UNIVERSITY OF LEICESTER

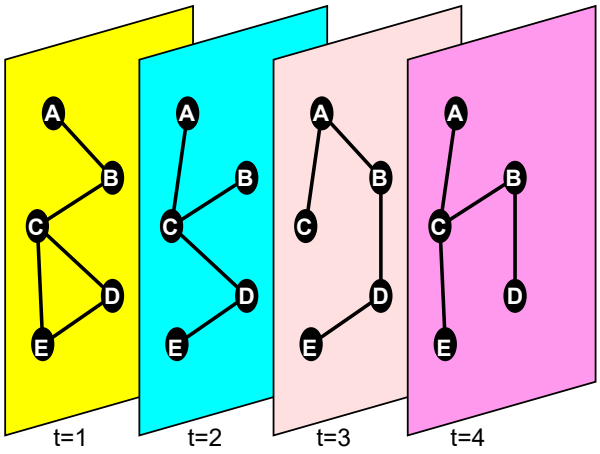
CSE-INF2-ERLE

Flows and Cuts in Time-Varying Networks

Highlights

- Studying classical concepts of cuts and flows in the novel setting of time-varying networks
- Developing approximation algorithms for temporal analogues of cut and flow problems
- Exploring applications of research on time-varying networks

Level	PhD
First Supervisor	Prof Thomas Erlebach
Second Supervisor	Dr Michael Hoffman
Application Closing Date	21st January 2019
Subject Areas	Computer Science & IT Mathematics Operational Research



Time-varying network with different edge sets in four time steps

Overview

In many settings, networks are not static but change over time: For example, links in a wireless network with mobile nodes appear and disappear, friendship relations in social networks change over time, and transport links in a public transportation network are only available at certain times. The study of graphs and networks that change over time has received increasing attention in the last few years, and efforts to adapt concepts and methods from the classical area of graph theory to time-varying graphs are under way.

In this project we will investigate temporal analogues of the classical concepts of flows and cuts in networks. How can one send as much flow as possible from one node of a temporal network to another? What is the smallest number of nodes or links that have to be disabled in order to block all temporal paths from a given source to a given destination?

Recent results have determined the complexity of the problem of computing temporal separators in various special classes of temporal graphs, and in this project we aim to study the approximability of temporal cut and flow problems. For NP-hard problem variants, we aim to develop approximation algorithms that are guaranteed to provide solutions that are provably close to the optimum, and to prove inapproximability results showing that approximations beyond a certain threshold cannot be achieved in polynomial time unless P=NP (where P is the class of decision problems that can be solved deterministically in polynomial time, and NP is the class of decision problems that can be solved in polynomial time by a non-deterministic Turing machine).

Methodology

We will consider the formulations of temporal flow and cut problems that have been proposed in previous work as well as variation such as multi-terminal flows, multiway cuts and multi-cuts. We will also study “sliding window” variants where cuts or flows must be realized within all time windows of a certain length during the network’s lifetime, or length-bounded flow and cut variants. For each of these variants, we will determine the approximability for arbitrary temporal graphs and, if we can show that it is impossible to achieve good approximation ratios unless

P=NP, we will study restricted classes of temporal graphs where better approximation ratios can be achieved. We will use known hardness results for length-bounded cuts as starting point for showing approximation hardness results for temporal cuts. Approximation algorithm design techniques such as linear programming and rounding or greedy algorithms will be applied to design approximation algorithms.

Further Reading

1. Thomas Erlebach, Michael Hoffmann, Frank Kammer: On Temporal Graph Exploration. In: *Proceedings of the 42nd International Colloquium on Automata, Languages and Programming* (ICALP 2015). LNCS 9134, Springer, 2015, pp. 444-455.
2. Philipp Zschoche, Till Fluschnik, Hendrik Molter, Rolf Niedermeier: The Complexity of Finding Small Separators in Temporal Graphs. In: *Proceedings of the 43rd International Symposium on Mathematical Foundations of Computer Science* (MFCS 2018), Leibniz International Proceedings in Informatics (LIPIcs), 2018, pp. 45:1-45:17.
3. Till Fluschnik, Hendrik Molter, Rolf Niedermeier, Philipp Zschoche: Temporal Graph Classes: A View Through Temporal Separators. In: *Proceedings of the 44th International Workshop on Graph-Theoretic Concepts in Computer Science* (WG 2018), LNCS 11159, Springer, 2018, pp. 216-227.

Funding

This research project is one of a number of projects in the Department. It is in competition for funding with one or more of these projects. Usually the project which receives the best applicant will be awarded the funding.

Home/EU Applicants

This project is eligible for a fully funded College of Science and Engineering studentship which includes :

- A full UK/EU fee waiver for 3.5 years
- An annual tax free stipend of £14,777 (2018/19)
- Research Training Support Grant (RTSG)

International Applicants

This project is eligible for a fully funded College of Science and Engineering studentship which includes :

- A full international fee waiver for 3.5 years
- Research Training Support Grant (RTSG)

Application Instructions

The online application and supporting documents are due by **Monday 21st January 2019**.

Any applications submitted after the deadline will not be accepted for the studentship scheme.

References should arrive no later than **Monday 28th January 2019.**

Applicants are advised to apply well in advance of the deadline, so that we can let you know if anything is missing from your application.

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Required Materials

1. Online application form
2. Two academic references
3. Transcripts
4. Degree certificate/s (if awarded)
5. Curriculum Vitae
6. CSE Studentship Form
7. English language qualification

Applications which are not complete by the deadline will not be considered for the studentship scheme. It is the responsibility of the applicant to ensure the application form and documents are received by the relevant deadlines.

All applications must be submitted online, along with the supporting documents as per the instructions on the website.

Please ensure that all email addresses, for yourself and your referees, are correct on the application form.

For more information, please visit our website at :
https://www2.le.ac.uk/colleges/scieng/research/postgraduate-opportunities/cse-2019/instructions