Polylogarithmic Time Algorithms for Shortest Path Forests in Programmable Matter

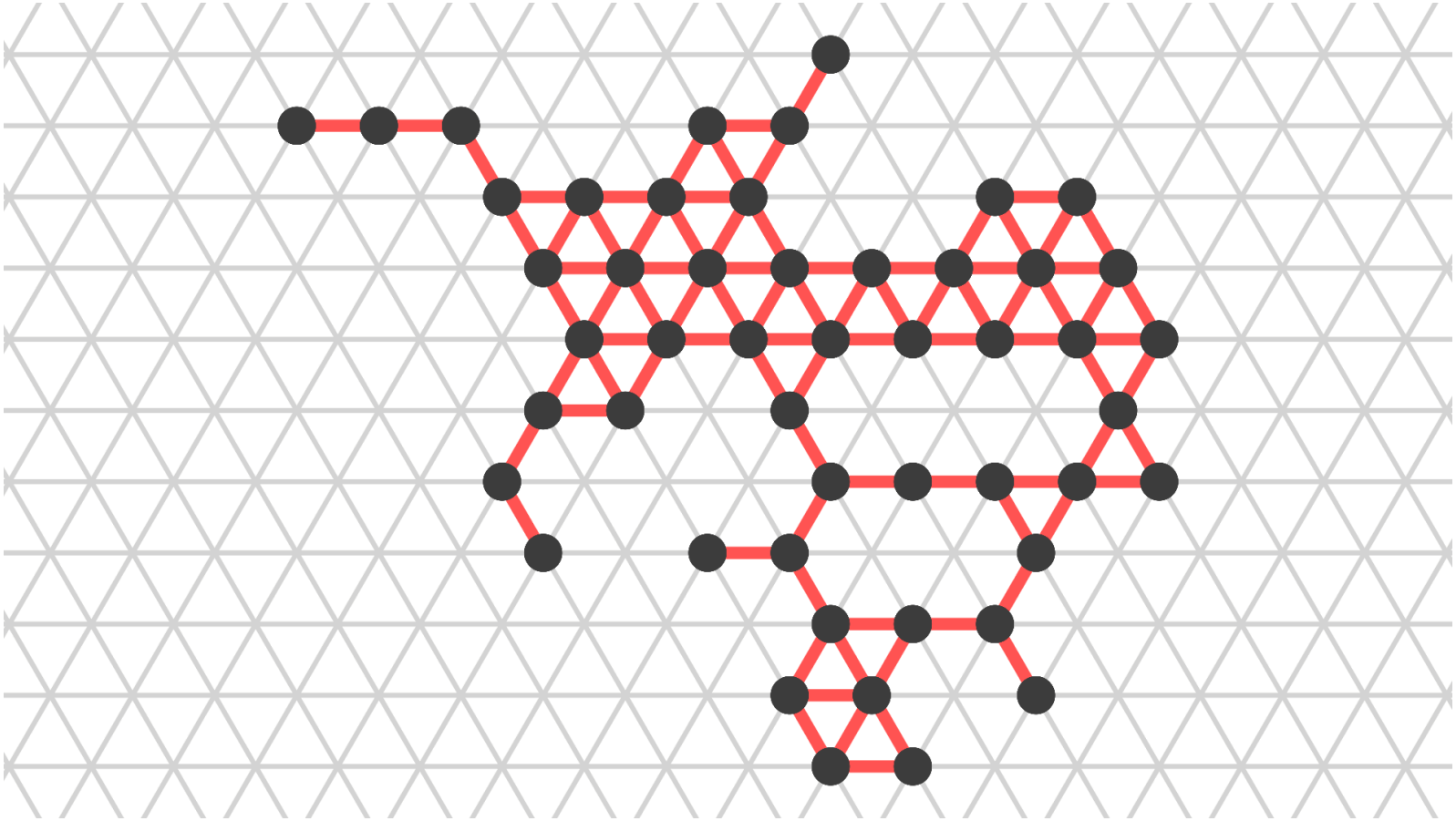
Andreas Padalkin, Christian Scheideler

Initialized at the Dagstuhl Seminar 23091 “Algorithmic Foundations of Programmable Matter”

