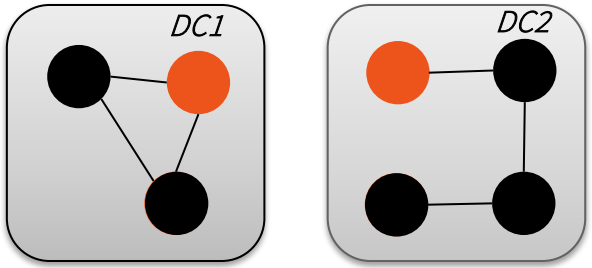
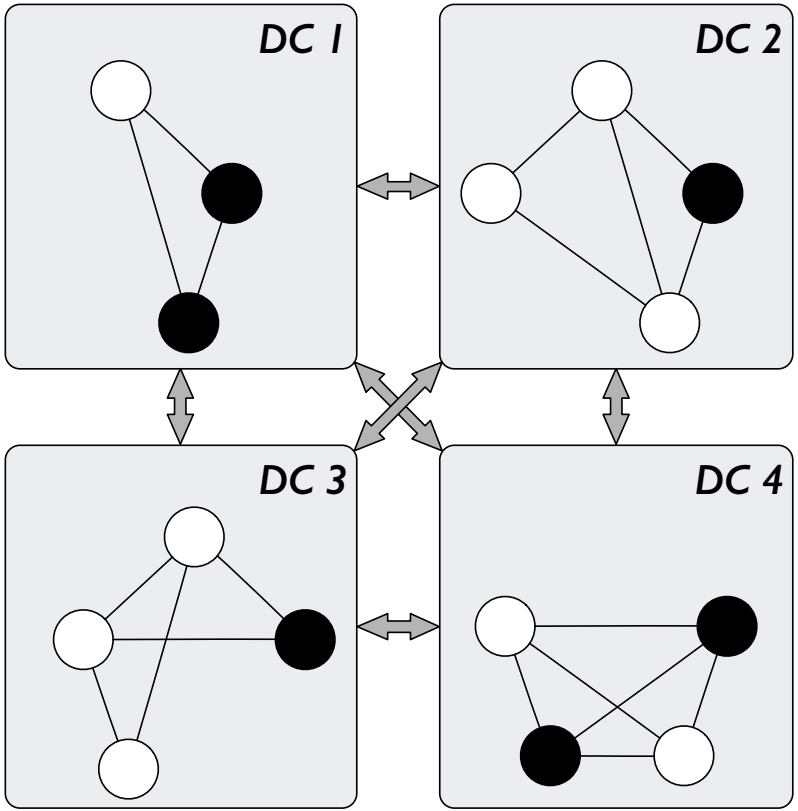


Geo-Distributed Graph Computation Model



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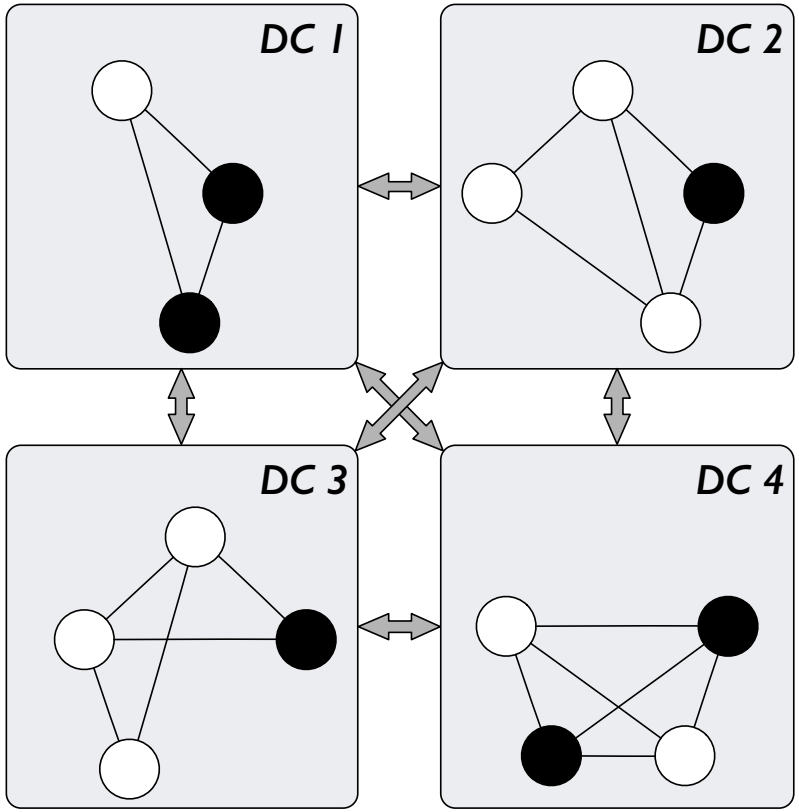
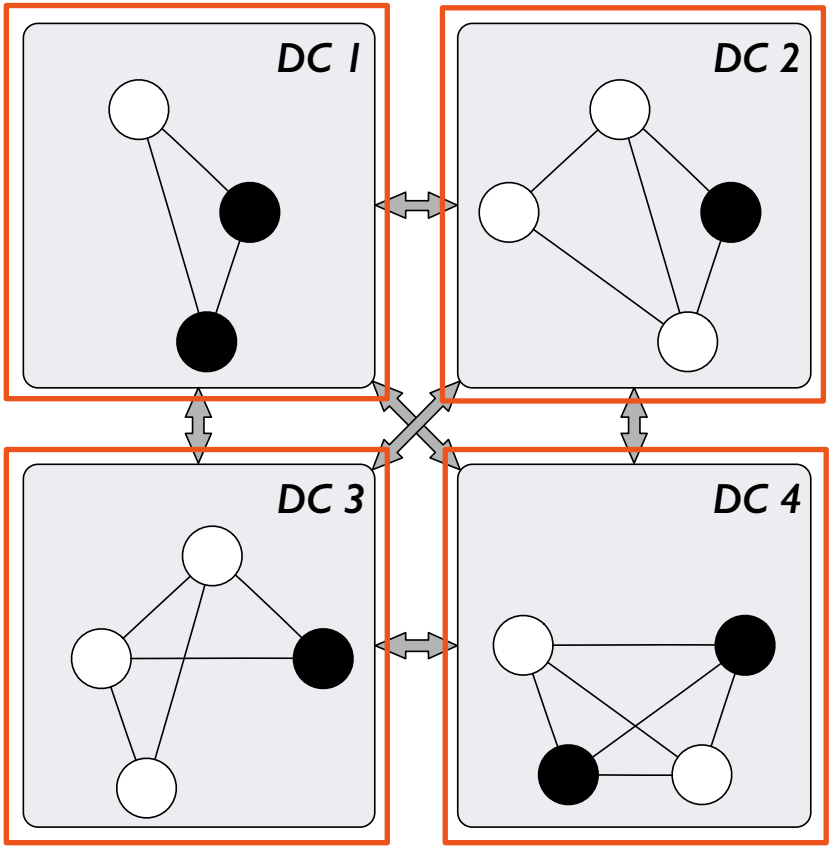


