An efficient algorithm for the T-Row Facility Layout Problem

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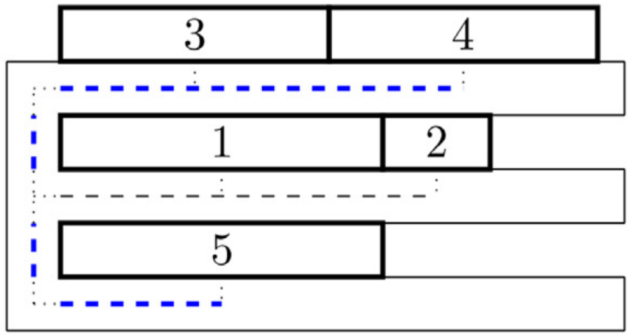
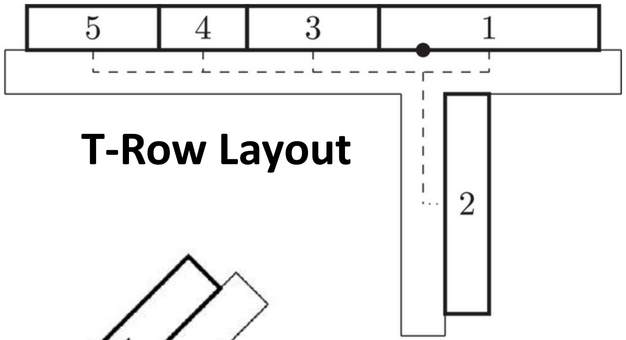
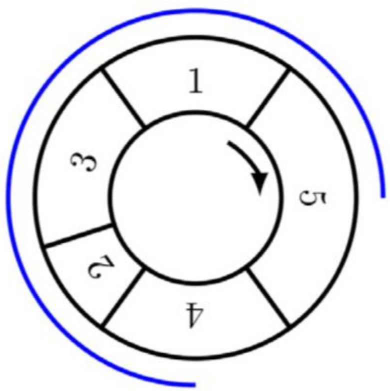
Facility Layout Problems



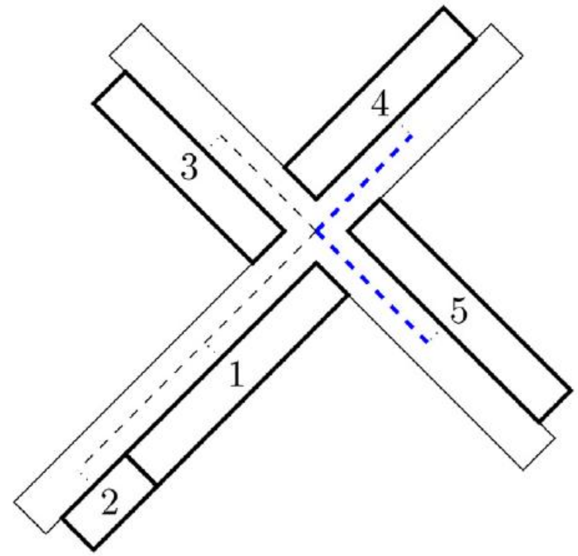
3-Bay Layout



T-Row Layout



Directed Circular Layout

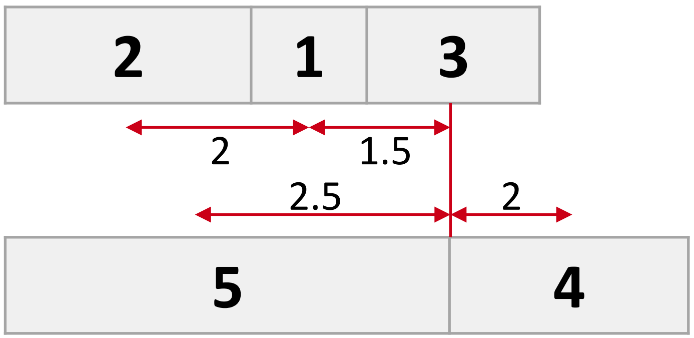


4-Pier Type Layout

Image sources: https://www.sciencedirect.com/science/article/pii/S0377221721001570
https://www.sciencedirect.com/science/article/pii/S0377221722003459

Row Facility Layout Problems

- Objective: **minimize** flow x distance
  - **Flow** (c_{ij}): usage / transit between two facilities.
  - **Distance** (d_{ij}): center to center.