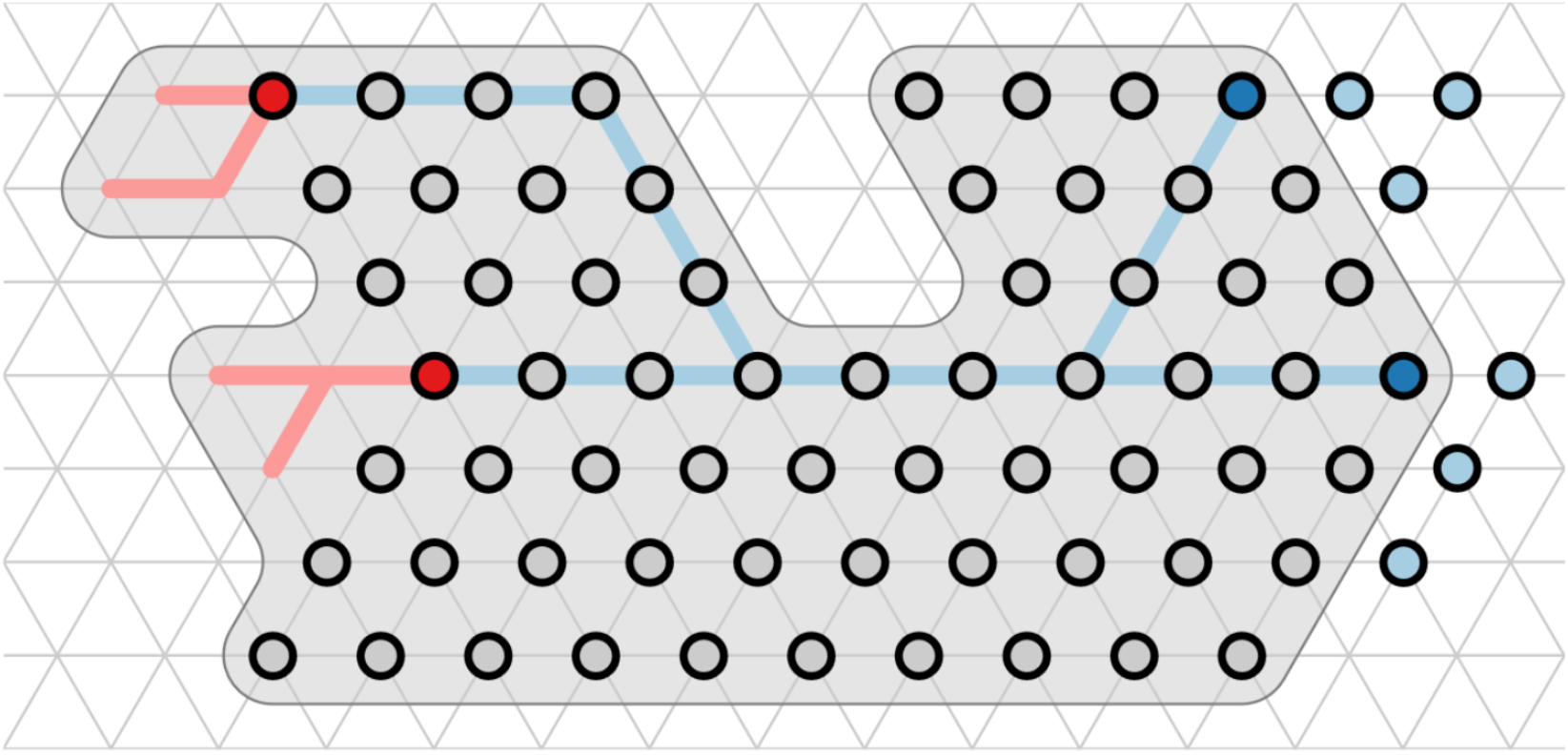
Thanks to
Shantanu Das, Yuval Emek, Maria Kokkou, Irina Kostitsyna, Tom Peters, Andrea Richa

Supported by the DFG Project SCHE 1592/10-1

Geometric Amoebot Model

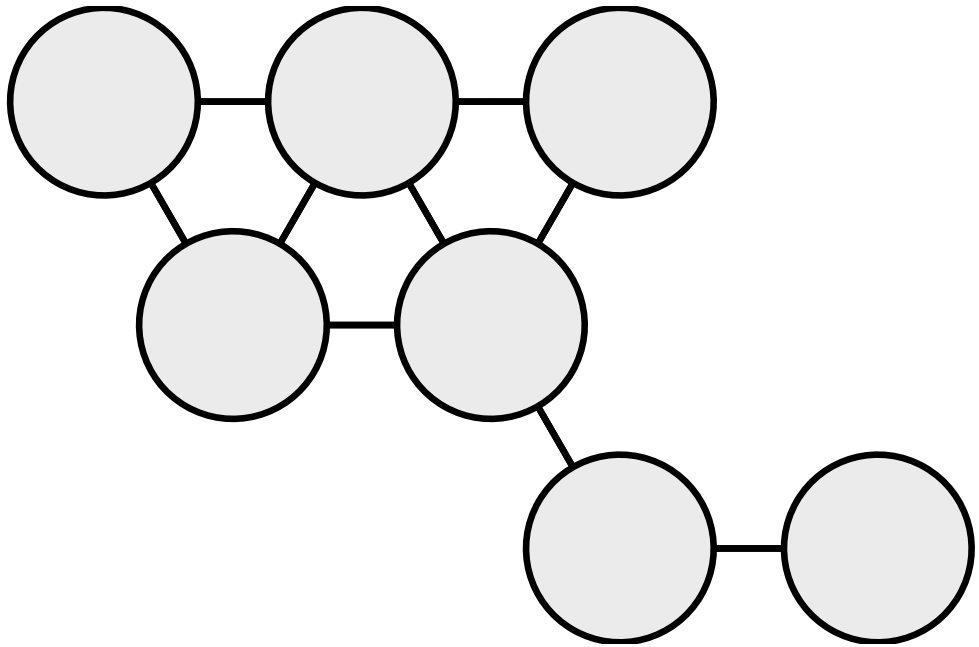


Shortest Paths in the Amoebot Model



Kostitsyna, Peters, Speckmann:
Fast Reconfiguration for Programmable Matter.
DISC 2023