Bootstrap

Geo-Distributed Graph Computation Model



Bootstrap

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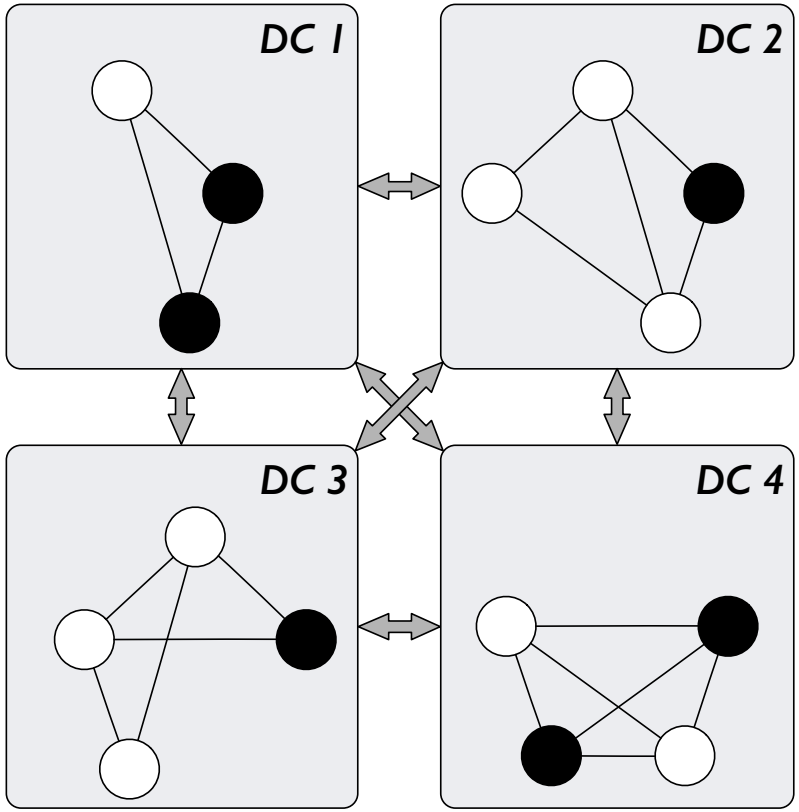
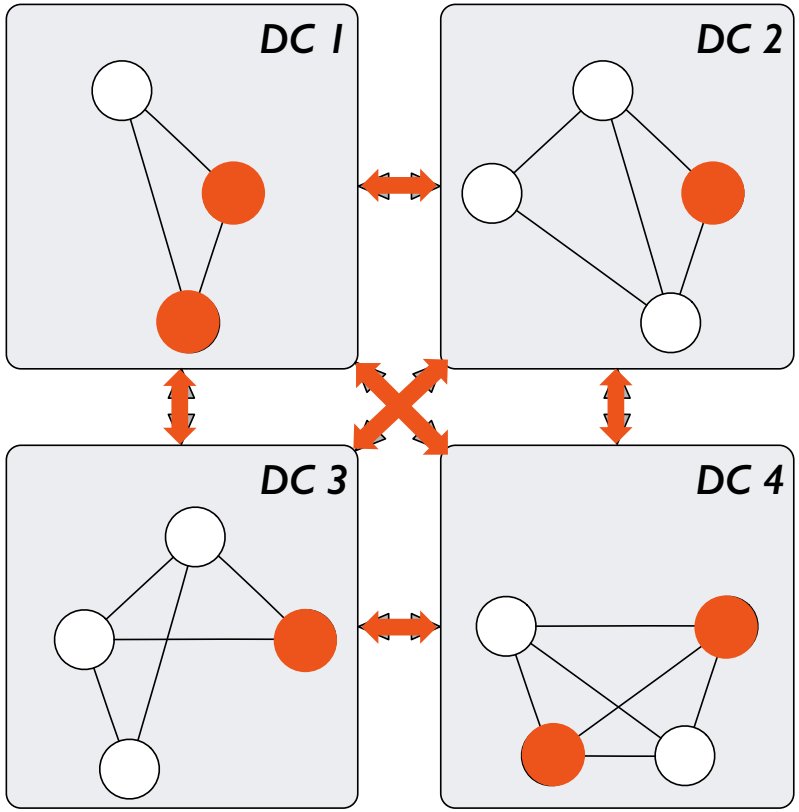


