Distributed Graph Computing Systems: Design, Implementation and Applications

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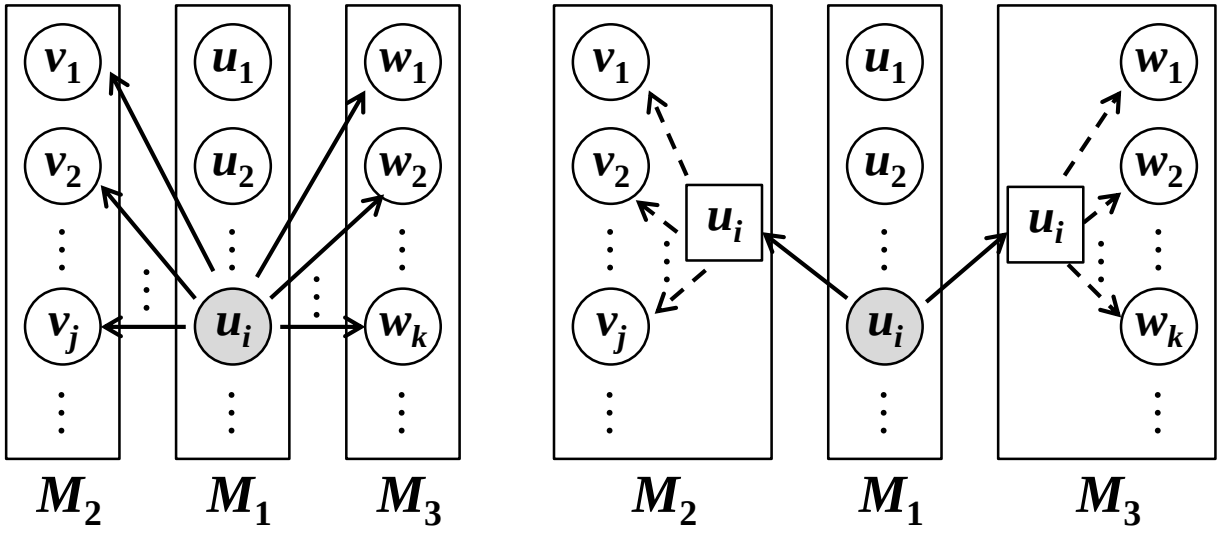
Pregel+

A Distributed Graph Computing Framework with Effective Message Reduction

http://www.cse.cuhk.edu.hk/pregelplus/

- Performance Highligts
  - HashMin on BTC, 15 machines

Pregel+	Pregel+ with Mirroring	Giraph	GraphLab (Sync)	GraphLab (Async)	GPS	GPS LALP
27 s	**10 s**	93 s	83 s	155 s	38 s	33 s



(a) Pregel's Message Passing

(b) Pregel+ with Mirroring

Pregel+

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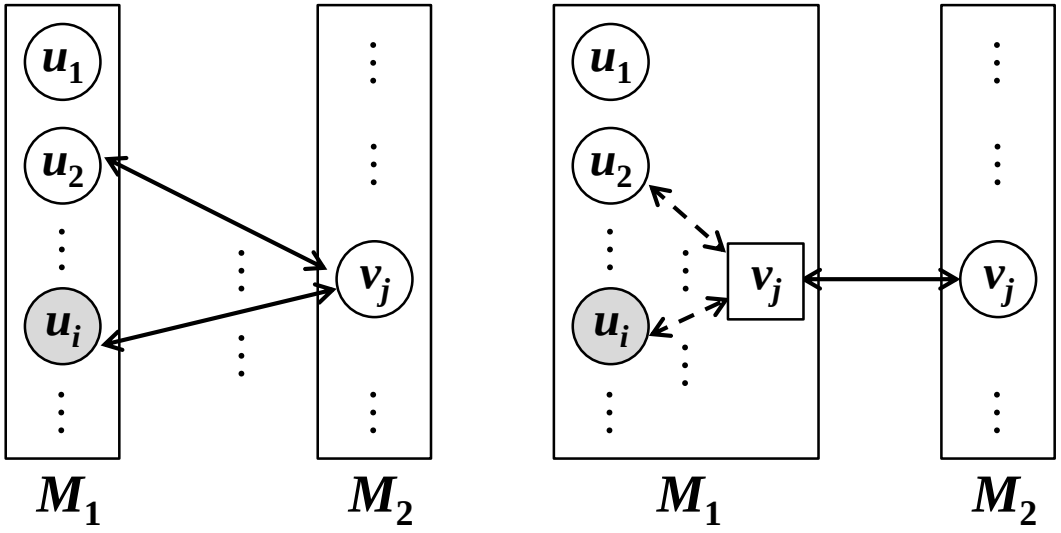
- Performance Highligts
  - SV on USA Road, 15 machines