Reconfigurable Circuit Extension



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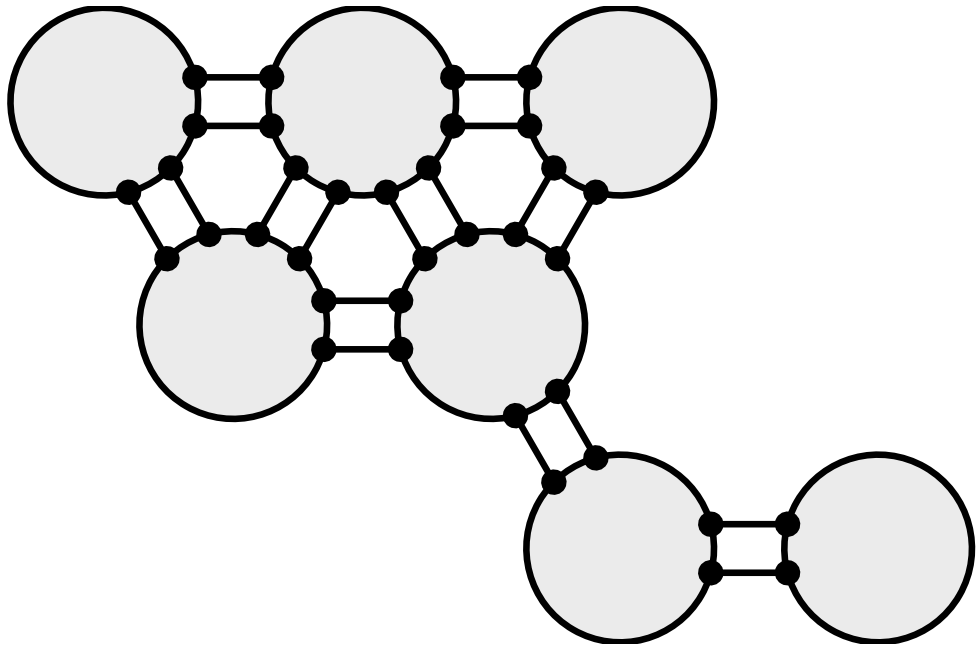

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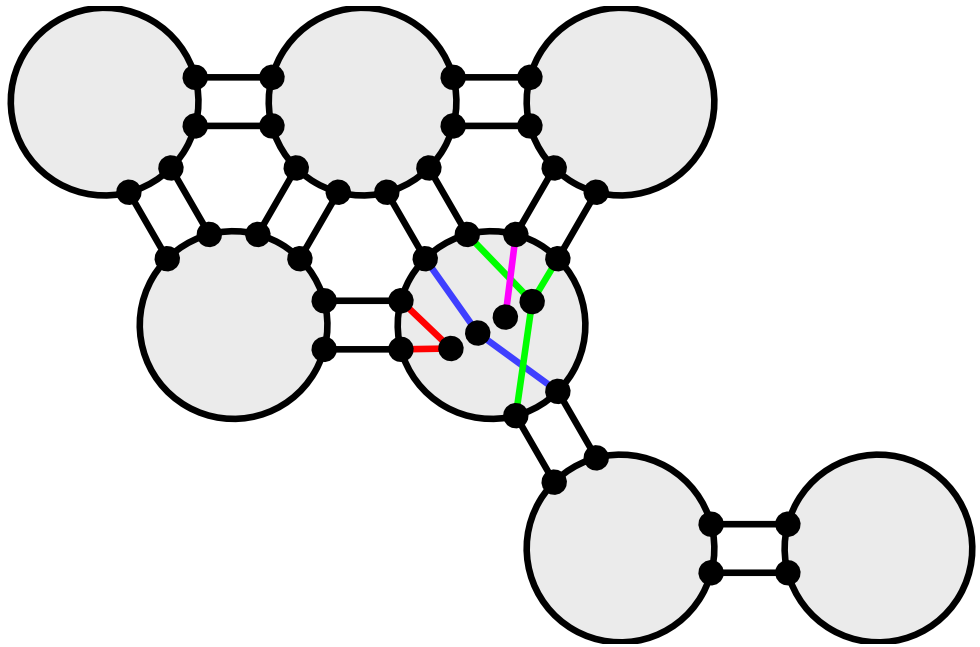