Bootstrap

Global Sync

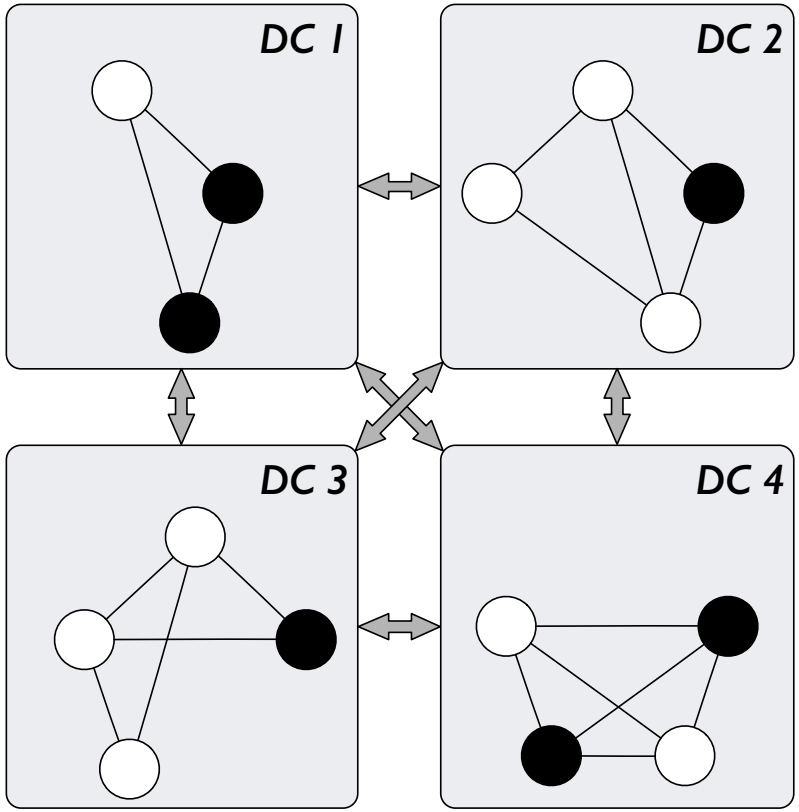
Geo-Distributed Graph Computation Model



Bootstrap

Global Sync

Geo-Distributed Graph Computation Model

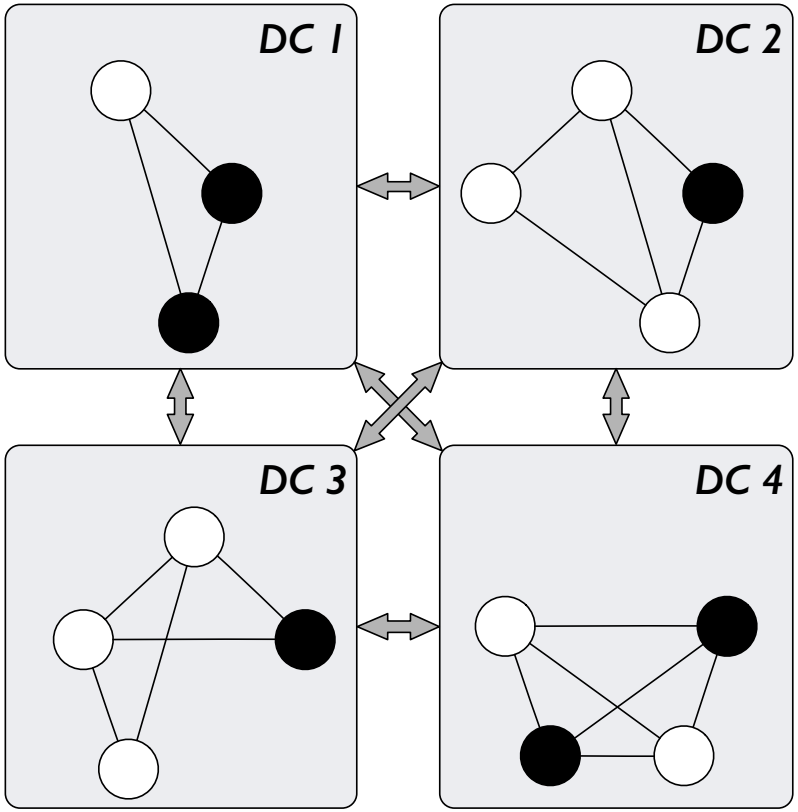


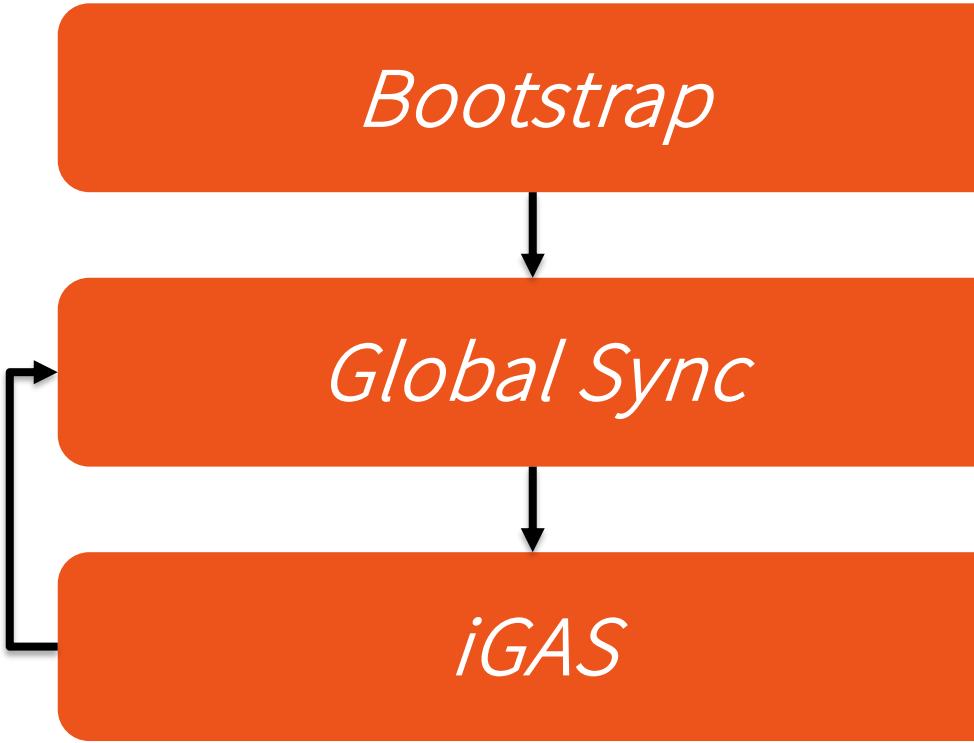
Bootstrap

Global Sync

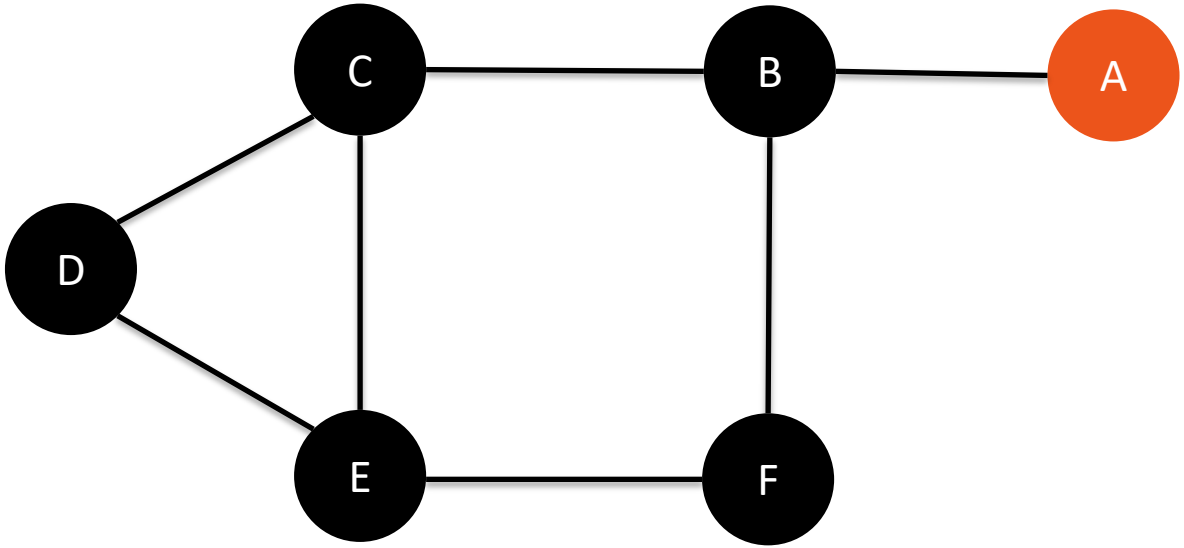
iGAS

