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Optimization methods and algorithms

ColoTe Project

a multistart tabu search approach

group **26**

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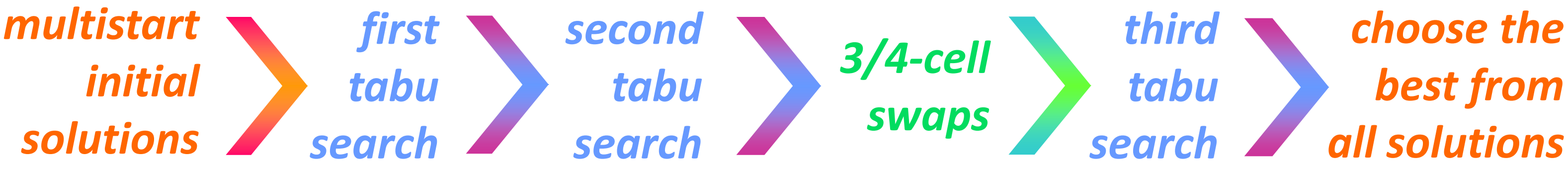
Algorithm overview



multistart initial solutions

first tabu search

second tabu search

3/4-cell swaps

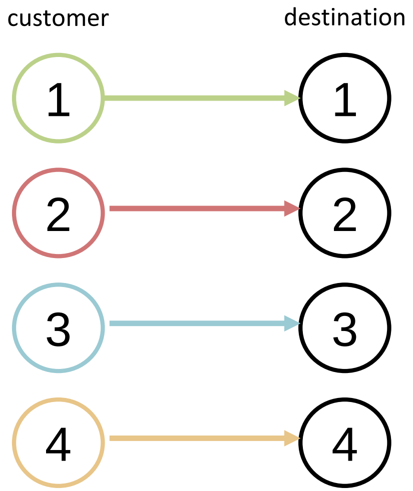
third tabu search

choose the best from all solutions

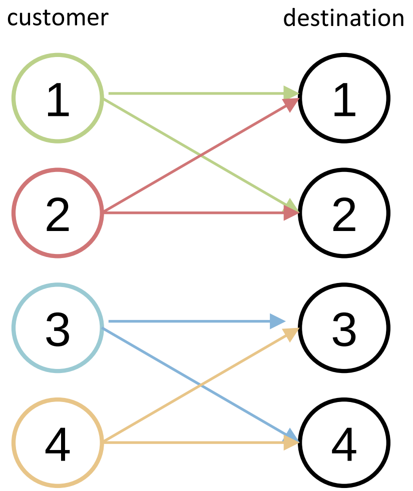
- Each **initial solution** is created by a thread with a different parameter
  - This variation produces **different initial solutions** (and, as a consequence, different final solutions)
  - Initial solutions make use of **arches sorting** (according to their costs) to obtain a good initial gap
- **Tabu search** performs swaps of users among cells. The program uses three kinds of tabu search, each one distinct from the others because of the different swap used
- **Cell swaps** perform some particular moves not done by the tabu search. They work with already taken users and deal with three or four cell at a time
- The solution of each instance is **the best** of all the different solutions produced by each thread

Initial greedy solution

- Distributes customers to destinations in **different orders**
  - From the first to the last destination
  - From the last to the first destination
  - Pseudorandom way (using fixed *seeds*)
- Assigns to the destination the **cheapest** customers available
- **Variety coefficient** is used to diversify the solution created
- Tracks all the tasks done in **surplus**
- Tracks all the **customers** assigned to more than one destination



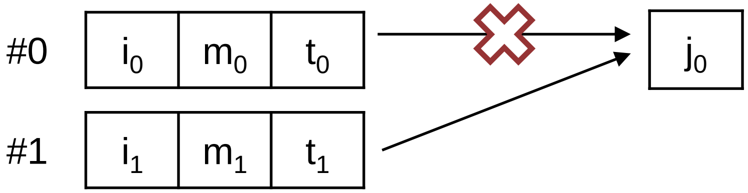
variety coefficient = 1



variety coefficient = 2

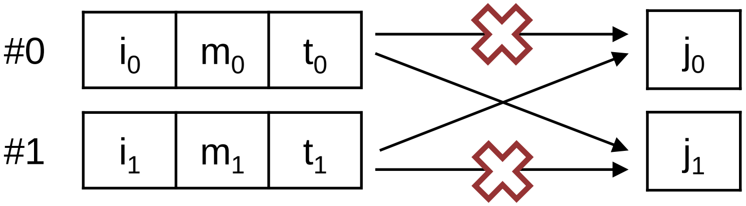
First tabu search: «free»

- **Neighborhood**: customers *not assigned* and close to the destination
- **Metaheuristic tuning:**
    - **Aspiration criterion**: best objective function
    - **Tabu move**: move of a customer to destination
    - **Reactive tabu list:**
        - Initial tenure: *10*
        - Tenure *+50%* if unimproving moves ≥ *4*
        - Tenure *-50%* if improving moves ≥ *16*
    - **Stopping criteria**: *55* number of iterations or *15* unimproving moves
    - **Neighborhood size**: *20* customers
- **Purpose**: improve the solution by swapping not assigned customers