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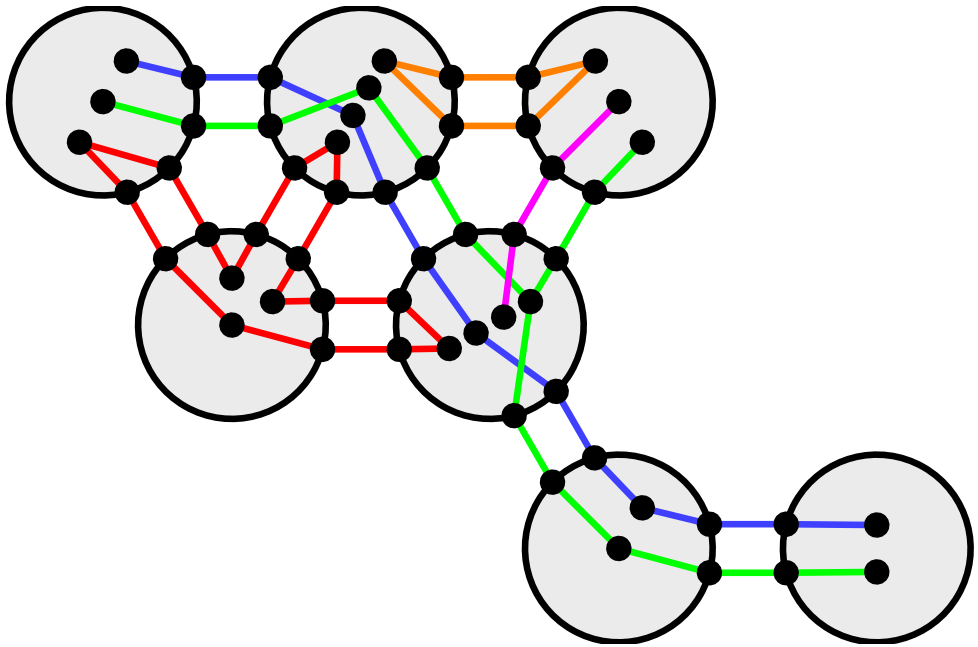
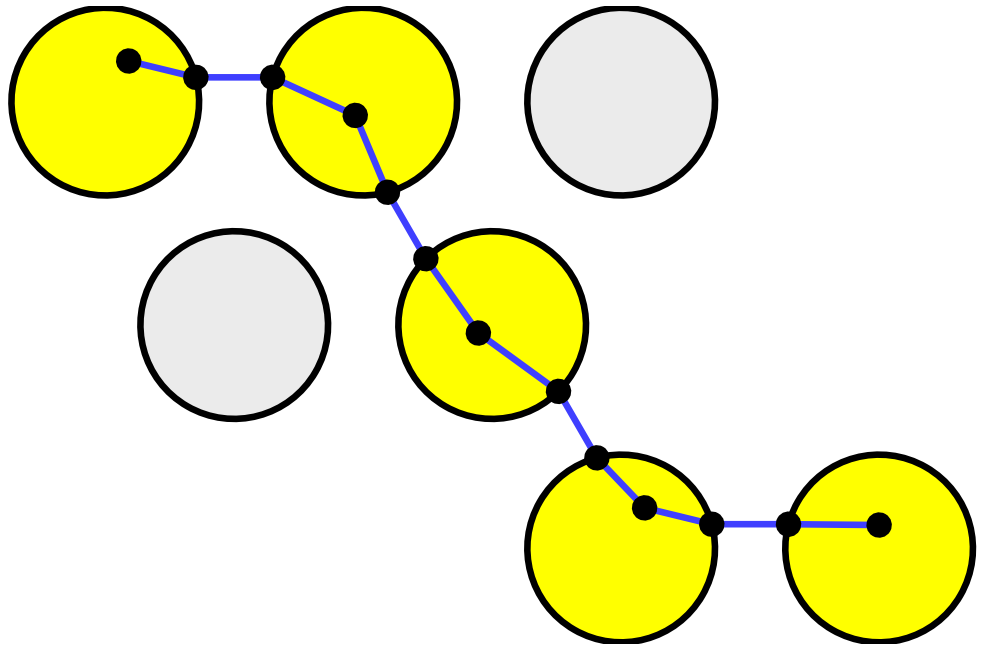


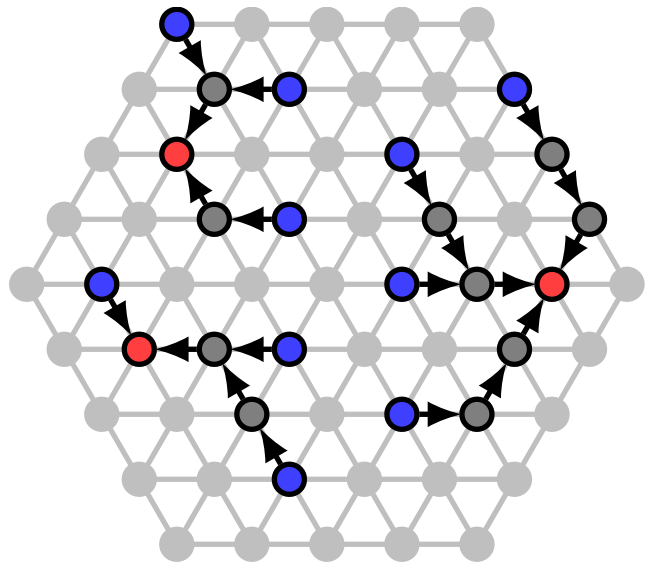
Reconfigurable Circuit Extension



Shortest Path Forest Problem

(k, ℓ)-shortest path forest problem

- Given: k sources, ℓ destinations
- Goal: compute a shortest path
  from each destination to the closest source



