On Theory of Distributed Computation

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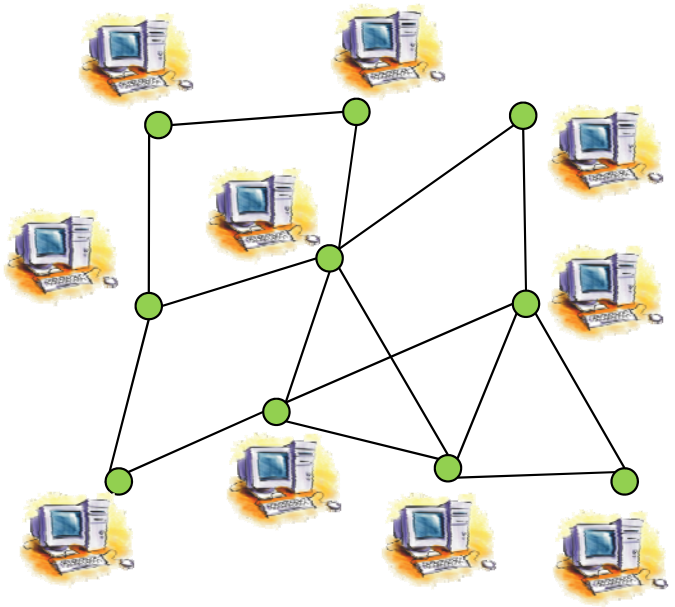
Distributed Computation & Network Algorithms

Distributed Lens: a network of entities communicate & collaborate towards a computational goal

- computers in a network,
- processors in a super-computer,
- cores on a chip,
- human being in a social network,
- ants in a colony,
- neurons in the brain,
- …



An area where the *Theory of Computation* meets *Communication Theory*.

Message Passing Model:

- one processor on each node of a network graph $G = (V, E)$,
- initially each node knows only its neighbors,
- per round, neighbors exchange one (small) message.
- complexity measure: number of rounds.

My Work During PhD @ MIT

Distributed Graph Algorithms:

Maximal Independent Set [SODA'16], Max Flow [PODC'15], Tree Embedding [DISC'14], Min-Cut [DISC'13], Connected Dominating Set Approximation [ICALP'13], Planar Embedding & Min-Spanning-Tree [SODA'16, and ??'16]

Distributed Communication Algorithms:

Throughput-Optimal Information Dissemination and Vertex Connectivity [SODA'15, SODA'14, PODC'14], Time-Optimal Information Dissemination [ICALP'15], Scheduling Distributed Communication Protocols [PODC'15], Consensus in Ant Colonies [PODC'15].

Coding for Interactive Communication:

Optimal Tolerable Error-Rate & Computationally-Efficient (near-linear time) Coding for Interactive Communication [STOC'14, FOCS'14]

Wireless Networks:

Information Dissemination with & without Network Coding [SODA'14, PODC'13, OPODIS'12], Graph Structures in Wireless Networks [SODA'13, PODC'13, DISC'13], Contention Management [DISC'12, DISC'11], Uncertainty in Wireless Networks [PODC'13]

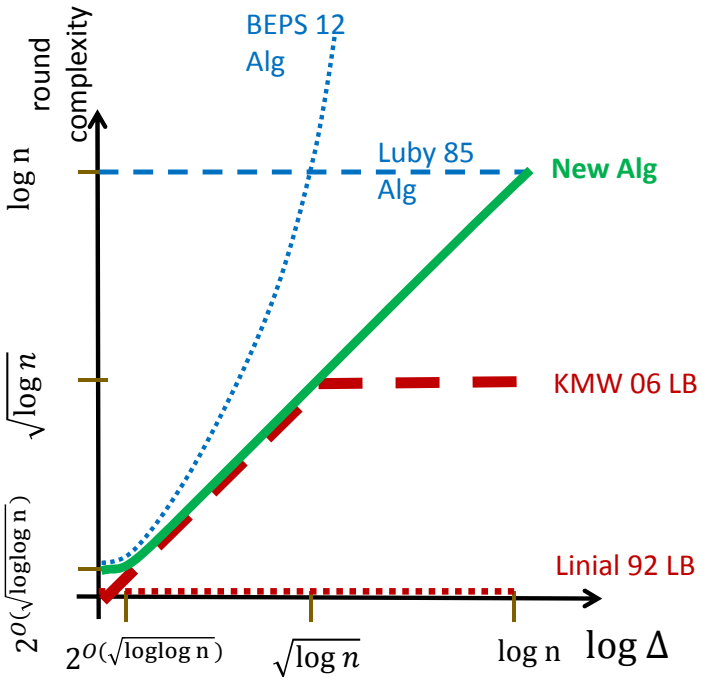
Honored by:

- Best Paper award at SODA'16
- Best Student Paper award at SODA'16
- Best Student Paper award at PODC'15
- Best Student Paper award at PODC'14
- Best Student Paper award at ICALP'14
- Best Paper award at DISC'13

Sample Result: Distributed Maximal Independent Set

Central problem in the area of Locality in Distributed Computing

- Karp-Wigderson [STOC'84]: $O(\log^4 n)$ algorithm
- Luby [STOC'85] - Alon, Babai, & Itai [JALG'86]: $O(\log n)$ algorithm
- Linial [SICOMP'92]: $\Omega(\log^* n)$ lower bound
- Kuhn, Moscibroda, & Wattenhofer [PODC'06]: lower bound, minimum of $\Omega(\log \Delta)$ and $\Omega\left(\sqrt{\log n}\right)$
- Barenboim, Elkin, Pettie, & Schneider [FOCS'12]: $O(\log^2 \Delta) + 2^{O\left(\sqrt{\log \log n}\right)}$ algorithm



[G., SODA'16]: $O(\log \Delta) + 2^{O\left(\sqrt{\log \log n}\right)}$ algorithm

- First algorithm with optimal bound in a range of parameters;
- Several implications: improved LOCAL algorithm for Lovasz Local Lemma, LCA-algorithm for MIS, …
- Extremely simple: 4-line algorithm; 1 page analysis.