Auto-Approximation of Graph Computing

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Motivation

- Why Approximate?
  - **Big** data: GB, TB, PB, EB, and still increasing.
  - **Slow** algorithm: from $O(n^2)$ to NP-Complete everywhere.
  - Approximate or not approximate?
    - Big data beats clever algorithm.
    - Approximated answers are usually sufficient for analytics.
    - Approximated good vs. exact bad. Which will you choose?
  - Answer delayed is answer denied.
- Why Auto?
  - Developing "big data" solution is hard.
    That's why we are having this conference.
  - Designing approximation algorithms is hard.
  - Designing distributed approx. algorithms is hard + hard.
- Our Target
  - Minimum level of user involvement.
  - Approximation "for dummies".
  - Ultimate Goal: "One button" approximation.

Our approach

- Sample the **PROGRAM**, not the **GRAPH**!
  - Why graph sampling is NOT working:
    - The vertices and edges are not independent at all.
    - The "connections" are exactly what we care most.
- How we do it?
  - Background: iterative, vertex-centric graph analytics.
  - We ignore some of the program instructions. That's it!
  - And carefully calibrate the answer to keep it unbiased. (See below.)
- Why it works?
  - *Can we always do it?*
    - Mostly. Even for complex queries, their vertex-centric instructions are usually simple and regular.
  - *Is the error small?*
    - Mostly. Under mild assumptions, we show the error will converge (to a small value).
    - We analyze it by analogizing it to the *social network information diffusion* and denote it as *error drifting*. Check paper for details.

Toolbox for Program Sampling

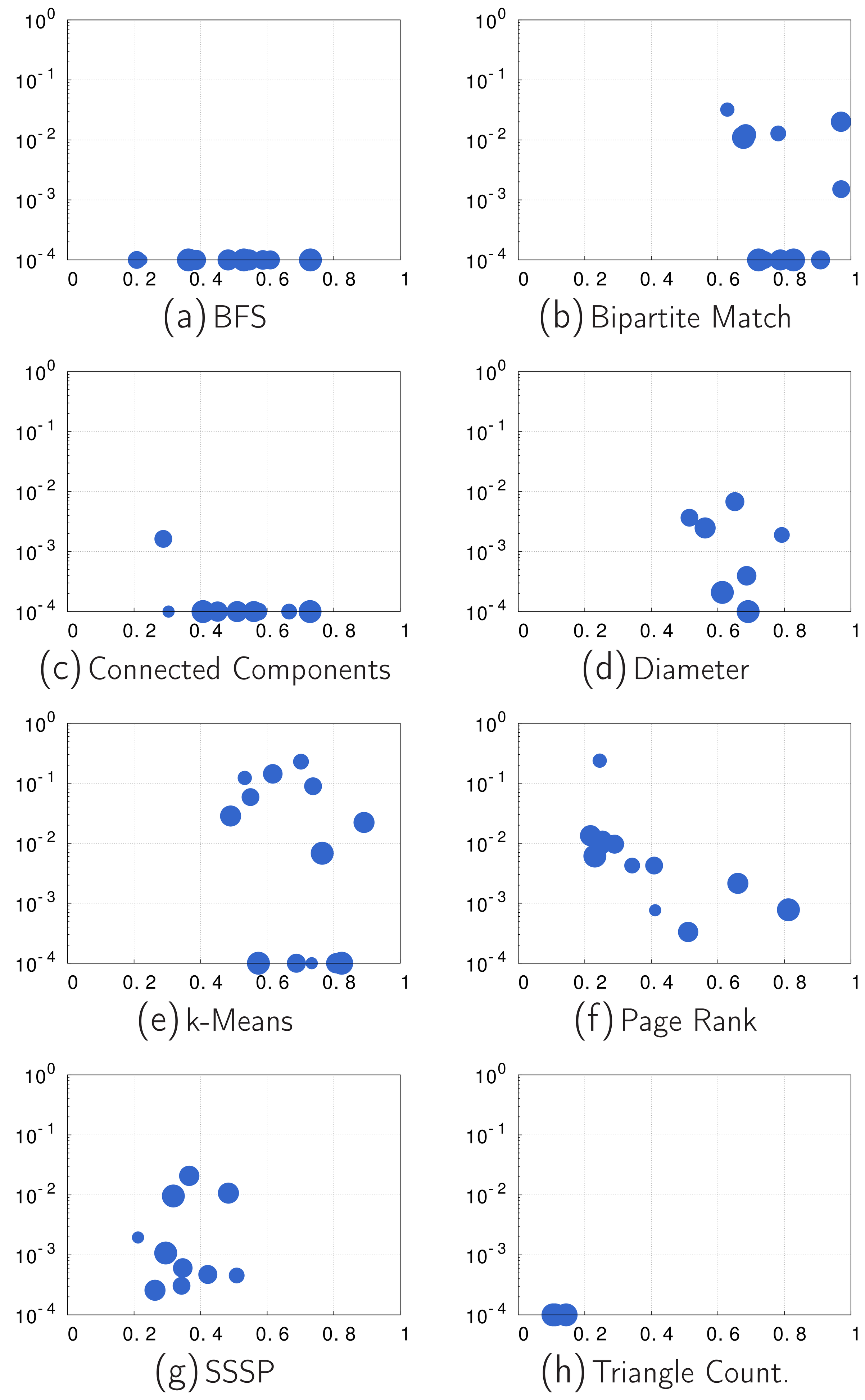
- For example, if the user sums all incoming messages, we sample each five of them.
  - This is not graph sampling!
  - We find such opportunities using program analyzing.
  - And compensate the final sum to keep it unbiased.
- Other alternatives:
  - Memorization: remember past answers.
  - Task skipping: take a nap this time. Work next call.
  - Interpolation: simple function replace complex one.
  - System function replacement: $1 + x$ for $exp(x)$.
  - And still extending!

