MESS 2024

Metaheuristics Summer School Competition

The Trigger Arc TSP

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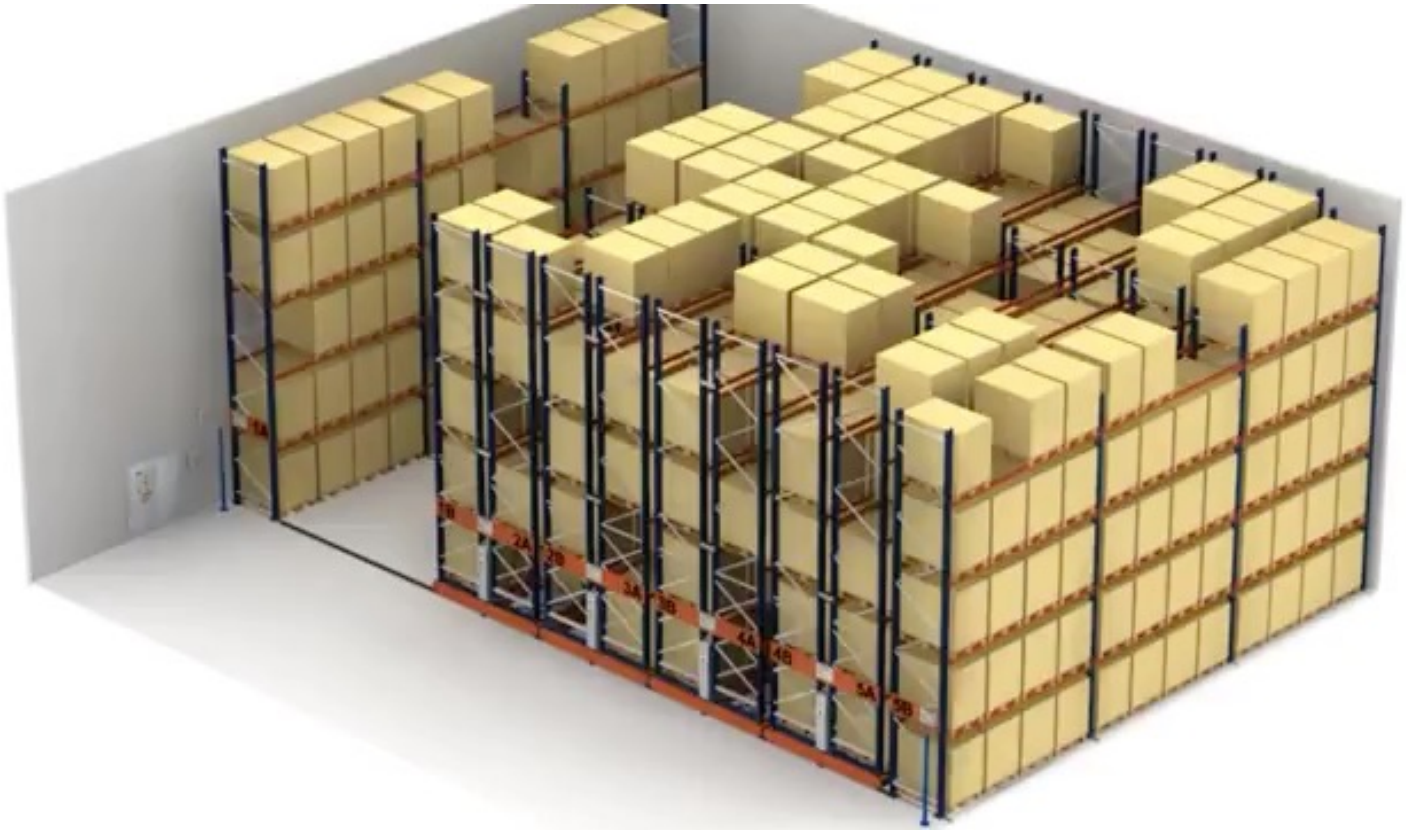
Outline of Presentation

- Introduction
  - Real-World Context
- Problem definition
- Competition Description

Introduction

Real-World Context

- The real-world application that inspired the definition of the *Trigger Arc Travelling Salesman* Problem is related to optimizing the *picking* phase of items in a warehouse equipped with a compactable storage system.



