Scalability! but at what COST?

Frank McSherry et al., HotOS 2015

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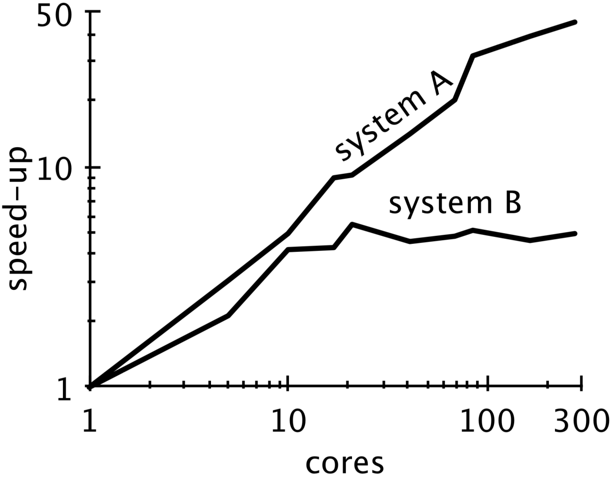
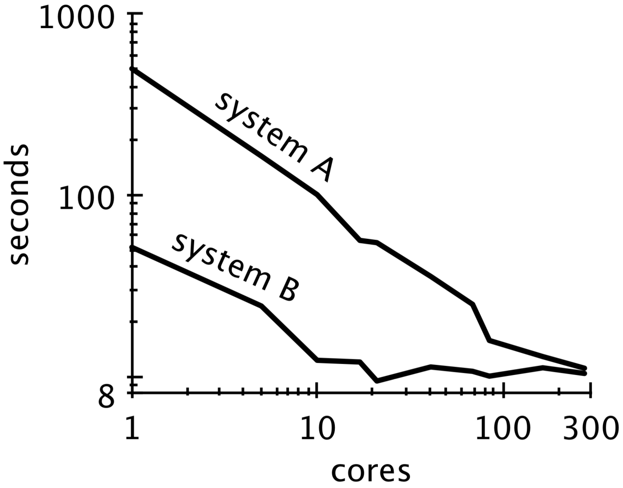
K Kleeberger
Z Sun
C Zhu
(Group 5)

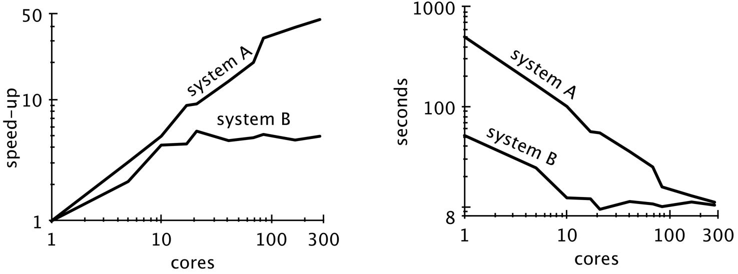
Which system is better, A or B?



What about now, A or B?

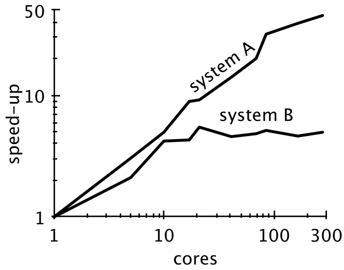


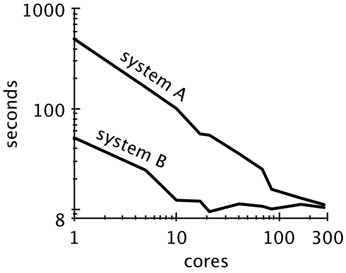
Question in hand



- Scalability is often touted as an essential attribute.
- Absolute performance is not related to scalability.

Question in hand





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To what degree are scalable systems truly improving performance, as opposed to parallelizing overheads introduced?

How can we measure?

"What you can't measure, you can't improve"

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COST - **C**onfiguration that **O**utperforms a **S**ingle **T**hread

Why measure against a single thread?

