

# Distributed Graph Computing Systems: Design, Implementation and Applications

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# Pregel+

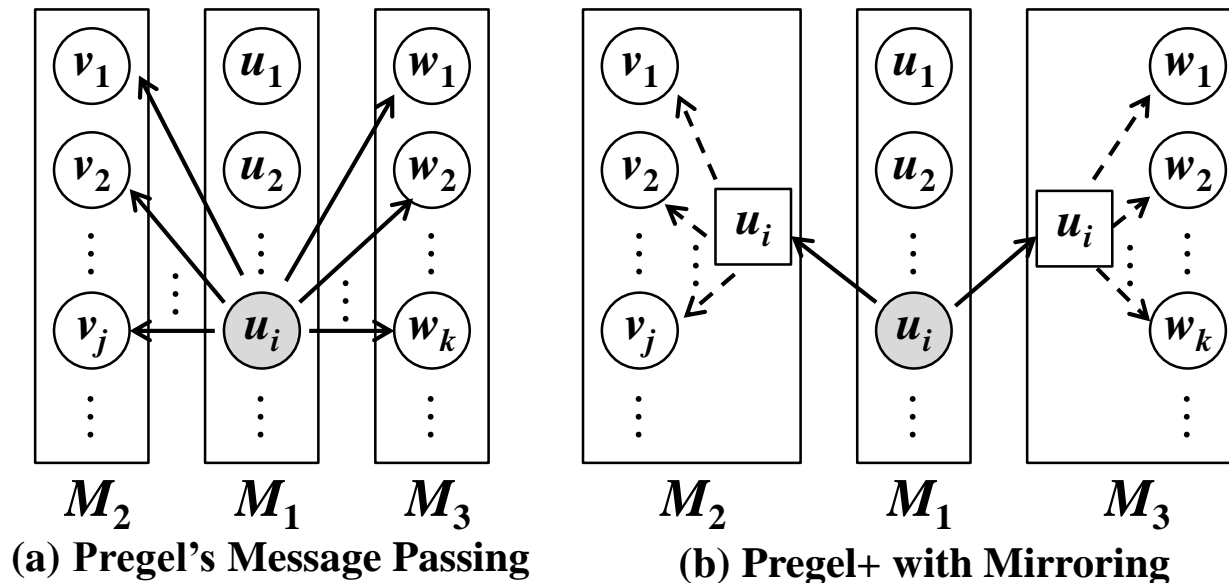
A Distributed Graph Computing Framework  
with Effective Message Reduction

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

- Performance Highlights

- HashMin on BTC, 15 machines

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



# Pregel+

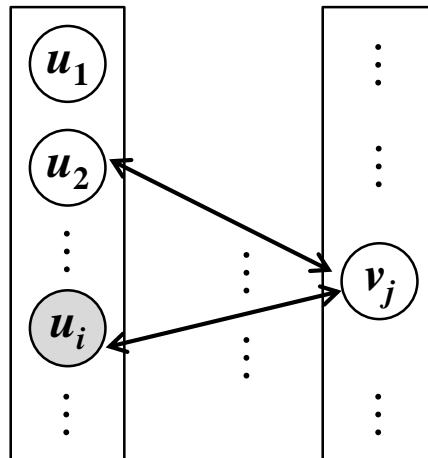
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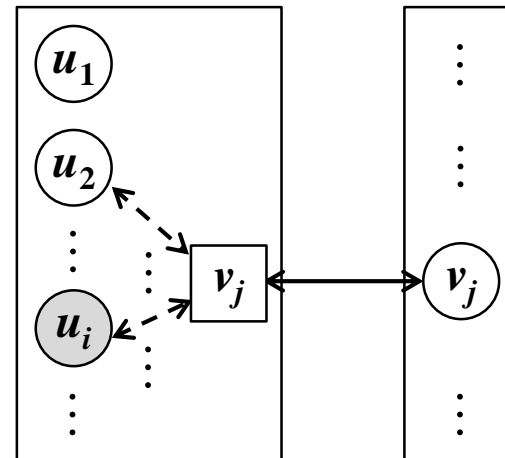
- Performance Highlights

- SV on USA Road, 15 machines

Pregel+	Pregel+ with Request-Response Paradigm	Giraph	GraphLab	GPS
262 s	<b>138 s</b>	690 s	inapplicable	190 s