While inspired by this application, the proposed model can be applied to model much more complex scenarios.

Introduction

Real-World Context

- A compact storage unit is a logistical solution that features a set of mobile shelving units.
- These shelving units move along specific rails, this system allows the company to optimize the available space but also incurs additional costs, both in terms of the energy consumption needed to move the shelves and in terms of the operational times required for the shelf movements.
- The presence of groups of compactable aisles in these warehouses requires, during the item-picking phase, opening the compact storage in the desired aisle, causing the closure of the other connected aisles. This procedure increases the costs associated with accessing the closed aisles. Since operational costs and access times directly depend on the number of aisles moved, accessing a specific aisle can lead to an increase or decrease in the costs of the connected aisles, depending on the new aisle configuration.

Problem definition

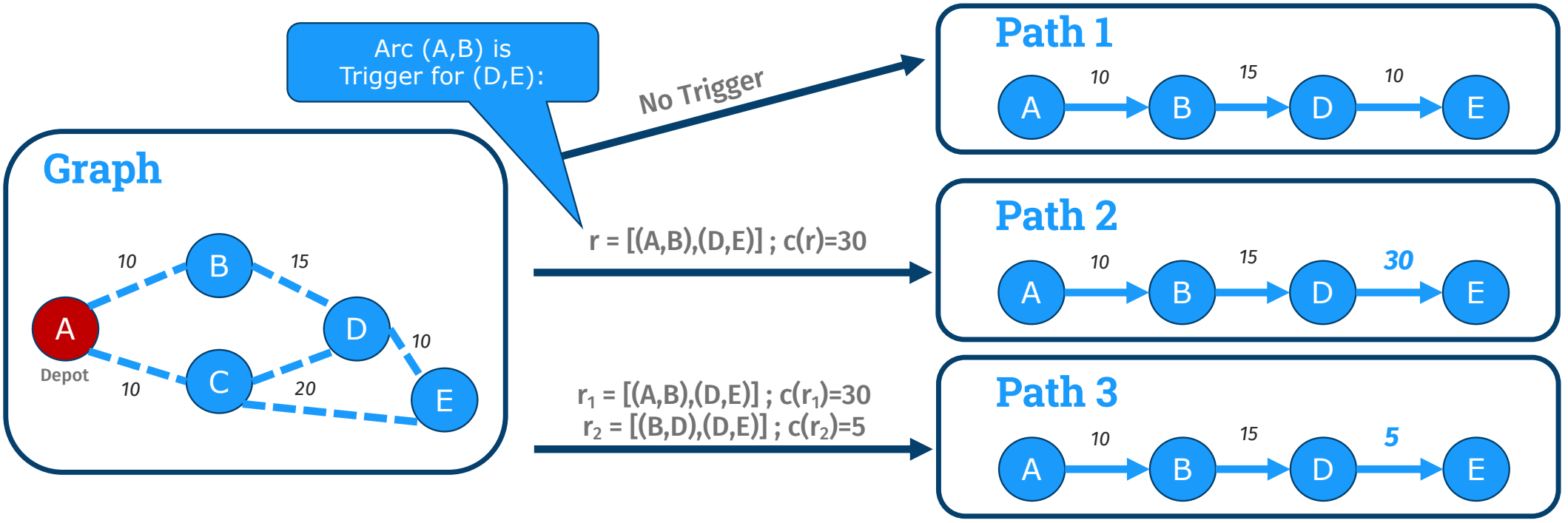
- The Trigger Arc Travelling Salesman Problem is defined as the problem of identifying in a graph G a Hamiltonian cycle of minimum cost considering relations defined between arcs.
- For each arc a in the graph, relations with other arcs can be defined, which act as triggers. If the trigger arc is traversed, the cost of the arc a is reset.
- Only the last trigger arc encountered before reaching the arc a is considered.
- The key concept in this problem is the definition of a trigger arc. If the relationship (t,a) is defined for arcs t and a, then arc t will act as a trigger for arc a, meaning that traversing arc t will result in the assignment of a new cost to arc a if a has not yet been traversed.