Geo-Distributed Graph Computation Model





Incremental GAS Model



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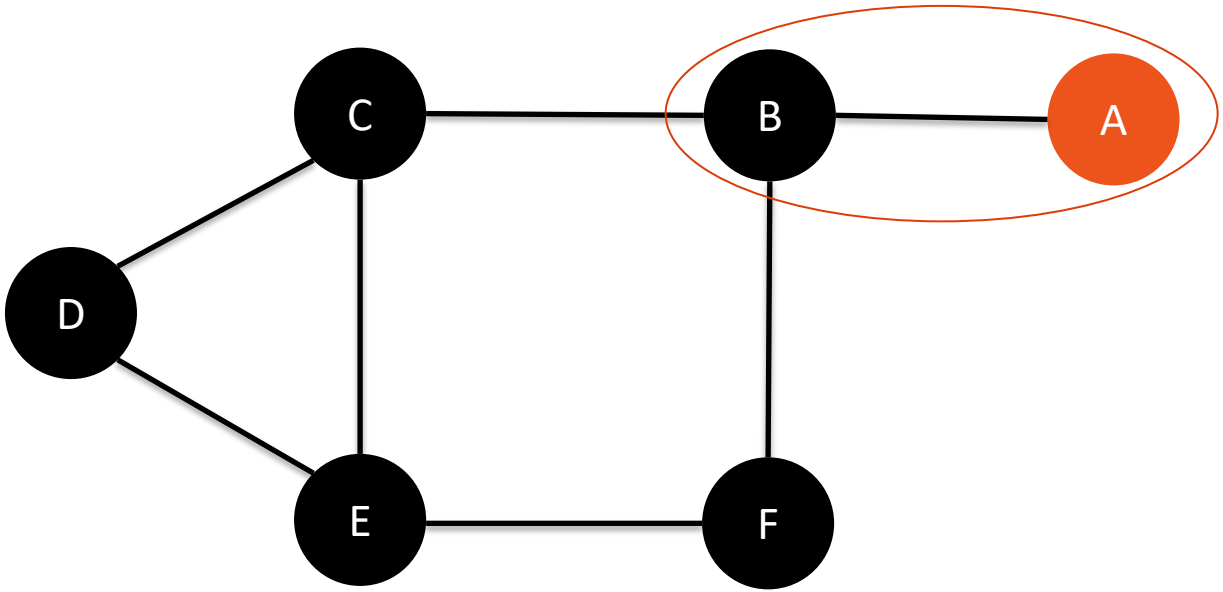

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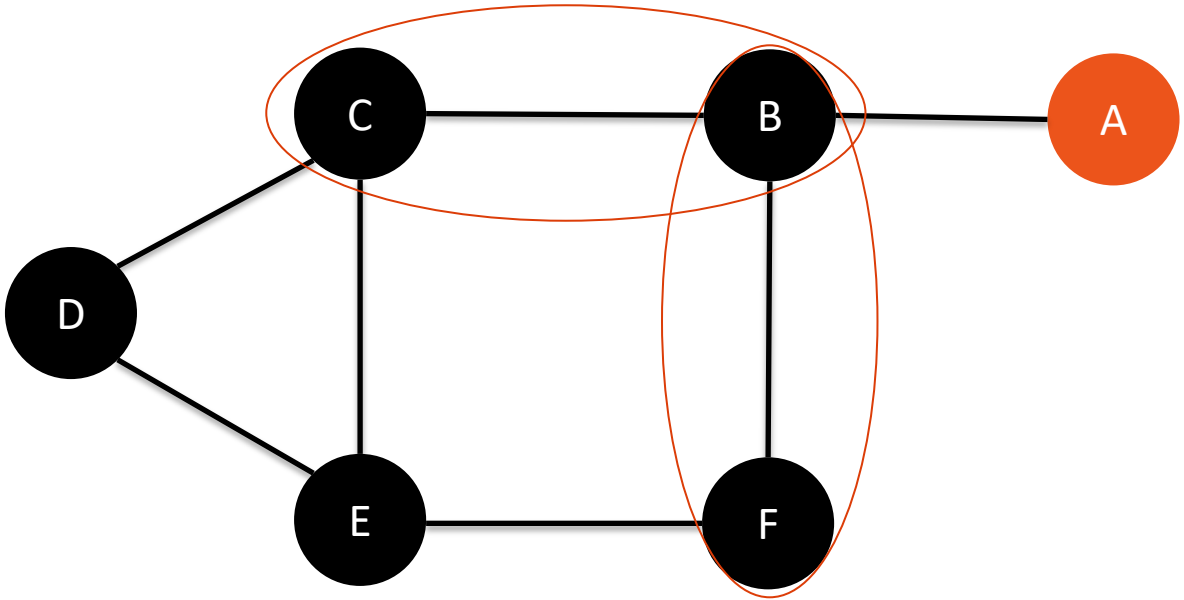

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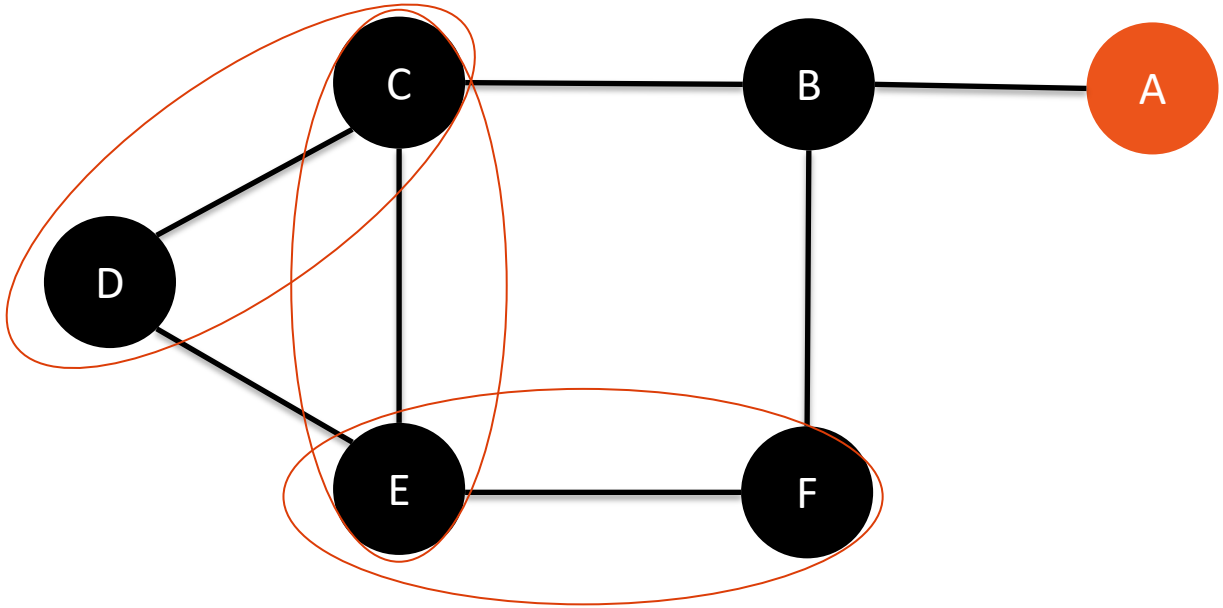