$$\sum_{i=1}^{|F|} \sum_{j=1}^{|F|} c_{ij} d_{ij}$$

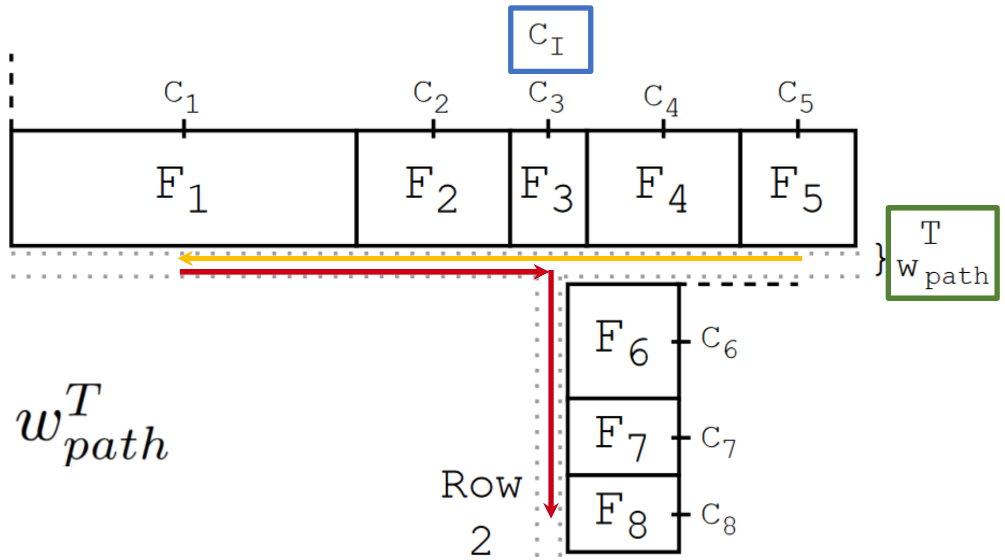
c_{ij}	1	2	3	4	5
1	0	0	1	1	4
2	0	0	3	0	2
3	1	3	0	1	2
4	1	0	1	0	1
5	4	2	2	1	0

Example: facility 3

1*1.5 + 3*3.5 + 1*2 + 2*2.5 = **19**

TR-FLP: Constraints

- Two rows must be placed in a **T shape**
- Distance measured as:



$$d_{ij} = |\overrightarrow{c_i - c_j}|$$
$$d_{ij} = |\overrightarrow{c_i - c_I}| + c_j + w^T_{path}$$

where:

- w^T_{path} is the **penalty for crossing** between rows
- c_I is the **crossing point**
- i is the **first facility**
- j is the **second facility**

NP-Hard

TR-FLP: State of the Art (I)

Solution approaches for facility layout problems

Dissertation

zur Erlangung des mathematisch-naturwissenschaftlichen Doktorgrades
„Doctor rerum naturalium“
der Georg-August-Universität Göttingen

im Promotionsstudiengang Mathematical Sciences
der Georg-August University School of Science (GAUSS)

vorgelegt von

Mirko Dahlbeck

aus Herne

TR-FLP: State of the Art (II)

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Production, Manufacturing, Transportation and Logistics

A mixed-integer linear programming approach for the T-row and the multi-bay facility layout problem

Mirko Dahlbeck [a b]

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Abstract

We introduce a new facility layout problem, the so-called T-Row Facility Layout Problem (TRFLP). The TRFLP consists of a set of one-dimensional departments with pairwise transport weights between them and two orthogonal rows which form a T such that departments in different rows cannot overlap. The aim is to find a non-overlapping assignment of the departments to the rows such that the sum of the weighted center-to-center distances measured in rectilinear directions is minimized. The TRFLP is a

TR-FLP: Algorithm Components

Constructives

- **Random**: Shuffle facilities and assign them to any row.
- **GRASP**: assignment cost in any position.

Shake

- **RandomMove:** Apply (k * n) random moves.

Local Search: FI & BI – **Neighborhoods**:

- **Insert**: reassign a facility to any position in any row.
- **Swap**: swap the position of two facilities.
- **ChangeIntersect**: adjusts the intersection point between both rows.
- **Extended**: combine movements from multiple neighborhoods.

TR-FLP: VNS approach

- Classic VNS + **GRASP** constructive:
  - **Best Improvement** LS: Extended(**Insert + Swap**)

Algorithm 1: $VNS(F, \alpha, k_{max})$

1: $S \leftarrow GraspConstructive(\alpha, F)$
2: $k \leftarrow 1$
3: **while** $k < k_{max}$ **do**
4: $\quad S' \leftarrow Shake(F, k, S)$
5: $\quad S'' \leftarrow ExtendedLocalSearch(S', F)$
6: $\quad$ **if** $\mathcal{F}(S'') \leq \mathcal{F}(S)$ **then**
7: $\quad\quad S \leftarrow S'$, $k \leftarrow 1$
8: $\quad$ **else**
9: $\quad\quad k \leftarrow k + 1$
10: **return** S

TR-FLP: Instances

- **Two types** of instances:
  - Classic FLP instances
  - Generated by Dahlbeck (2021)