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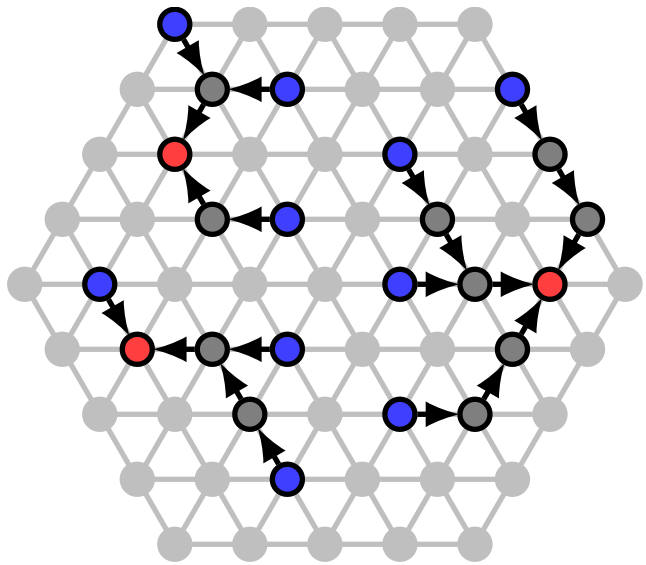
Assumptions

- No holes
- Leader
- Common chirality/compass orientation



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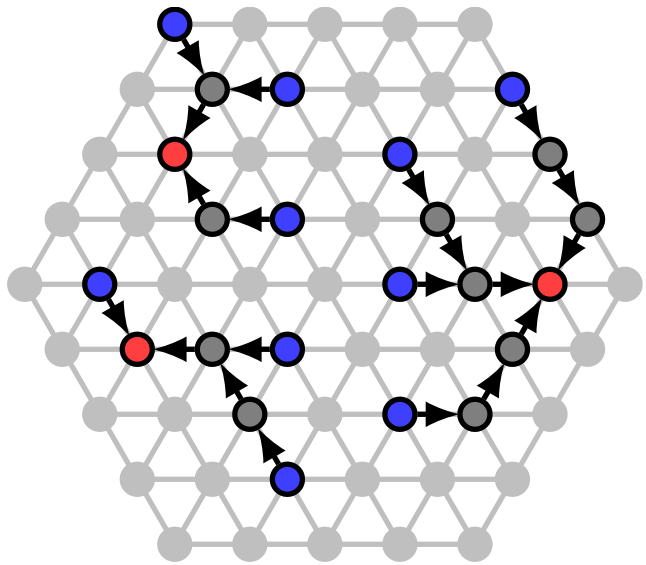

Assumptions

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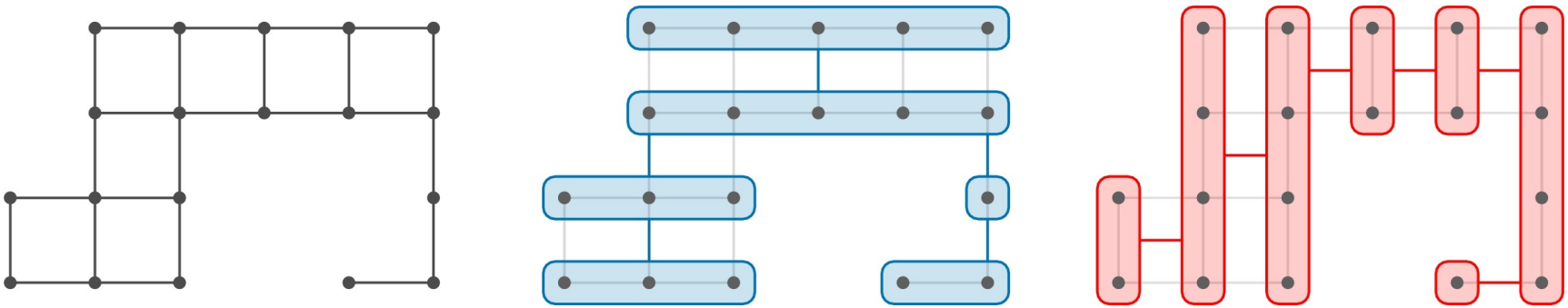
Sources	Destinations	Runtime
1	ℓ	$O(\log \ell)$
k	ℓ	$O(\log n \log^2 k)$

