Graduate Seminar on Discrete Optimization

Steiner Tree and Steiner Forest: LP Relaxations and Approximation Algorithms

Summer term 2025

How the Seminar runs

Each talk shall run as follows:

1. Part 1 (10–20 minutes)
   Introduce the topic.
   What will be the main results?
   Why are they important and interesting?
   Embed your topic into a broader context, e.g., by showing connections to other talks in this seminar or related results in the literature.
2. Questions to the audience
   Ask one or two (multiple-choice) questions to check whether the audience has understood the key concepts.
   This is also a good opportunity for the audience to ask questions.

How the Seminar runs

Each talk shall run as follows:

1. Part 1 (10–20 minutes)
2. Questions to the audience
3. Part 2 (55–65 minutes)
   Explain proofs, but focus on the main ideas rather than detailed calculations.
4. Discussion (15 minutes)
   Questions of the audience to the speaker. Everyone should participate in the discussion!

The two parts of the talk together must not exceed 75 minutes.
If you use definitions or proofs from previous talks, remind the audience by repeating relevant things briefly.

What we expect from you

- Understand every aspect of your topic
- Prepare your talk on the assigned topic carefully, including questions to the audience.
- Prepare a 1- or 2-page summary of your talk, with the most important definitions and results. Distribute hardcopies of this before your talk to the audience.
- Give a rehearsal talk about 2–3 weeks before your main talk.
- Participate actively in the discussions in the seminar.

Besides the text assigned to you, it is usually necessary and always helpful to study further sources (e.g., read other papers).

Assignment of topics and registration

If you want to participate in this seminar, send an e-mail to Ulrich Brenner (brenner@dm.uni-bonn.de) with your name and your favorite topics no later than

Tuesday, January 28, 16:00.

A few days later we will inform you by e-mail about the assignment of the topics.

After the assignment you have one week for the final registration. After that we may give your place to another student.

In addition, you have to register in BASIS in early April (before the seminar begins).

Each participant will be assigned an advisor (usually one of our PhD students) who can help with questions.

Main Sources

AKR A. Agrawal, P. Klein, R. Ravi: When trees collide: an approximation algorithm for the generalized Steiner problem on networks. SIAM Journal on Computing 1995

GW M.X. Goemans, D.P. Williamson: A general approximation technique for constrained forest problems. SIAM Journal on Computing 1995

WS D.P. Williamson, D.B. Shmoys: The Design of Approximation Algorithms. Cambridge University Press, 2010

KOPRSV J. Könemann, N. Olver, K. Pashkovish, R. Ravi, C. Swamy, J. Vygen: On the Integrality Gap of the Prize-Collecting Steiner Forest LP. APPROX 2017

AGHJM1 A. Ahmadi, I. Gholami, M.T. Hajiaghayi, P. Jabbarzade, M. Mahdavi: 2-approximation for prize-collecting Steiner forest. SODA 2024, arXiv2309.05172

AGHJM2 A. Ahmadi, I. Gholami, M.T. Hajiaghayi, P. Jabbarzade, M. Mahdavi: Prize-collecting Steiner tree: a 1.79 approximation. STOC 2024, arXiv2405.03792

V R. Vicari: Simplex based Steiner tree instances yield large integrality gaps for the bidirected cut relaxation. arXiv:2002.07912

BGT1 J. Byrka, F. Grandoni, V. Traub: The bidirected cut relaxation for Steiner tree has integrality gap smaller than 2. FOCS 2024, arXiv2407.19905

BGT2 J. Byrka, F. Grandoni, V. Traub: On the bidirected cut relaxation for Steiner forest. IPCO 2025, arXiv:2412.06518

HK E. Halperin, R. Krauthgamer. Polylogarithmic inapproximability. STOC 2003

LL S. Li, B. Laekhanukit: Polynomial integrality gap of flow LP for directed Steiner tree. ACM Trans. Alg. 2024

GKR N. Garg, G. Konjevod, R. Ravi: A polylogarithmic approximation algorithm for the group Steiner tree problem. Journal of Algorithms 2000

Topics of the Talks

0. Primal-dual algorithm for Steiner forest [AKR, GW, WS (sec. 7.4)] Read before!
1. Prize-collecting Steiner tree, Steiner forest [GW (sec. 4.3), WS (sec. 5.7, ex. 14.5)]
2. On the integrality gap of the prize-collecting Steiner forest LP [KOPRSV]
3. 2-approximation for prize-collecting Steiner forest [AGHJM1]
4. 1.79-approximation for prize-collecting Steiner tree [AGHJM2]
5. Bidirected cut relaxation for Steiner tree: lower bound (1) [V, sec. 1–2]
6. Bidirected cut relaxation for Steiner tree: lower bound (2) [V, sec. 3]
7. Bidirected cut relaxation for Steiner tree: upper bound (1) [BGT1, sec. 2–4.2]
8. Bidirected cut relaxation for Steiner tree: upper bound (2) [BGT1, sec. 4.3–5]
9. On the bidirected cut relaxation for Steiner forest [BGT2]
10. Polylogarithmic inapproximability for directed Steiner tree [HK]
11. Polynomial integrality gap of flow LP for directed Steiner tree [LL]
12. Polylogarithmic approximation for group Steiner tree [GKR]