$M_1$   $M_2$   
(a) Without Req-Resp API



$M_1$   $M_2$   
(b) With Req-Resp API

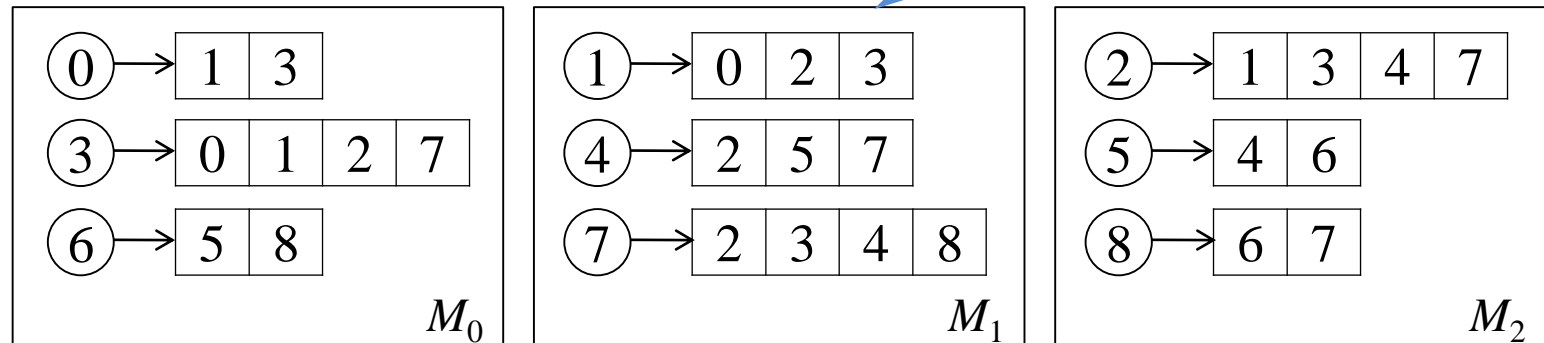
# Blogel

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

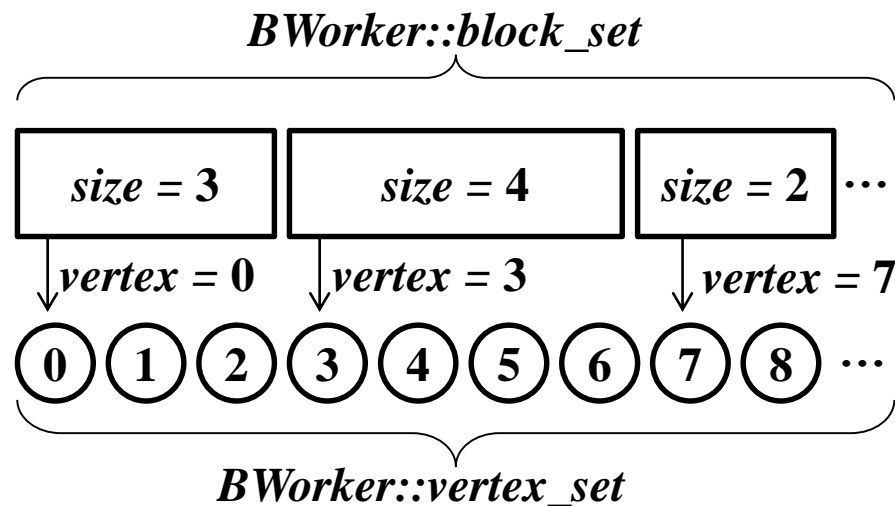
<http://www.cse.cuhk.edu.hk/blogel/>

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

- Pregel Computing model



