We propose to develop an algorithmic toolbox for designing distributed optimization algorithms which drastically outperform state-of-the-art algorithms on non-worst-case topologies.

The modern computation and information processing systems shaping our world have become massively distributed and a fundamental understanding of distributed algorithmics has never been more important. This shift towards distributed systems has resulted in increased interest and fast acceleration in our theoretical understanding of distributed optimization problems. At the same time, extremely general lower bounds uncovered that any distributed optimization requires Omega(sqrt n) rounds on worst-case topologies, even if the diameter of the diameter of the network is small. Many fundamental optimization problems, including MST, shortest paths, and cut/flow problems, now have ``optimal'' algorithms matching this worst-case performance bound.

Real world networks, however, are never worst-case and no network of interest shares the limiting bottleneck characteristics of the lower bound topology. In fact, there is no known barrier for ultra-fast polylogarithmic round distributed algorithms on any network of interest. This exponential gap between worst-case-optimal Theta(sqrt n) algorithms and the O(log^c n) performance which is likely possible in many, if not all, interesting small-diameter networks motivates this proposal and shows clearly that further studies going beyond worst-case topologies are necessary.

Our prior work shows that o(sqrt n) round algorithms are possible for several important problems such as the MST and min-cut when the network is planar, genus-bounded, treewidth-bounded or, more generally, has excluded minors. We first ask the following ambitious questions: are the techniques used to achieve the above results sufficient to construct uniform algorithms that are optimal across each possible instance, i.e., are instance-optimal?

Barring the question of instance-optimality, another direction we propose is adapting our techniques to novel problems for which no o(sqrt n) algorithms currently exist (such as the shortest path problem), or for alternative models (e.g., faulty models or O(n)-message complexity in KT1).

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