Portal Graphs

$$\mathrm{dist}(u,v) = \mathrm{dist}_x(u,v) + \mathrm{dist}_y(u,v)$$

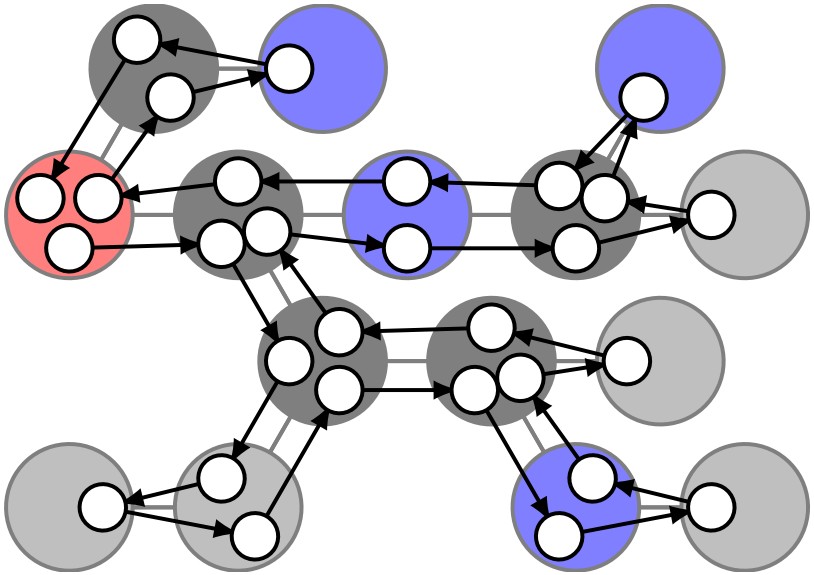


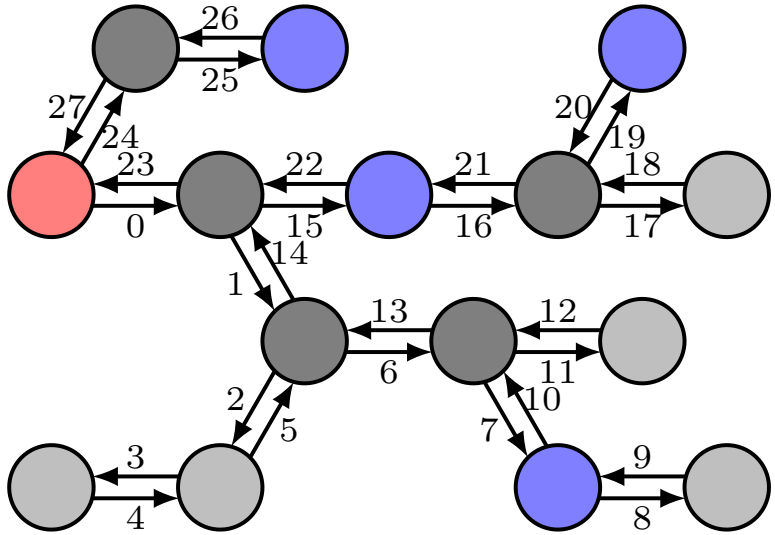
Coy, Czumaj, Scheideler, Schneider, Werthmann:
Routing schemes for hybrid communication networks.
Theor. Comput. Sci. 2024

Portal Graphs

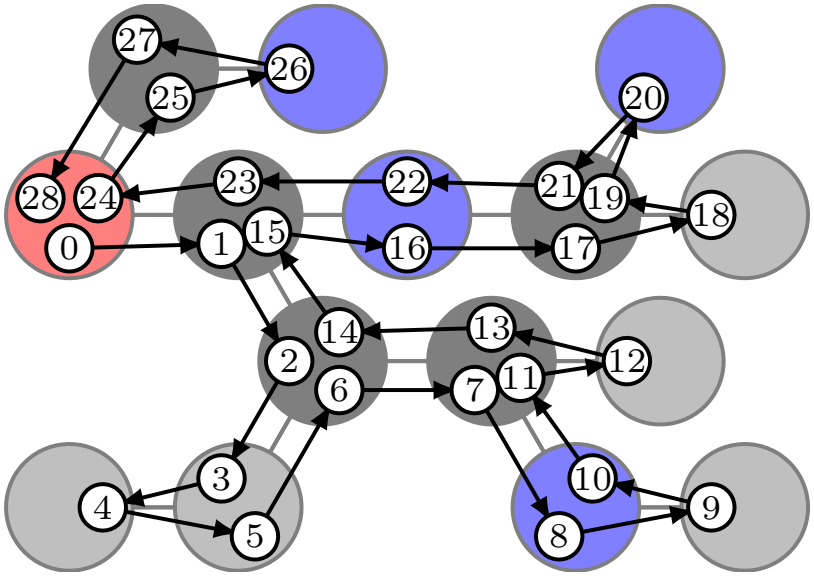
$$2 \cdot \mathrm{dist}(u, v) = \mathrm{dist}_x(u, v) + \mathrm{dist}_y(u, v) + \mathrm{dist}_z(u, v)$$

