Expanding the Boundaries of Local Computation Algorithms

Abstract:

Given an input \( x \), and a search problem \( F \), local computation algorithms (LCAs) implement access to specified locations of \( y \) in a legal output \( y \in F(x) \), using polylogarithmic time and space. Previous work on LCAs restricted its focus to graphs of bounded degree, or degree of bounded expectation that is distributed binomially.

Using a new palette of techniques, we show that it is possible to obtain LCAs for maximal independent set (MIS) and maximal matching (MM) on trees with degree bounded by \( \text{polylog}(n) \). Our result immediately extends to all graphs with degree bounded by \( \text{polylog}(n) \), as long as they do not contain short cycles (of length \( \text{polylog}(n) \)).

We define a family of graphs called \( d \)-light graphs, and show how to convert a large class of online algorithms (including MIS and MM) to LCAs on these graphs. We then show that applying the MIS (or MM) LCA on appropriately selected \( d \)-light subgraphs, allows us to quickly address all of the vertices of the \( \text{polylog}(n) \)-degree graph.

In addition to expanding the range of LCAs to graphs of polylogarithmic degree, our new techniques also significantly improve the running times and space requirements, expand the family of graphs, and better define the family of algorithms to which previous results apply. Furthermore our proofs are simpler and more concise than the previous proof methods.

Joint work with Omer Reingold.