Pregel+	Pregel+ with Request-Respond Paradigm	Giraph	GraphLab	GPS
262 s	**138 s**	690 s	inapplicable	190 s



(a) Without Req-Resp API (b) With Req-Resp API

Blogel

A Block-Centric Framework for Distributed Computation on Real-World Graphs

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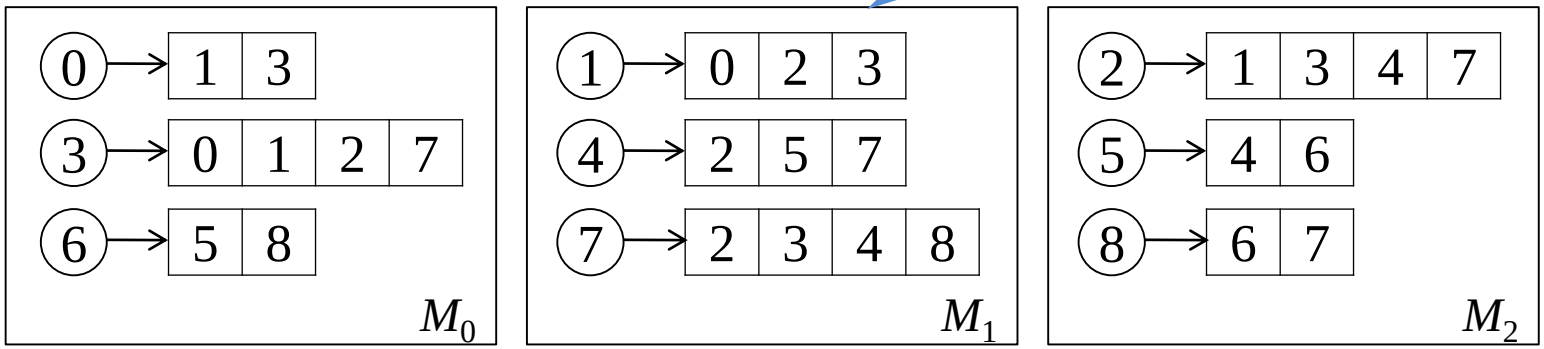
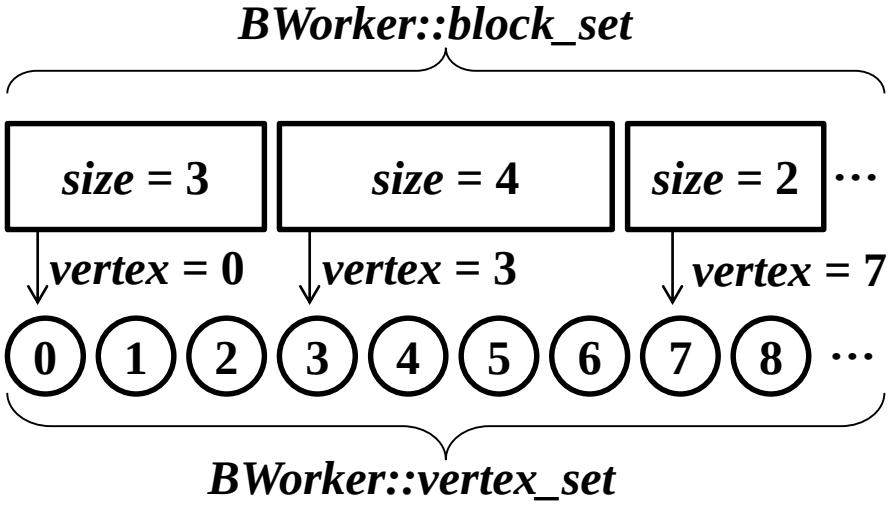
$hash(v) = id(v) \bmod \#\{machines\}$