- Distributed systems can have huge overheads.
- Most systems have *unbounded* COST!
- More optimizations can be applied

A case study - *Graph* Big Data Systems

Why choose Graph?

- Non-trivial to parallelize
- Data-driven
- No structure
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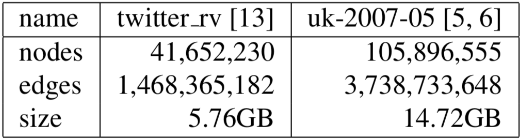
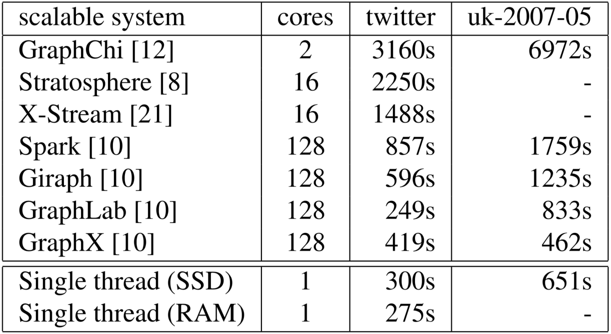
Vertex Centric

- Program from a vertex perspective
- Only messages from other vertices as input
- Useful for PageRank and other graph algos
- "Think Like A Vertex", Pregel, etc.

PageRank (20 Iterations)



name	twitter_rv [13]	uk-2007-05 [5, 6]
nodes	41,652,230	105,896,555
edges	1,468,365,182	3,738,733,648
size	5.76GB	14.72GB



scalable system	cores	twitter	uk-2007-05
GraphChi [12]	2	3160s	6972s
Stratosphere [8]	16	2250s	-
X-Stream [21]	16	1488s	-
Spark [10]	128	857s	1759s
Giraph [10]	128	596s	1235s
GraphLab [10]	128	249s	833s
GraphX [10]	128	419s	462s
Single thread (SSD)	1	300s	651s
Single thread (RAM)	1	275s	-

Label Propagation (Connected Components)

A common machine learning technique

scalable system	cores	twitter	uk-2007-05
Stratosphere [8]	16	950s	-
X-Stream [21]	16	1159s	-
Spark [10]	128	1784s	$\geq$ 8000s
Giraph [10]	128	200s	$\geq$ 8000s
GraphLab [10]	128	242s	714s
GraphX [10]	128	251s	800s
Single thread (SSD)	1	153s	417s

More Optimization - Data Layout

- The order in which edges are presented affects performance.
- Hilbert order vs Vertex order.

[1] More at https://bigdataatsvc.wordpress.com/2013/07/02/graph-analysis-and-hilbert-space-filling-curves/

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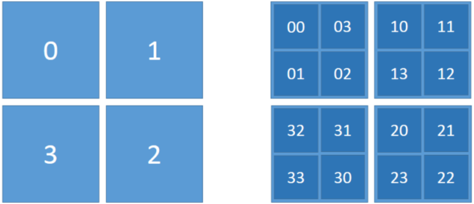
Hilbert Curves - Cleverly ordering the edges[1]

- Assume that edges are stored in an adjacency matrix
- Recursively partitions the matrix
- Excellent for memory locality + parallelizing



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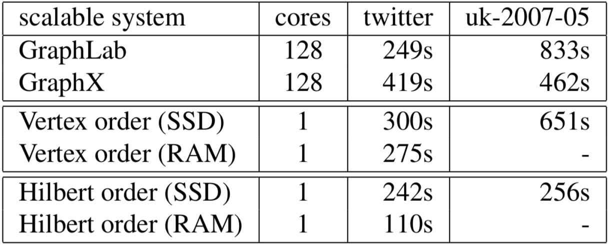

scalable system	cores	twitter	uk-2007-05
GraphLab	128	249s	833s
GraphX	128	419s	462s
Vertex order (SSD)	1	300s	651s
Vertex order (RAM)	1	275s	-
Hilbert order (SSD)	1	242s	256s
Hilbert order (RAM)	1	110s	-