Problem definition (2)

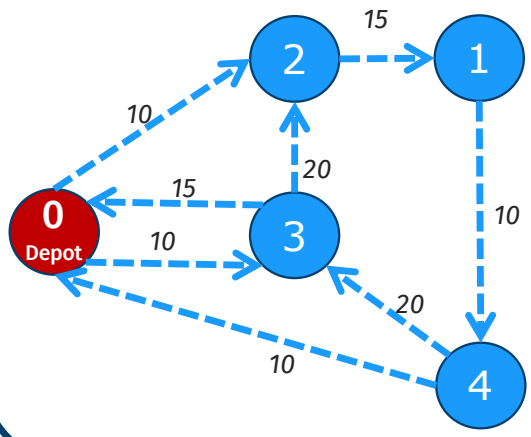
More formally, consider a directed graph $G = (N, A)$ with weights on the arcs. The node $0 \in N$ is designated as the starting node(depot). Let $c(a) \in \mathbb{R}^+ \; \forall a \in A$ be defined as the cost of traversing the arc a. For each arc $a = (h, k)$, a set of relations $R_a = \{(a_1, a) | a_1 \in A\}$ is associated. Finally, let $c(r) \in \mathbb{R}^+ \; \forall r \in R_a$, be the traversal cost of the arc a if the relation r is active. Let $T = (a_1, a_2, a_3, \ldots, a_{|N|})$ be the ordered sequence of arcs starting at node 0 representing a Hamiltonian cycle in G. The relation $r = (a_i, a_j)$ is active if and only if the arcs $a_i, a_j \in T$, and the arc a_i precedes the arc a_j in T and there is no active relation $r_1 = (a_{\hat{i}}, a_j) \in R_{a_j}$ such that a_i precedes $a_{\hat{i}}$ in T. It follows that for each arc a, at most one relation can be active. As a result, the traversal cost of the arc $a = (h, k)$ will be equal to $c(a)$ if there are no active relations in R_a or $c(r)$ if r is the only active relation in R_a.

Trigger Example

- If the relationship (t,a) is defined for arcs t and a, then arc t will act as a ***trigger*** for arc a, meaning that traversing arc t will result in the assignment of a new cost to arc a if a has not yet been traversed.



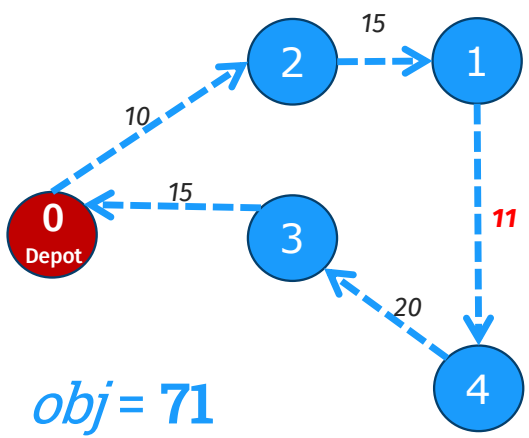
Graph



Relations

#	Trigger / Target	Cost
r_1	(0,2),(1,4)	$c(r_1)=3$
r_2	(2,1),(1,4)	$c(r_2)=11$
r_3	(2,1),(3,2)	$c(r_3)=3$
r_4	(2,1),(4,0)	$c(r_4)=6$
r_5	(3,0),(1,4)	$c(r_5)=5$

Solution 1



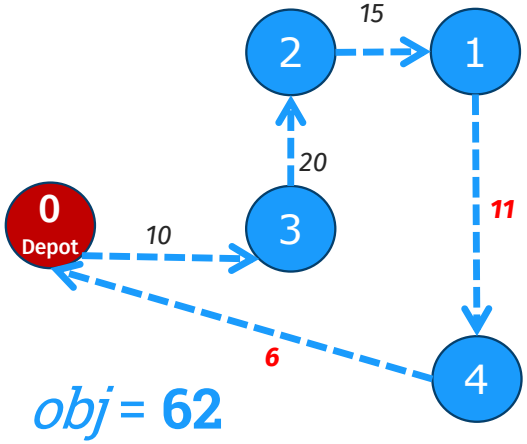
obj = **71**

Starting our tour from node 0, in this solution we have the r_2 relation active thanks to the traversal of the trigger arc (2,1); this relation has changed the cost of arc (1,4) to 11.