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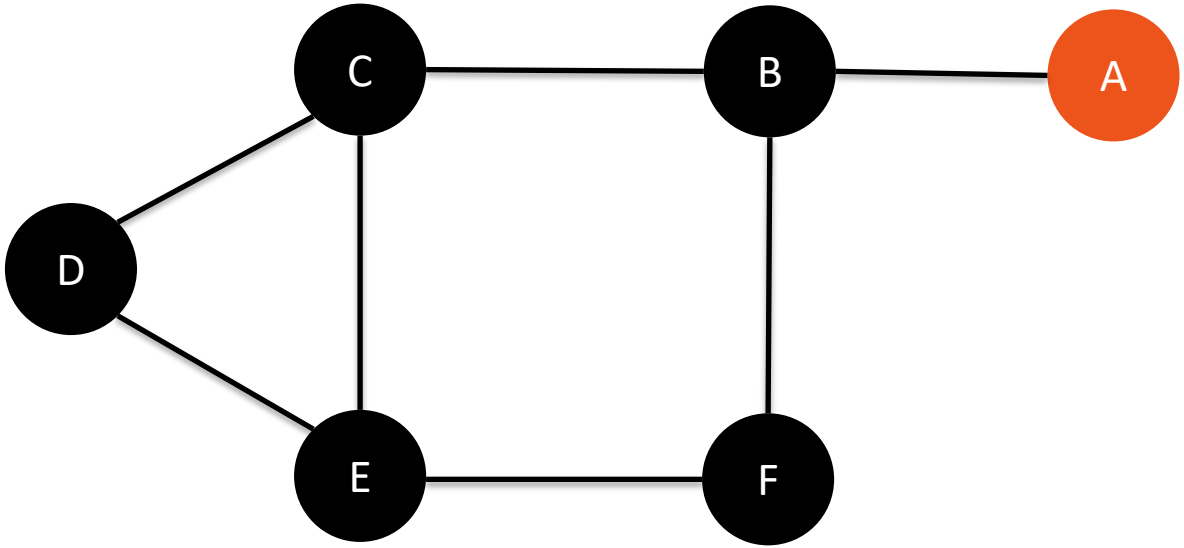

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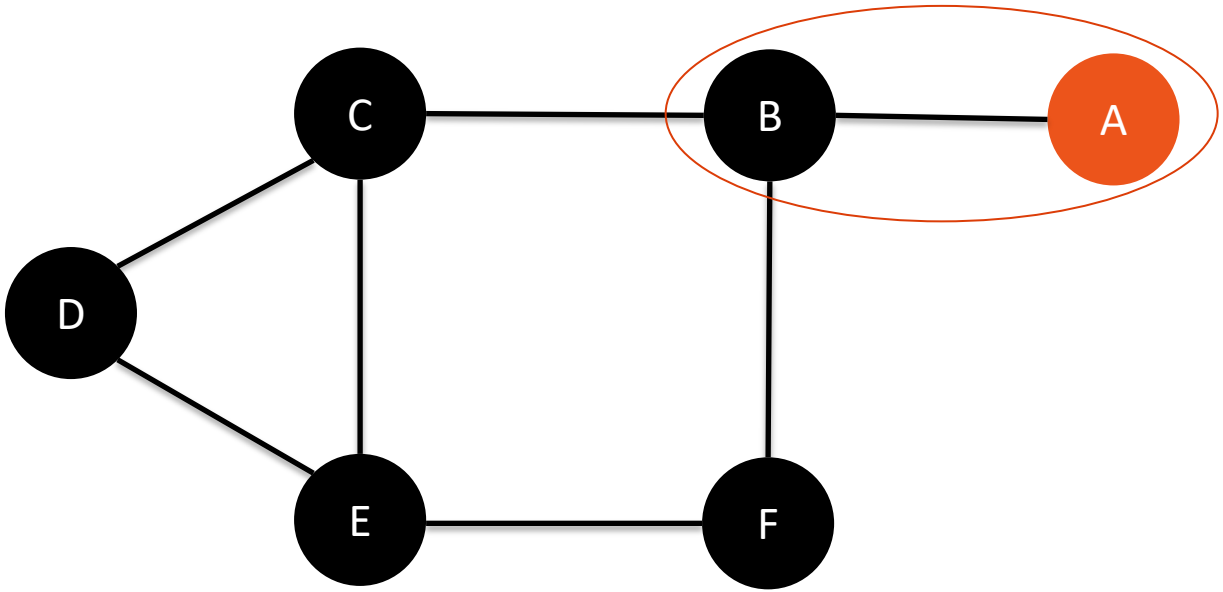

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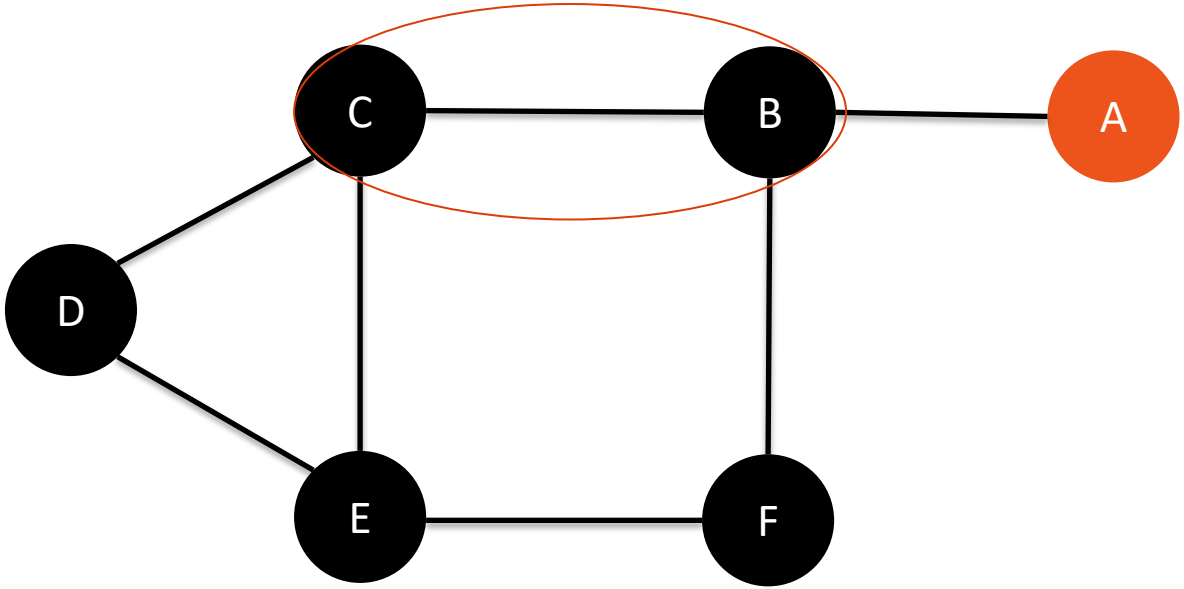