Even More Optimization! - Programming Model

- We are not restricted to "Think like a Vertex" programming model.
- Label propagation is sub-optimal, typically $O(n^3 + mn^2)$
- Use Weighted Union-Find, $O(m \log n)$

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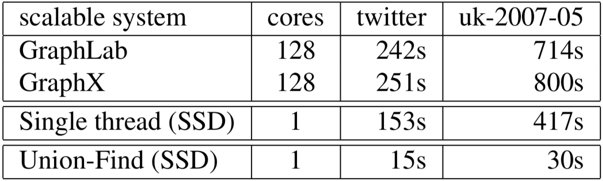
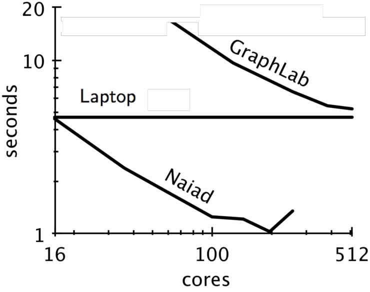
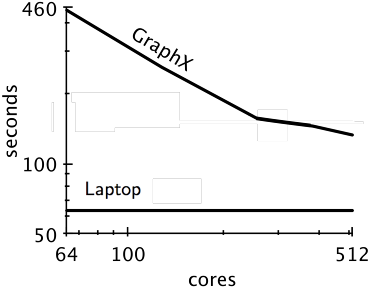


scalable system	cores	twitter	uk-2007-05
GraphLab	128	242s	714s
GraphX	128	251s	800s
Single thread (SSD)	1	153s	417s
Union-Find (SSD)	1	15s	30s

Applying COST

COST is the point of intersection[2]





[2] Plots simplified for illustration purposes

Applying COST

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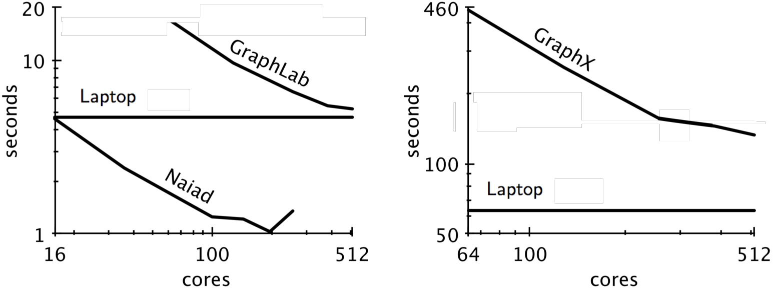

- Naiad has a COST of 16 cores for PageRank
- GraphX has an unbounded COST (does not intersect)

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Lessons

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Scalability != Performance

"*Can it scale well?*" - not the right question!

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Before you build a big data system,

- Beware of misleading marketing. "One tool for all screws"
- Self-investigation is necessary.
- Use appropriate algorithms.
- Choose to solve the problem locally,
  don't distribute unless absolutely necessary.

Interesting stuff

Further reading:

- Boruvkas algorithm
- Galois and Ligra systems
- Naiad - timely dataflow

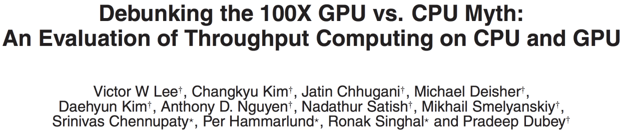
People/Things to follow:

Frank McSherry - https://github.com/frankmcsherry/

Kyle Kingsbury - https://aphyr.com/

Jepsen - https://github.com/jepsen-io/jepsen

Interesting stuff



Debunking the 100X GPU vs. CPU Myth: An Evaluation of Throughput Computing on CPU and GPU

Victor W Lee[†], Changkyu Kim[†], Jatin Chhugani[†], Michael Deisher[†],
Daehyun Kim[†], Anthony D. Nguyen[†], Nadathur Satish[†], Mikhail Smelyanskiy[†],
Srinivas Chennupaty[*], Per Hammarlund[*], Ronak Singhal[*] and Pradeep Dubey[†]

Thank you!

Questions