- Blogel Computing model

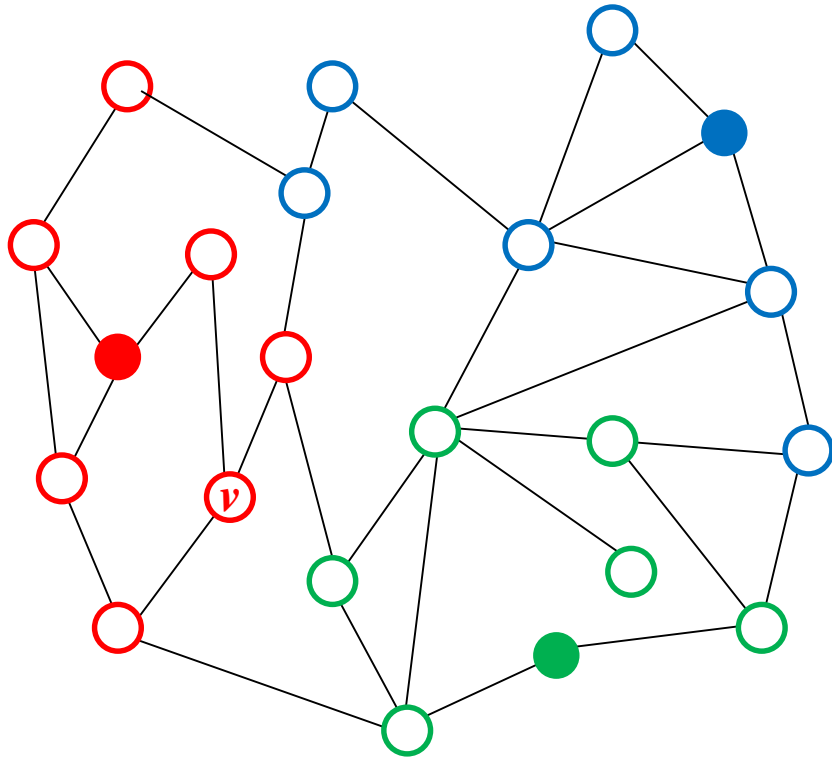


# Blogel

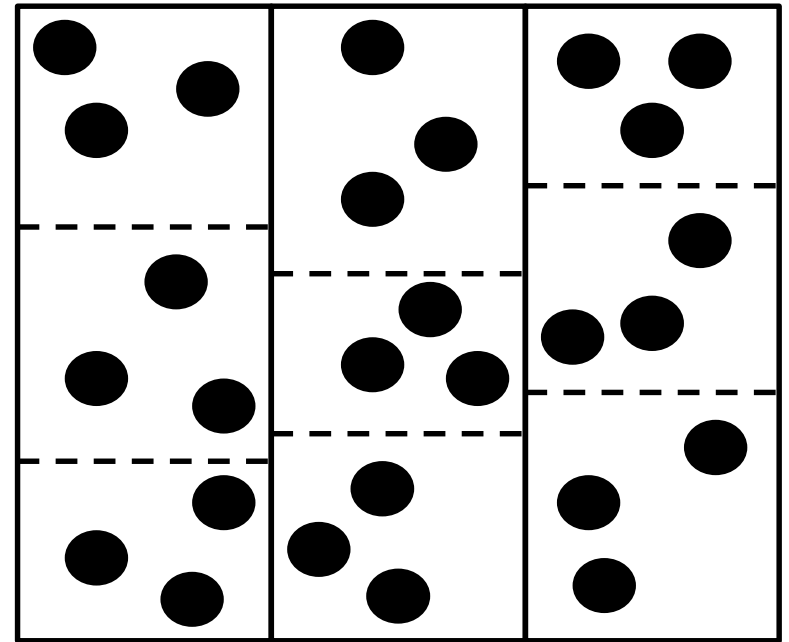
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- Graph Voronoi Diagram (GVD) & 2D Partitioning



GVD



2D

# Blogel

A Block-Centric Framework for Distributed  
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- Performance Highlights

