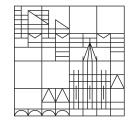
[Draft] Locality Optimization

for traversal-based queries on graph databases

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Some New Abstract Text

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1 Introduction

Essay-like Intro.

Organisation

Contributions

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- 2.1.3 Data Structures
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5.1 Discussion

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- 5.2 Future Work
- 5.3 Summary

Bibliography

- [1] Renzo Angles and Claudio Gutierrez. "Survey of graph database models". In: ACM Computing Surveys (CSUR) 40.1 (2008), pp. 1–39.
- [2] L. Belady. "A Study of Replacement Algorithms for Virtual-Storage Computer". In: *IBM Syst. J.* 5 (1966), pp. 78–101.
- [3] Vincent D Blondel et al. "Fast unfolding of communities in large networks". In: *Journal of statistical mechanics: theory and experiment* 2008.10 (2008), P10008.
- [4] Marek Ciglan and Kjetil Nørvåg. "SGDB–Simple graph database optimized for activation spreading computation". In: *International Conference on Database Systems for Advanced Applications*. Springer. 2010, pp. 45–56.
- [5] Allan M Collins and Elizabeth F Loftus. "A spreading-activation theory of semantic processing." In: *Psychological review* 82.6 (1975), p. 407.
- [6] Patricia Conde-Céspedes, Jean-François Marcotorchino, and Emmanuel Viennet. "Comparison of linear modularization criteria using the relational formalism, an approach to easily identify resolution limit". In: Advances in Knowledge Discovery and Management. Springer, 2017, pp. 101–120.
- [7] Peter J Denning. "The locality principle". In: Communication Networks And Computer Systems: A Tribute to Professor Erol Gelenbe. World Scientific, 2006, pp. 43–67.
- [8] Edsger W Dijkstra et al. "A note on two problems in connexion with graphs". In: *Numerische mathematik* 1.1 (1959), pp. 269–271.
- [9] Bura Gedik and Rajesh Bordawekar. "Disk-based management of interaction graphs". In: *IEEE Transactions on Knowledge and Data Engineering* 26.11 (2014), pp. 2689–2702.
- [10] Andrew V Goldberg and Chris Harrelson. "Computing the shortest path: A search meets graph theory." In: In SODA (Vol. 5, pp. 156-165).
- [11] Peter E Hart, Nils J Nilsson, and Bertram Raphael. "A formal basis for the heuristic determination of minimum cost paths". In: *IEEE transactions on Systems Science and Cybernetics* 4.2 (1968), pp. 100–107.
- [12] Jürgen Hölsch and Michael Grossniklaus. "An algebra and equivalences to transform graph patterns in neo4j". In: EDBT/ICDT 2016 Workshops: EDBT Workshop on Querying Graph Structured Data (GraphQ). 2016.
- [13] Karl Pearson. "The problem of the random walk". In: *Nature* 72.1867 (1905), pp. 342–342.
- [14] Raghu Ramakrishnan and Johannes Gehrke. Database management systems. McGraw-Hill, 2000.
- [15] Ian Robinson, Jim Webber, and Emil Eifrem. *Graph databases: new opportunities for connected data*. "O'Reilly Media, Inc.", 2015.
- [16] Marko A Rodriguez and Peter Neubauer. "The graph traversal pattern". In: *Graph Data Management: Techniques and Applications*. IGI Global, 2012, pp. 29–46.
- [17] Robert Soulé and Bura Gedik. "RailwayDB: adaptive storage of interaction graphs". In: *The VLDB Journal* 25.2 (2016), pp. 151–169.
- [18] Robin Steinhaus, Dan Olteanu, and Tim Furche. "G-Store: a storage manager for graph data". PhD thesis. University of Oxford, 2010.

- [19] Vincent A Traag, Ludo Waltman, and Nees Jan Van Eck. "From Louvain to Leiden: guaranteeing well-connected communities". In: *Scientific reports* 9.1 (2019), pp. 1–12.
- [20] Abdurrahman Yaar. "Scalable layout of large graphs on disk". PhD thesis. Bilkent University, 2015.
- [21] Abdurrahman Yaar, Bura Gedik, and Hakan Ferhatosmanolu. "Distributed block formation and layout for disk-based management of large-scale graphs". In: *Distributed and Parallel Databases* 35.1 (2017), pp. 23–53.
- [22] Konrad Zuse. "Über den allgemeinen Plankalkül als Mittel zur Formulierung schematischkombinativer Aufgaben". In: Archiv der Mathematik 1.6 (1948), pp. 441–449.