- Pregel Computing model



- Blogel Computing model



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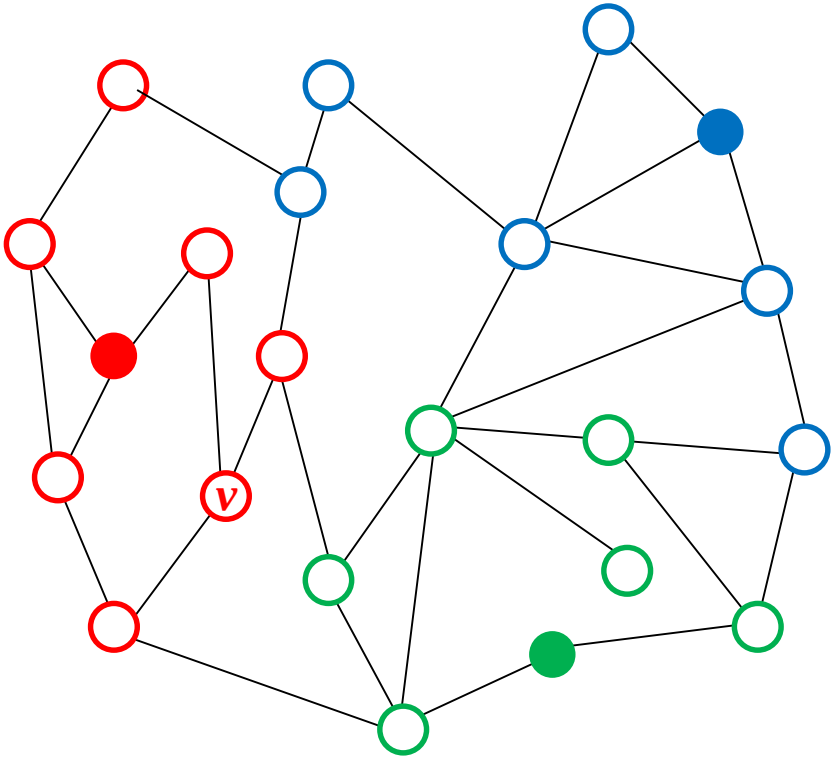
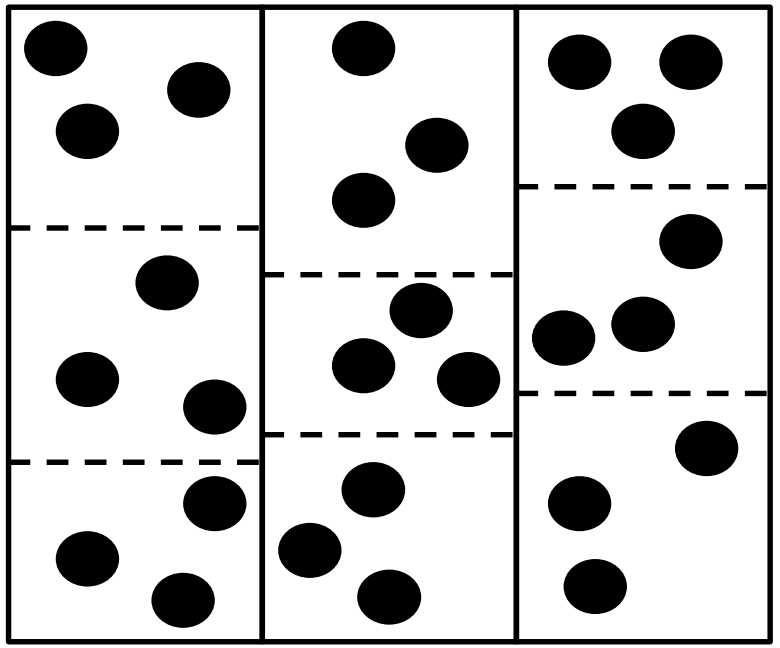
- Graph Voronoi Diagram (GVD) & 2D Partitioning



GVD



2D

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- Performance Highligts
  - HashMin on Friendster, 15 machines

Superstep		1	2	3	4	5	6	7	8	...
Pregel+	Time	26.86 s	27.64 s	27.86 s	26.97 s	8.96 s	0.43 s	0.15 s	0.11 s	
	Msg #	1,725,523,081	1,719,438,065	1,717,496,808	1,636,980,454	416,289,356	8,780,258	1,484,531	587,275	
Blogel	Time	0.53 s	1.53 s	0.25 s	0.10 s	0.06 s				
	Msg #	6,893,957	6,892,723	5,620,051	4,134	0				

  - Single-Source Shortest Path, 15 machines

		Time	Step #
Euro Road	Pregel+	1767.69 s	6210
	B-GVD	36.11 s	248
	B-2D	11.10 s	60
USA Road	Pregel+	9788.08 s	10789
	B-GVD	84.44 s	458
	B-2D	12.48 s	58