The trigger in r_1 was activated after crossing the arc (0,2), but it was canceled by the trigger in r_2 since the arc (2,1) was crossed afterwards.

The r_5 relation was not activated because the arc (3,0) was crossed only after already using the arc (1,4).

Solution 2



obj = **62**

In this solution, the relations r_2 and r_4 are active as a result of crossing the edge (2,1) and modify the cost of edges (1,4) and (4,0).

For the other edges, the cost from the initial graph applies.

Competition Description

- Participants will need to form groups consisting of up to 3 people.
- Participants are expected to develop the most suitable metaheuristic algorithms to solve the given problem.
- The created solutions must be uploaded to the portal.
- The score for each instance will be calculated based on the objective function value and the submission date of the solution.
- The leaderboard will be created based on the sum of the scores of individual instances.
- During the three months of the competition, new instances will be released, usually created with different generators. The use of heterogeneous instances is intended to ensure that the developed techniques are adaptable and flexible.
- Participants can update their submitted solutions at any time until the end of the competition.

Schedule of the Competition

- **Monday, 15th July 16:30** **Presentation**
- **Tuesday, 16th July 12:30** **Discussion & ideas exchange**
  - Constructive discussion on the problem, possible approaches, and clarification of any doubts.
- **Thursday, 18th July 15:00** **Presentation of proposals**
  - All groups will have a few minutes to present their ideas. A proposal of about one page should be prepared, in which groups describe their basic idea or the main ideas they have gathered. This proposal is not binding regarding the technique that will eventually be implemented.
- **After July 22nd** **Credentials**
  - You will receive the necessary credentials to start submitting solutions.
- **October 16th** **End**
  - Will be the last day to submit solutions. The leaderboard will be frozen, and the winners will be announced.

Competition Web Portal

- **You can access the competition portal at the following link:**

https://fourclicks.eu/fck/mess2024/frontend/#

- **To create an account, please send an email to *mess2024competition@gmail.com* including the following information:**
  - Team name
  - Team members and their nationalities and affiliations
- **You will receive your login credentials via email (*after the 22 of July*).**
- **On the website, the following will be immediately available (*even without logging in*):**
  - An initial set of instances to solve.
  - Problem description.
  - Description of the ranking calculation.
  - The ability to test the admissibility and value of the produced solutions.
- **Only after obtaining the credentials will it be possible to start submitting your solutions.**

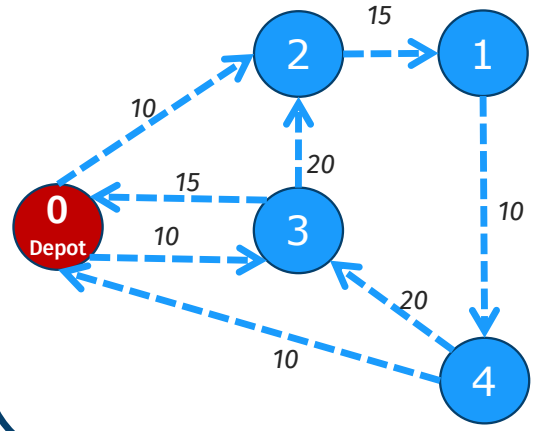
Instance Format

- The instances are provided as text files (UTF-8).
- The first line contains the number of nodes, number of arcs, and number of relationships separated by spaces:|N| |A| |R|.
- Nodes are represented by integers between 0 and (|N|-1). Node 0 is also the depot.
- Following this, there are |A| lines associated with the arcs. Each line consists of arc index, from node, to node, and cost.
- Next, there are |R| lines containing: Relationship index, (index, from, to) for the trigger arc, (index, from, to) for the target arc, and new target arc cost.

File

```
5 8 4
0 0 2 10.0
1 0 3 10.0
2 1 4 10.0
3 2 1 15.0
4 3 0 15.0
5 3 2 20.0
6 4 0 10.0
7 4 3 20.0
0 0 0 2 2 1 4 3.0
1 3 2 1 2 1 4 11.0
2 3 2 1 3 5 2 3.0
3 3 2 1 6 4 0 6.0
```

Graph



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