



**University of
Zurich** UZH

Department of Informatics

University of Zürich
Department of Informatics
Binzmühlestr. 14
CH-8050 Zürich
Phone. +41 44 635 43 11
Fax +41 44 635 68 09
www.ifi.uzh.ch/dbtg

UZH, Dept. of Informatics, Binzmühlestr. 14, CH-8050 Zürich

Prof. Dr. Michael Böhlen
Professor
Phone +41 44 635 43 33
Fax +41 44 635 68 09
boehlen@ifi.uzh.ch

Zürich, 22. April 2022

MSc Project: Implementing hierarchical forests on dynamic connectivity

The connectivity problem, which checks if there is a connection between two nodes in a graph, is a fundamental problem in graph algorithms. Connectivity queries are important in application areas such as communication and transport networks to check their reliability and they are also relevant for social networks to investigate whether there are connections between users and the groups they belong to.

For static graphs, the connected components can be precomputed and information about them can be stored in auxiliary data structures, speeding up the query processing significantly. However, such methods are impractical for fully-dynamic large graphs since every single update demands the recomputation of the stored information. Computing connectivity on the fly using search strategies like breadth-first search (BFS) and depth-first search (DFS) is prohibitively expensive for large graphs. The state-of-the-art theoretic approach for dynamic connectivity is leveraging hierarchical forests.

The goal of this MSc project is to have an implementation of the work [3] based on hierarchical forests and evaluate the implementations on given datasets.

Optional: implementing related work [2, 1].



Tasks

1. Study the research paper [3] on dynamic connectivity.
2. Implement the following from the work [3].
 - A baseline approach. For example, simplified version of cluster tree, online BFS or DFS.
 - Hierarchical forests with levels.
 - Hierarchical forests with local tree.
 - Hierarchical forests with local tree and bitmaps.
 - Hierarchical forests with lazy local tree.
 - Hierarchical forests including all components.
3. Conduct sanity check on the implementations.
4. Evaluate the implementations on the given datasets, *e.g.* email communications and social network.
5. Summarize the implementations and experimental results in a technical report.

References

- [1] S.-E. Huang, D. Huang, T. Kopelowitz, and S. Pettie. Fully dynamic connectivity in $O(\log n(\log \log n)^2)$ amortized expected time. SODA '17, page 510–520, USA, 2017. Society for Industrial and Applied Mathematics.
- [2] M. Thorup. Near-optimal fully-dynamic graph connectivity. In *Proceedings of the Thirty-Second Annual ACM Symposium on Theory of Computing*, STOC '00, page 343–350, New York, NY, USA, 2000. Association for Computing Machinery.
- [3] C. Wulff-Nilsen. Faster deterministic fully-dynamic graph connectivity. In *Proceedings of the twenty-fourth Annual ACM-SIAM Symposium on Discrete Algorithms*, pages 1757–1769. SIAM, 2013.

Supervisor: Qing Chen (qing@ifi.uzh.ch), Sven Helmer (helmer@ifi.uzh.ch)

Start date: 10 March 2022

End date: 9 March 2023

University of Zurich
Department of Informatics

Prof. Dr. Michael Böhlen
Professor