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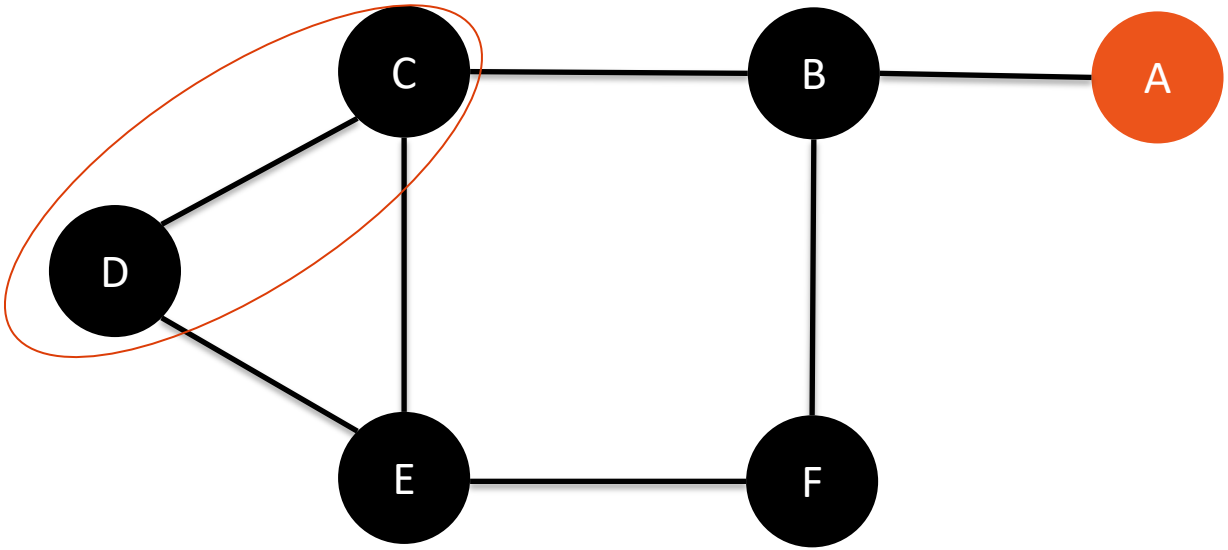

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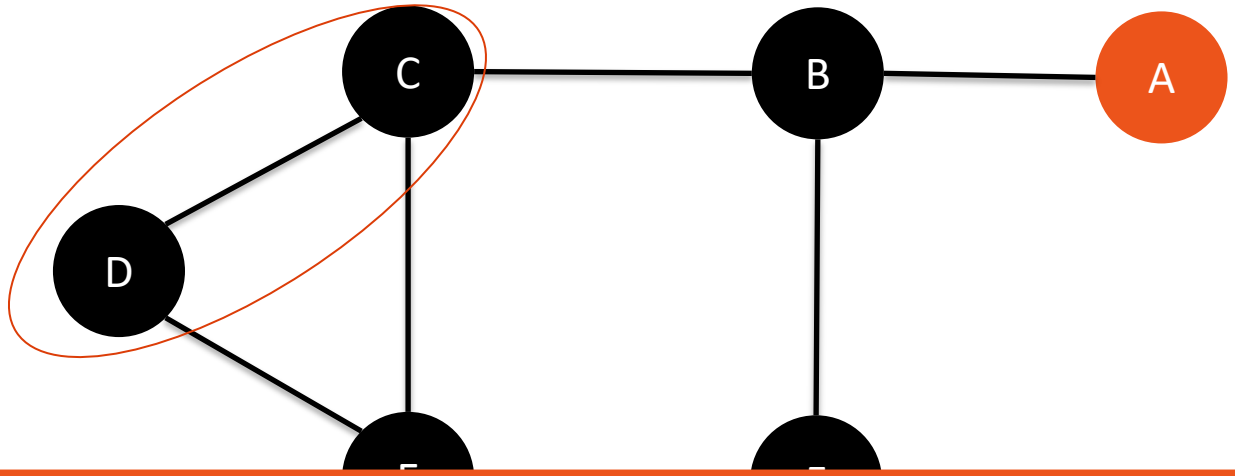
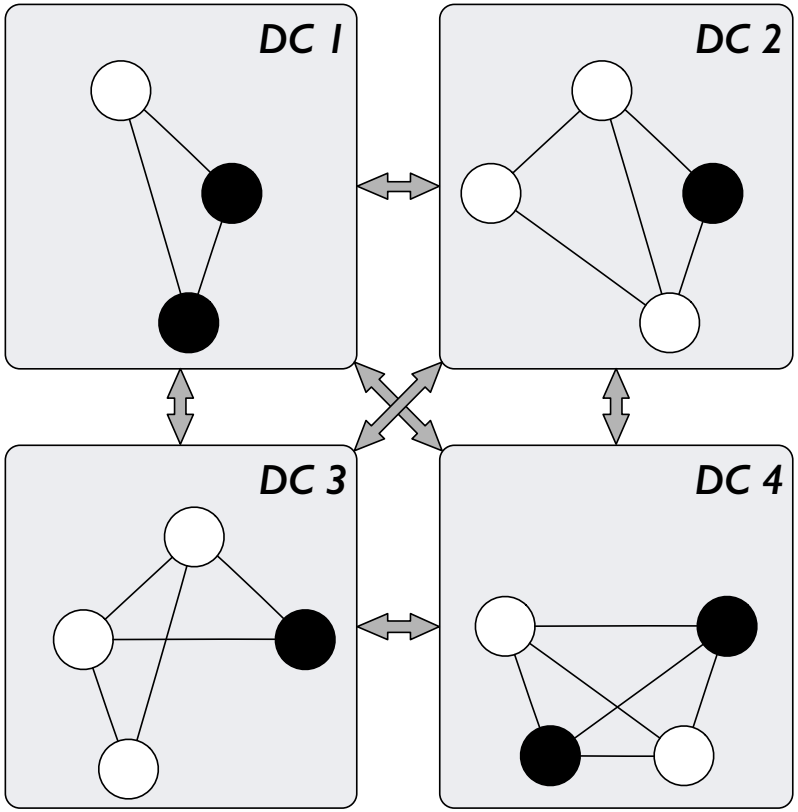
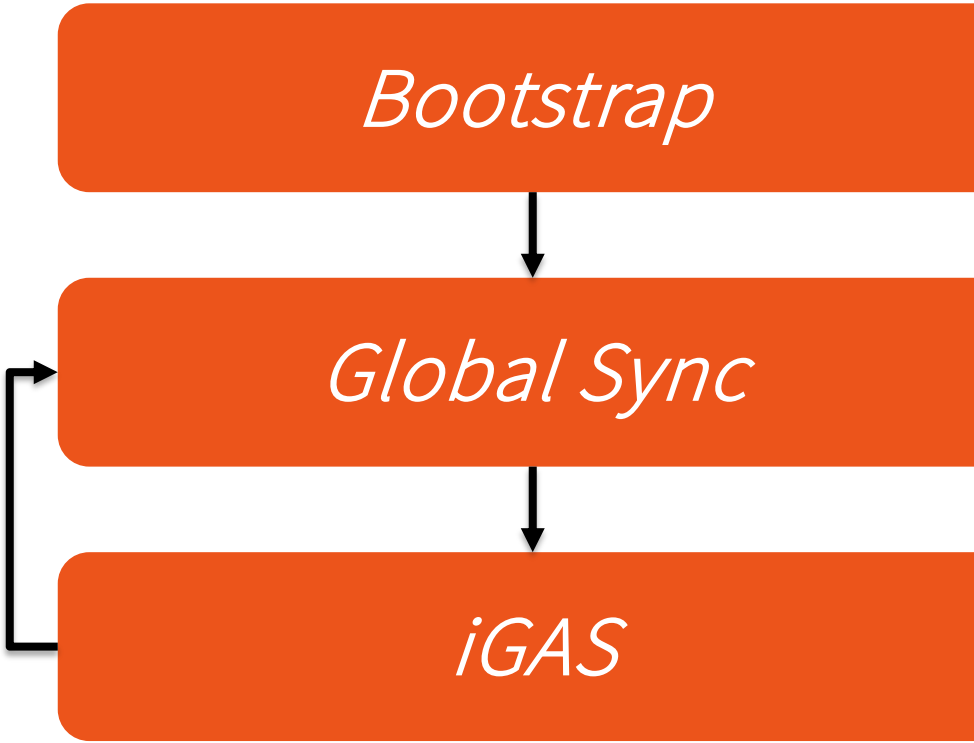


Which graph algorithms can use the iGAS model?
How much state needs to be kept at the entities for accuracy?