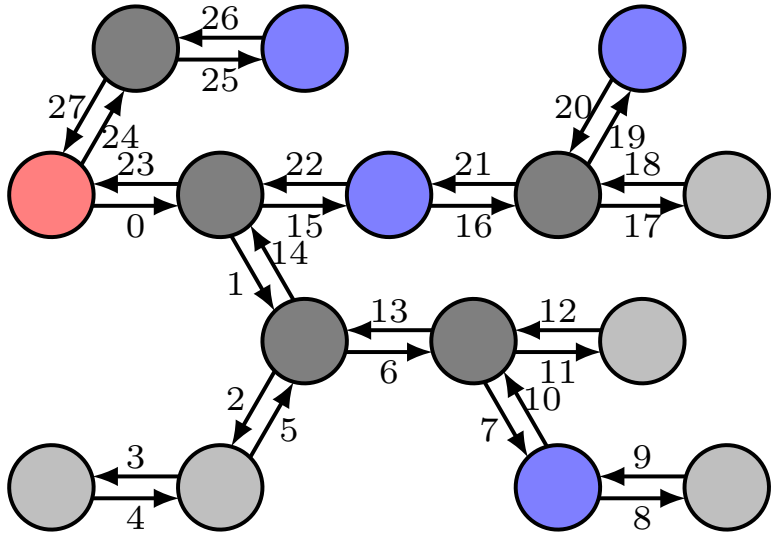
Euler Tour Technique and PASC Algorithm





Euler Tour Technique and PASC Algorithm





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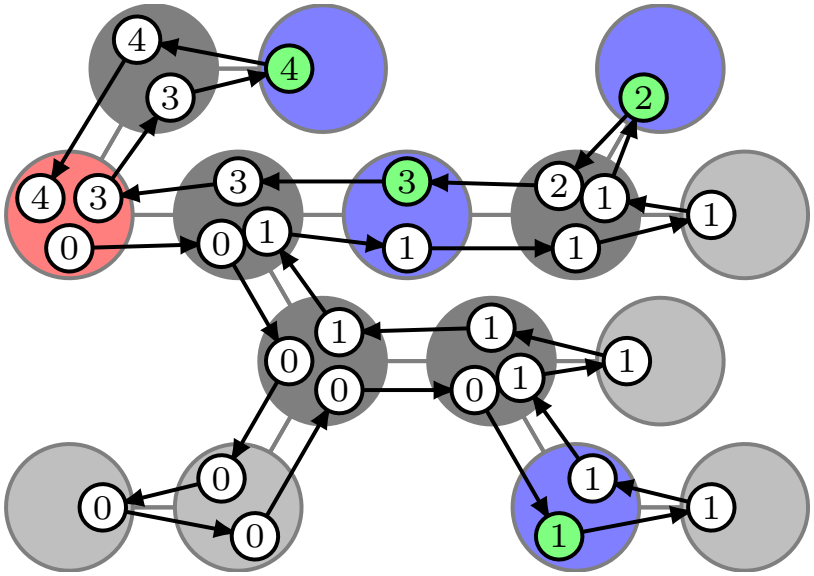
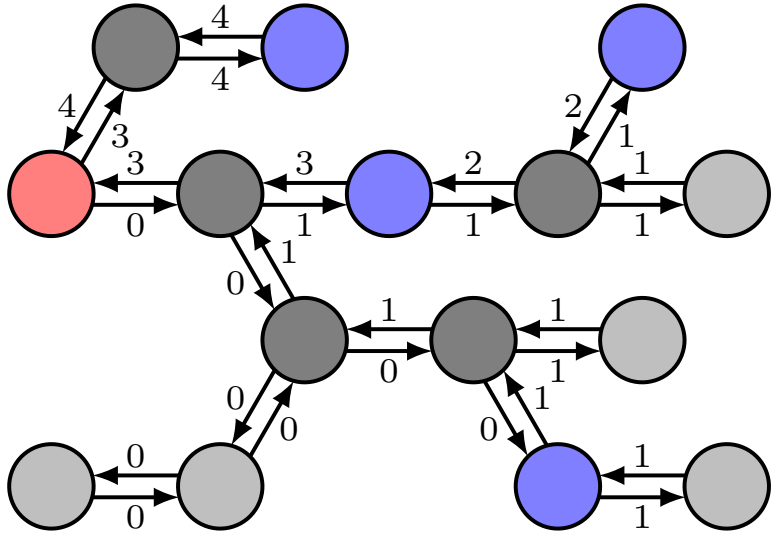