- 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

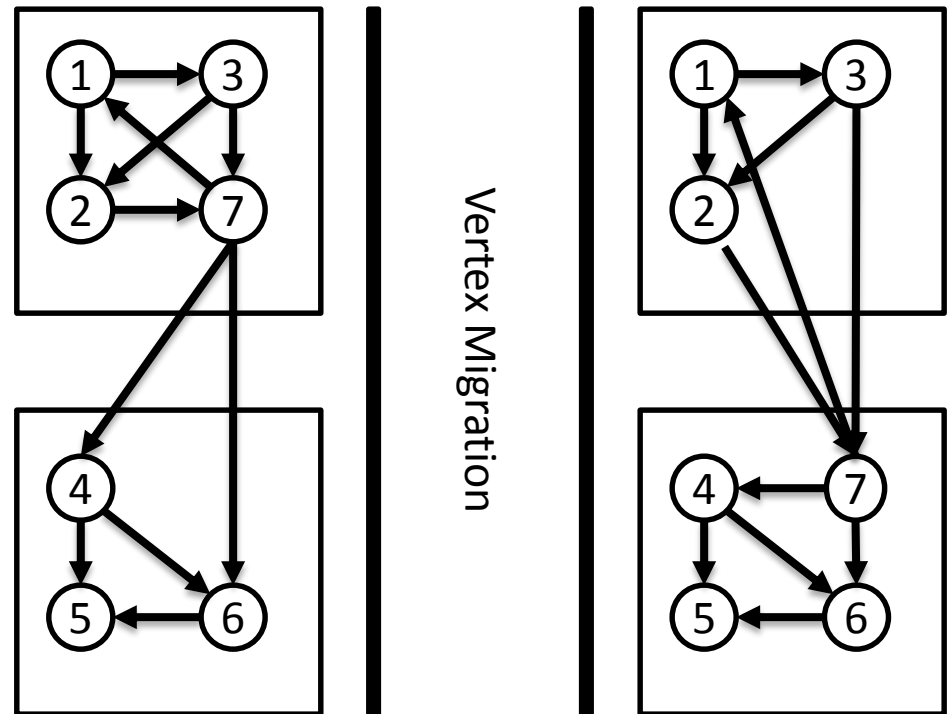
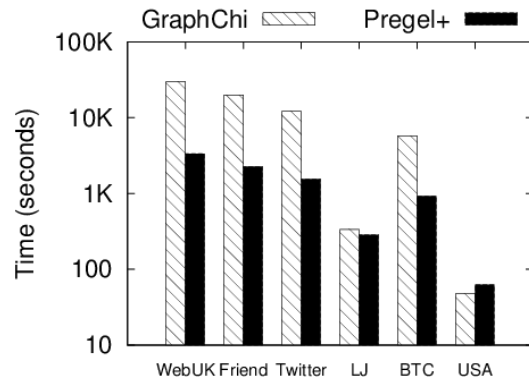


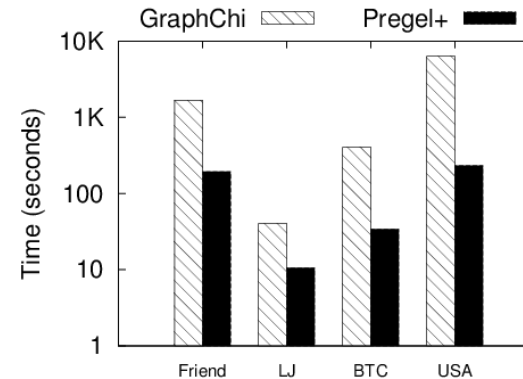
Illustration for dynamic partitioning



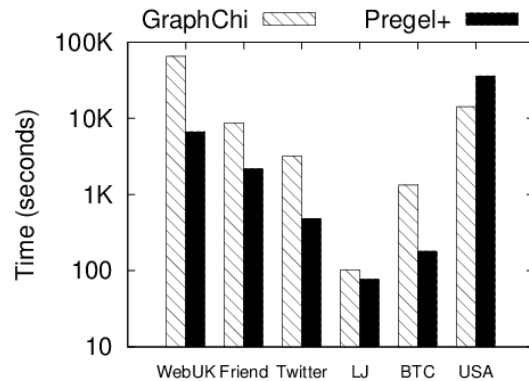
# Distributed v.s. Single-machine



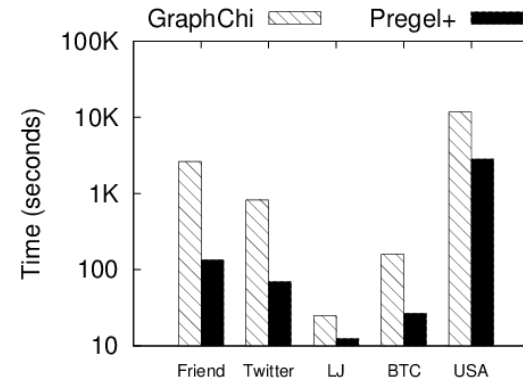
PageRank



HashMin



Diameter Est



SSSP

# 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.