Does it work?

We conducted experiments on a wide spectrum of algorithms and datasets.

They demonstrates our approach works quite well on both convex and non-convex (!), continuous and discrete (!) cases.

x-axis is relative computation time compared to the original (un-approx.) algorithm, y-axis is relative error (in *log* scale), dots for datasets. Dot size for data size.

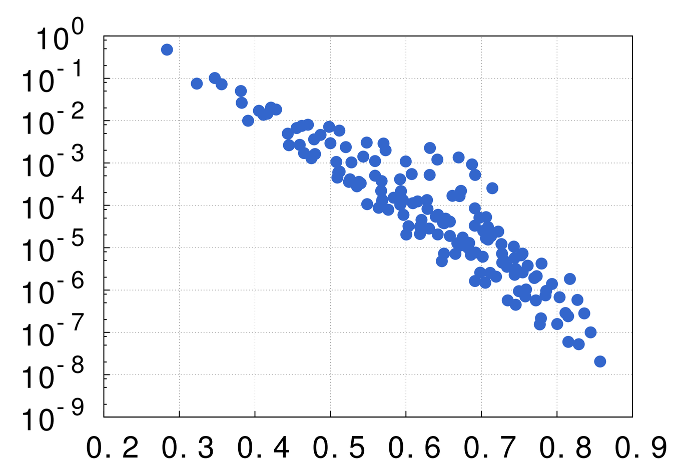


(a) BFS (b) Bipartite Match (c) Connected Components (d) Diameter (e) k-Means (f) Page Rank (g) SSSP (h) Triangle Count.

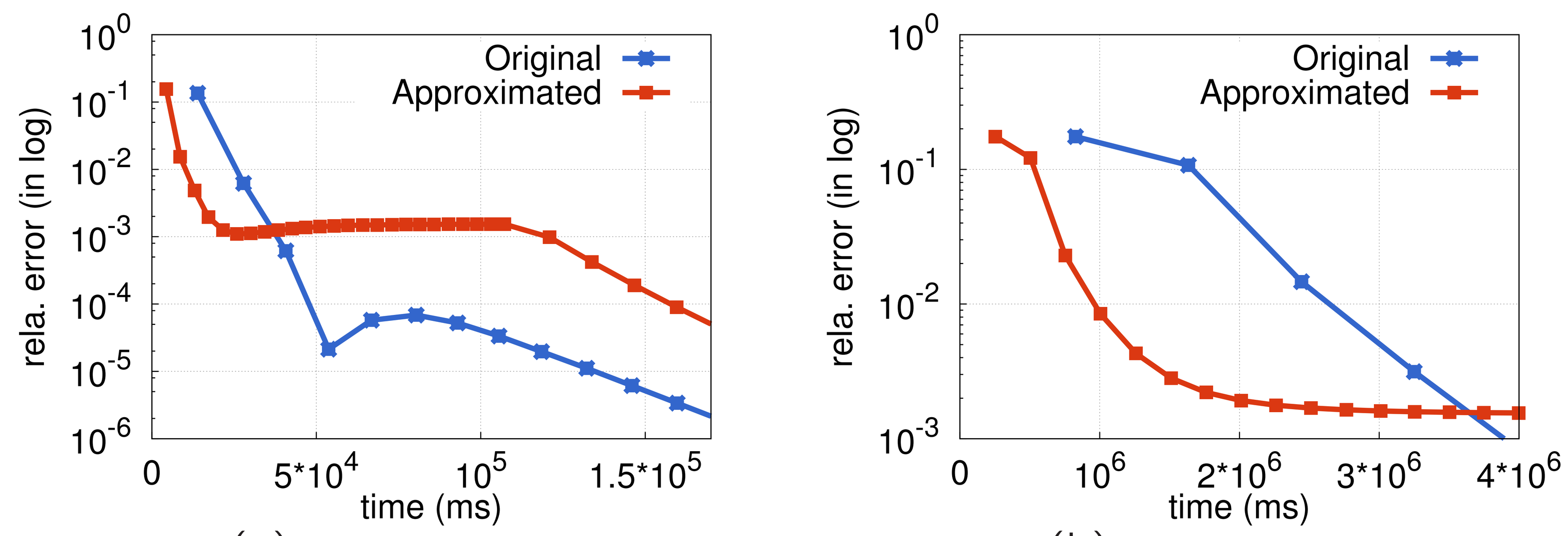
Opportunities and Challenges

By manipulating parameters it generates a wide spread trade-off between accuracy and time. We are investigating how to make full use of it. (Cost model? Discussions are welcomed.)

x-axis is relative computation time compared to the original (un-approx.) algorithm, y-axis is relative error (in *log* scale), dots for combinations of parameters.



Works for both synchronize and asynchronize computing. We will try distributed environment later.



(a) PR in Async. (b) PR in Sync.

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