- Instance **sizes**: $11 \leq |n| \leq 21$

- Environment:
  CPU Ryzen 1700, **Java** 21, 4GB Heap Limit

- Same methodology as SOTA:
  - $w_{path}^{T} = \{0, 3, 10\}$

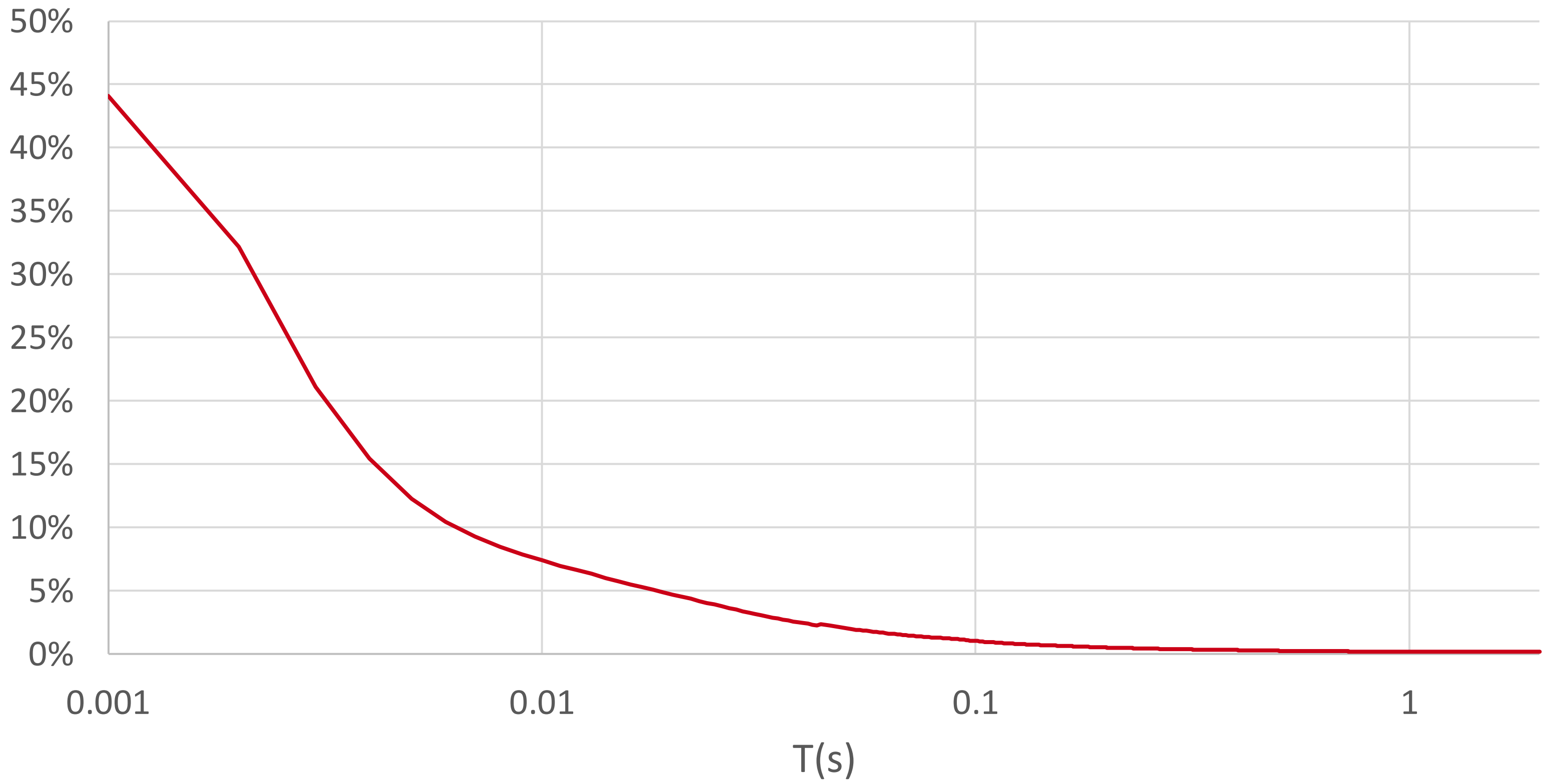
TR-FLP: Results (I)

- Dahlbeck 2021 (**MILP**):
  Mixed-Integer Linear Programming

	MILP		VNS	
w^T_{path}	#Best	Avg. T(s)	#Best	Avg. T(s)
0	49/50	2311.42	**50/50**	**0.72**
3	17/19	6549.63	**19/19**	**0.52**
10	17/19	6807.05	**19/19**	**0.50**
Total	83/88	5222.70	**88/88**	**0.58**

TR-FLP: Results (II)

- **%Gap** to best known value, averaged for all instances.



Conclusions & Future work

- **Promising results** in relation to the state of the art.
- Simple & **fast** algorithm based on the VNS metaheuristic.
- Future work:
  - **Automated tuning**: instead of manually configuring the approach.
  - Introduce **more challenging instances**.

https://github.com/mork-optimization

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