Geo-Distributed Graph Computation Model





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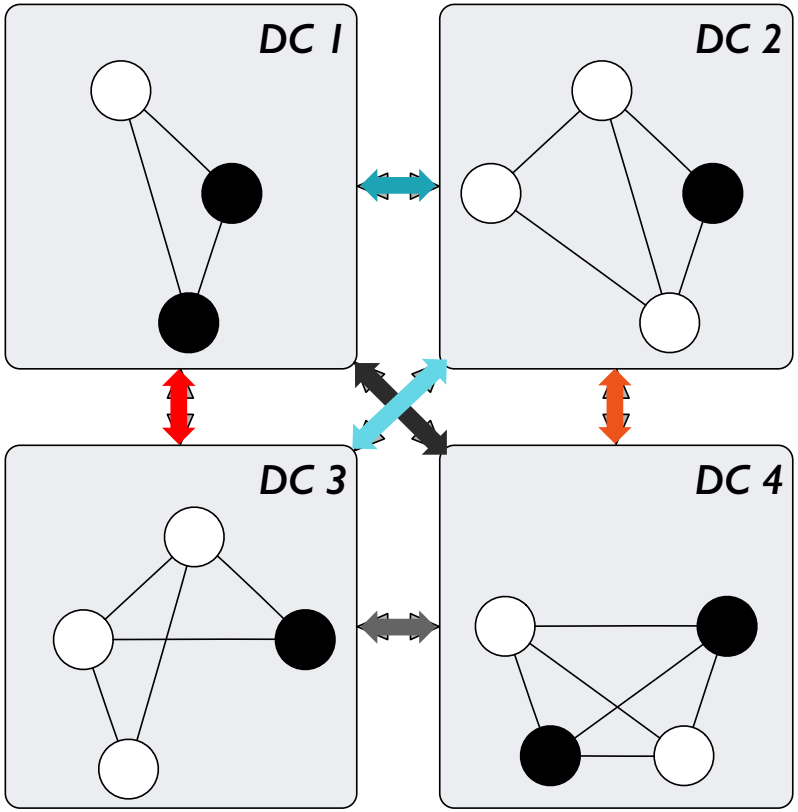

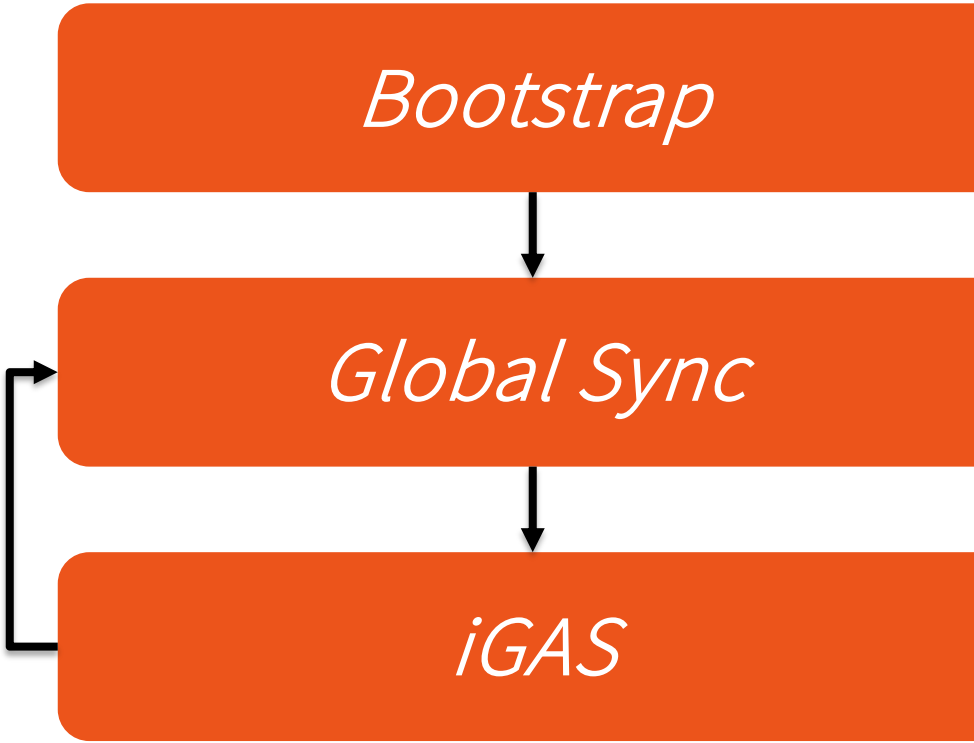

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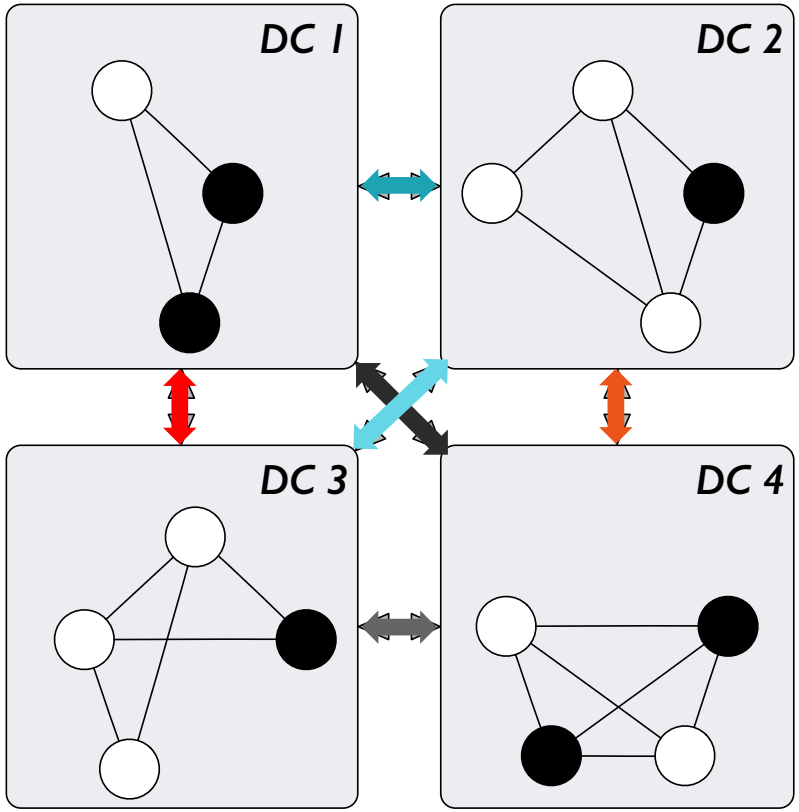