Nearly 2 orders of magnitude improvements

Analysis of Graph Computing Frameworks

		Giraph	GPS	Pregel+	PowerGraph	GraphChi
Always-active	PageRank	√	√	√	√	√
	Diameter Estimation	√	√	√	√	√
Graph traversal	Single-Source Shortest Paths	√	√	√	√	√
	HashMin	√	√	√	√	√
Multi phase	Shiloach-Vishkin's Algorithm	√	√	√	X	X
	Bipartite Maximal Matching	√	√	√	√	√
Graph mutation	Graph Coloring	√	√	√	√	X

systematic + algorithmic optimizations

- Large adjacency-list partitioning
- **Dynamic partitioning**
- Multi-threading
- Message combiner
- Mirroring
- Asynchronous execution
- Vertex-cut partitioning
- Out-of-core computation
- Selective scheduling

- Finishing Computations Serially
- Edge Cleaning On Demand
- Single Pivot

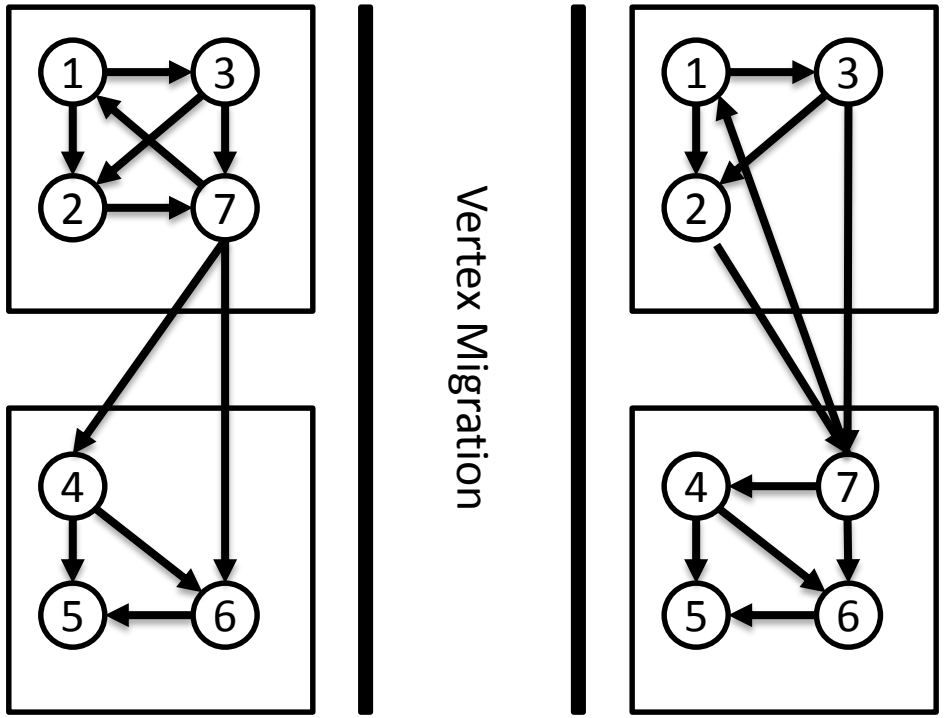

Illustration for dynamic partitioning

Pregel Algorithms for Massive Graphs

- Linear space usage
- Linear computation cost
- Linear communication cost
- At most logarithmic number of rounds

- Graph connectivity problems
  - Connected components
  - Bi-connected components
  - Strongly connected components

List of publications

- 2015
  - **Yi Lu**, James Cheng, Da Yan, Huanhuan Wu
    Large-Scale Distributed Graph Computing Frameworks: An Experimental Evaluation
    In *Proc. of the VLDB Endowment (**PVLDB**), Volumn 8(3), Kohala Coast, Hawaii, 2015.*

  - Da Yan, James Cheng, **Yi Lu**, Wilfred Ng
    Effective Techniques for Message Reduction and Load Balancing in Distributed Graph Computation
    In *Proc. of International World Wide Web (**WWW**) Conference, Florence, Italy, 2015.*

- 2014
  - Da Yan, James Cheng, **Yi Lu**, Wilfred Ng
    Blogel: A Block-Centric Framework for Distributed Computation on Real-World Graphs
    In *Proc. of the VLDB Endowment (**PVLDB**), Volumn 7(14), Hangzhou, China, 2014.*

  - Da Yan, James Cheng, Kai Xing, **Yi Lu**, Wilfred Ng, Yingyi Bu
    Pregel Algorithms for Graph Connectivity Problems with Performance Guarantees
    In *Proc. of the VLDB Endowment (**PVLDB**), Volumn 7(14), Hangzhou, China, 2014.*

  - Huanhuan Wu, James Cheng, Silu Huang, Yiping Ke, Yi Lu, Yanyan Xu
    Path Problems in Temporal Graphs
    In *Proc. of the VLDB Endowment (**PVLDB**), Volumn 7(9), Hangzhou, China, 2014.*