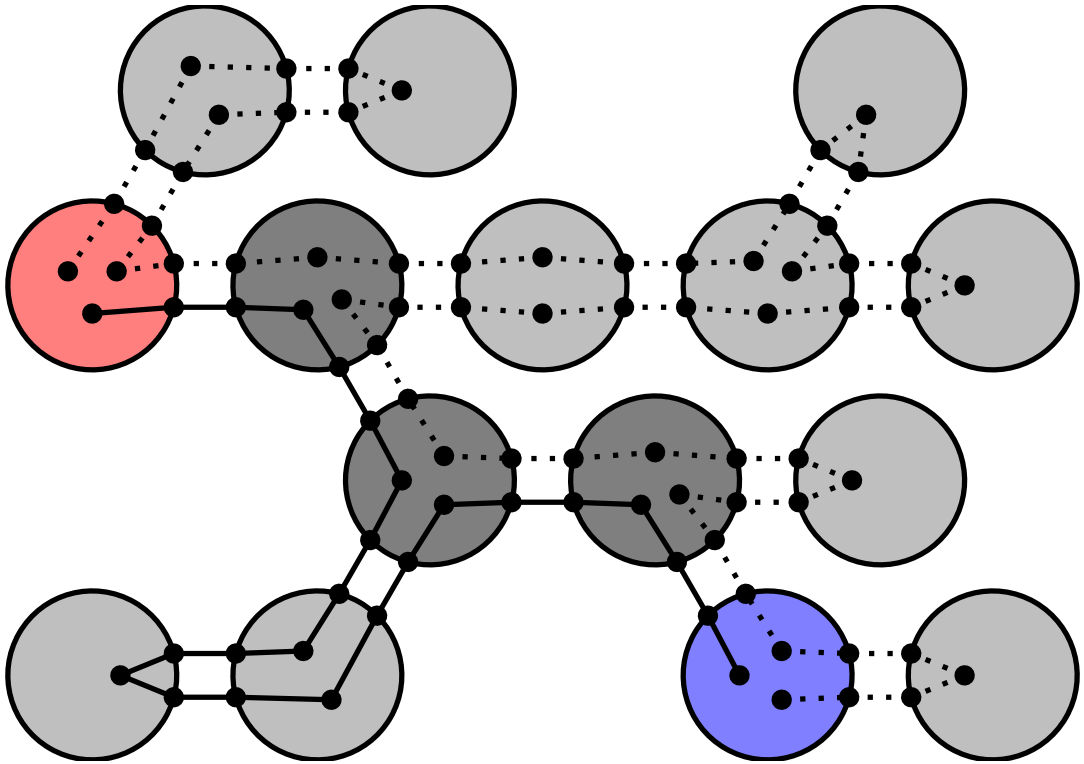
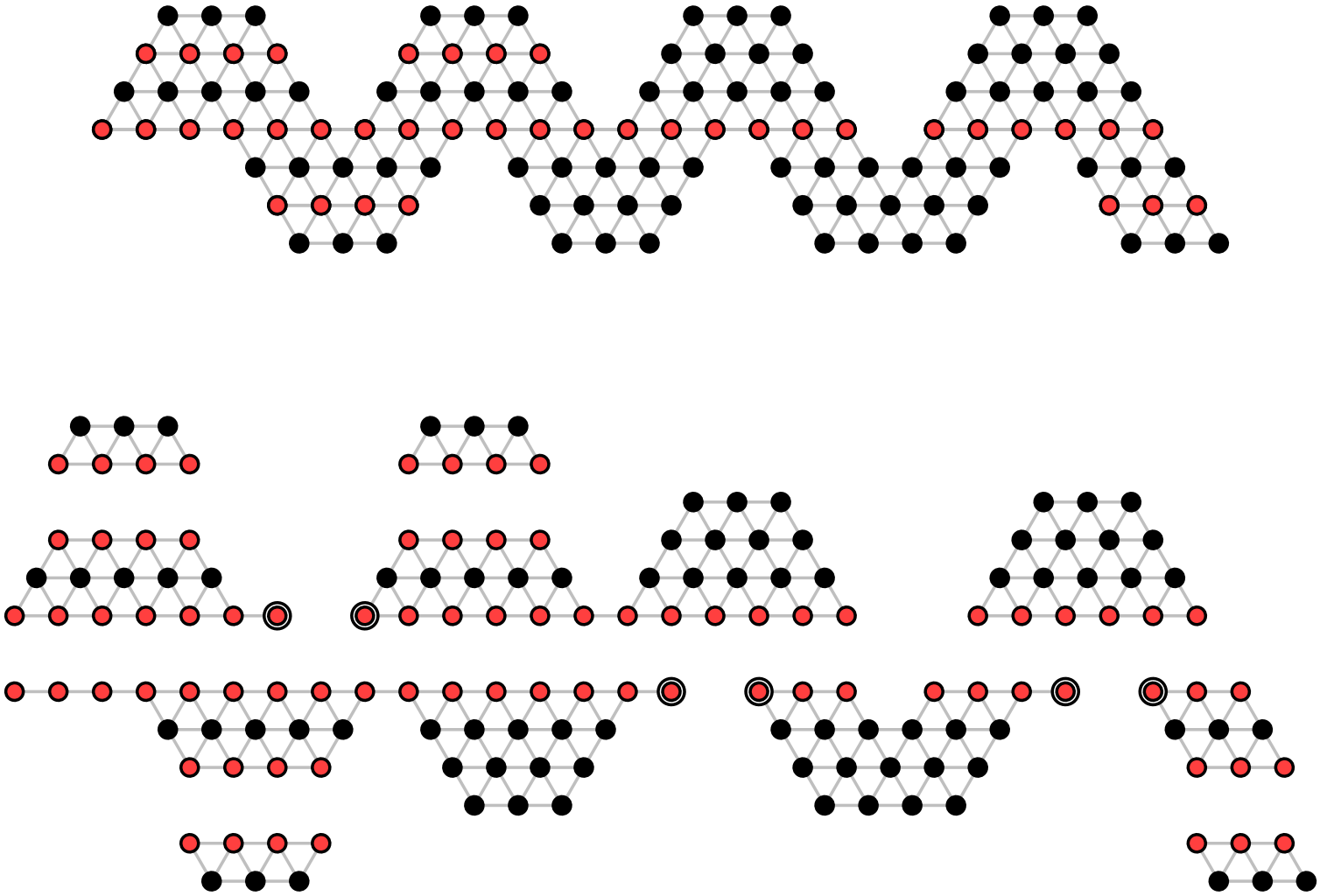




Single Pair Shortest Path (SPSP)



Shortest Path Forest with a Multiple Sources



Thank you for your attention

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