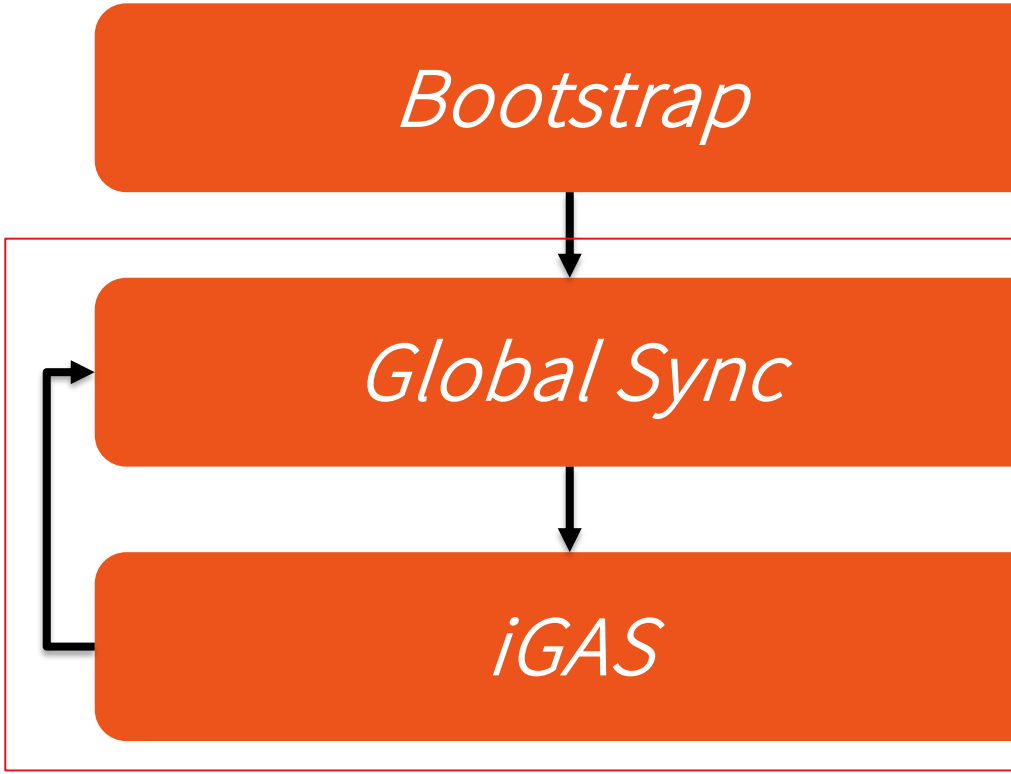

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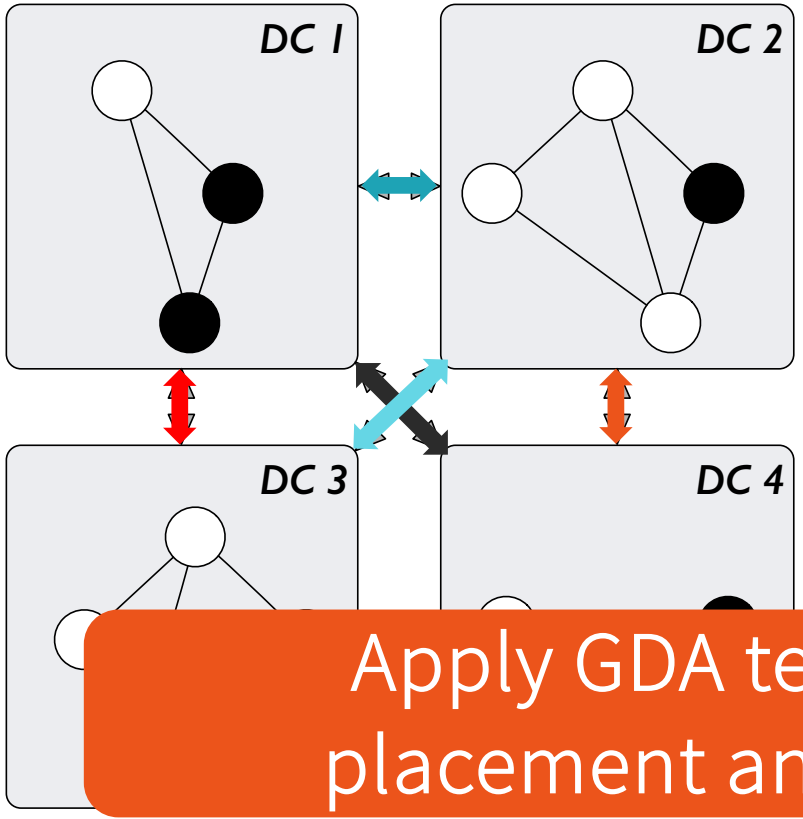


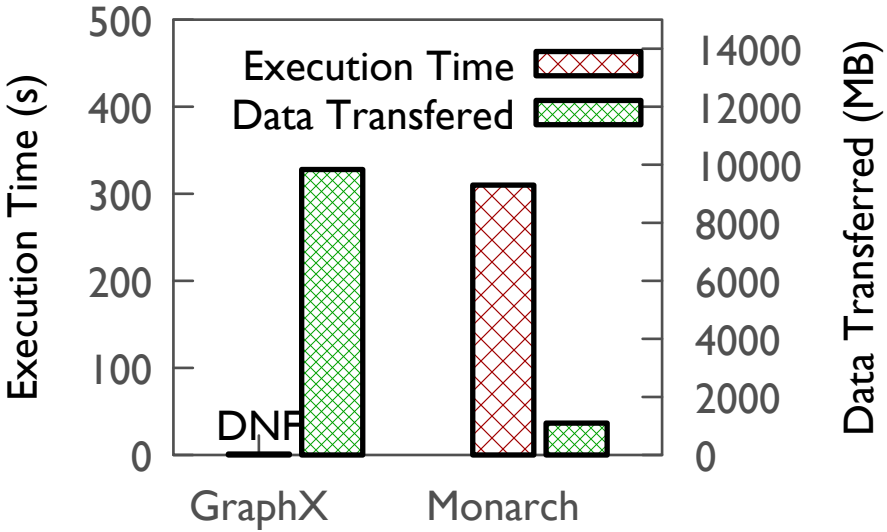
Bootstrap

Global Sync

Apply GDA techniques on task placement and data movement

Evaluation of Potential

- 16 node Apache Spark cluster across 4 regions
- Modified GraphX to incorporate the proposed model



Other Open Questions

- Convergence properties due to our modified execution model
- Better execution models at bootstrap stage
  - How would the global sync work?
- Multi-tenancy
  - Would it provide opportunities to leverage existing GDA techniques?
- Graph updates
  - What is an incremental model in this case?

Conclusion

- Several emerging applications produce graph data in a geo-distributed fashion
  - Can benefit from geo-distributed graph analytics.
- Our proposal Monarch:
  - Early attempt at bringing geo-distributed analytics to graph processing.
  - Initial results are encouraging.

http://www.cs.berkeley.edu/~api
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