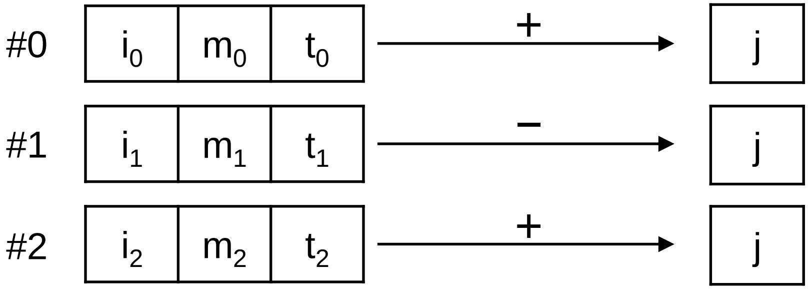
Second tabu search: «taken»

- **Neighborhood**: customers *already assigned* and close to the destination
- **Metaheuristic tuning:**
  - **Aspiration criterion**: best objective function
  - **Tabu move**: move of a customer to destination
  - **Reactive tabu list:**
    - Initial tenure: *10*
    - Tenure *+50%* if unimproving moves ≥ *4*
    - Tenure *-50%* if improving moves ≥ *16*
  - **Stopping criteria**: *40* number of iterations or *15* unimproving moves
  - **Neighborhood size**: *20* customers
- **Purpose**: improve the solution by swapping already assigned customers



First swap: «three-cell»

- Swap between 3 customers who have the same destination



#0	i_0	m_0	t_0	+	j
#1	i_1	m_1	t_1	−	j
#2	i_2	m_2	t_2	+	j

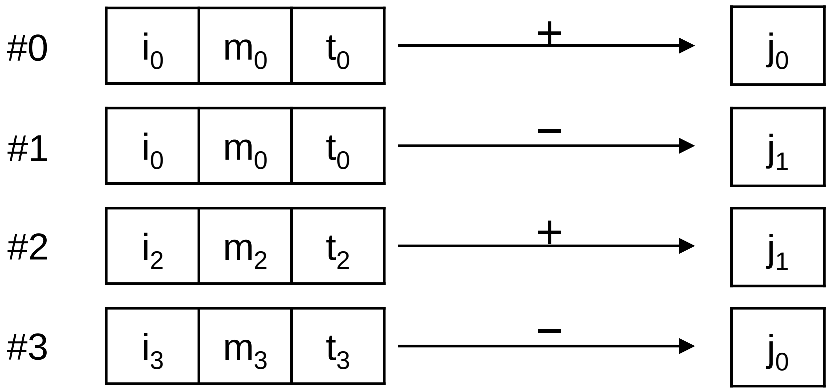
Neighborhood size = 20

Constraint: the tasks done by user *#1* must be replaced by the same amount of tasks, done by user *#0* and *#2*.

tasks m_1 = *tasks* m_0 + *tasks* m_2

Second swap: «four-cell»

- Swap between 4 customers who have two destinations in common



#0 i_0 m_0 t_0 $\xrightarrow{+}$ j_0

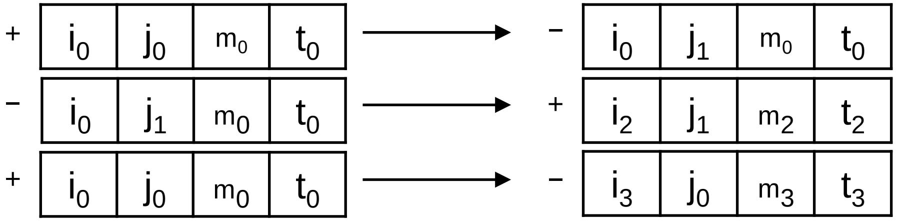
#1 i_0 m_0 t_0 $\xrightarrow{-}$ j_1

#2 i_2 m_2 t_2 $\xrightarrow{+}$ j_1

#3 i_3 m_3 t_3 $\xrightarrow{-}$ j_0

Neighborhood size = 20

Constraints:



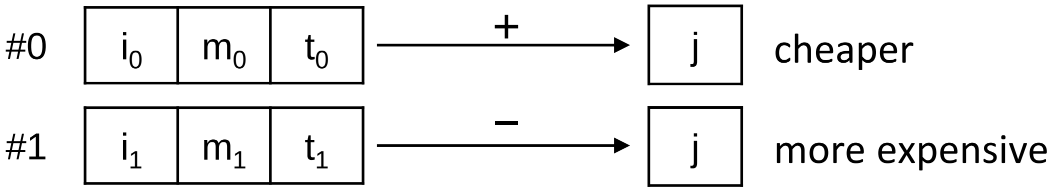
$+$ i_0 j_0 m_0 t_0 $\longrightarrow$ $-$ i_0 j_1 m_0 t_0

$-$ i_0 j_1 m_0 t_0 $\longrightarrow$ $+$ i_2 j_1 m_2 t_2

$+$ i_0 j_0 m_0 t_0 $\longrightarrow$ $-$ i_3 j_0 m_3 t_3

Third tabu search: «trim»

- **Neighborhood**: customers not assigned or assigned close to the destination
- **Metaheuristic tuning:**
    - **Aspiration criterion**: best objective function
    - **Tabu move**: move of a customer to destination
    - **Reactive tabu list:**
        - Initial tenure: *10*
        - Tenure *+50%* if unimproving moves ≥ *4*
        - Tenure *-50%* if improving moves ≥ *16*
    - **Stopping criteria**: *30* number of iterations or *5* unimproving moves
    - **Neighborhood size**: *10* customers
- **Purpose**:
    - remove the tasks in surplus
    - assign as much tasks as possible to the cheaper customers



#0 i_0 m_0 t_0 $\xrightarrow{+}$ j cheaper

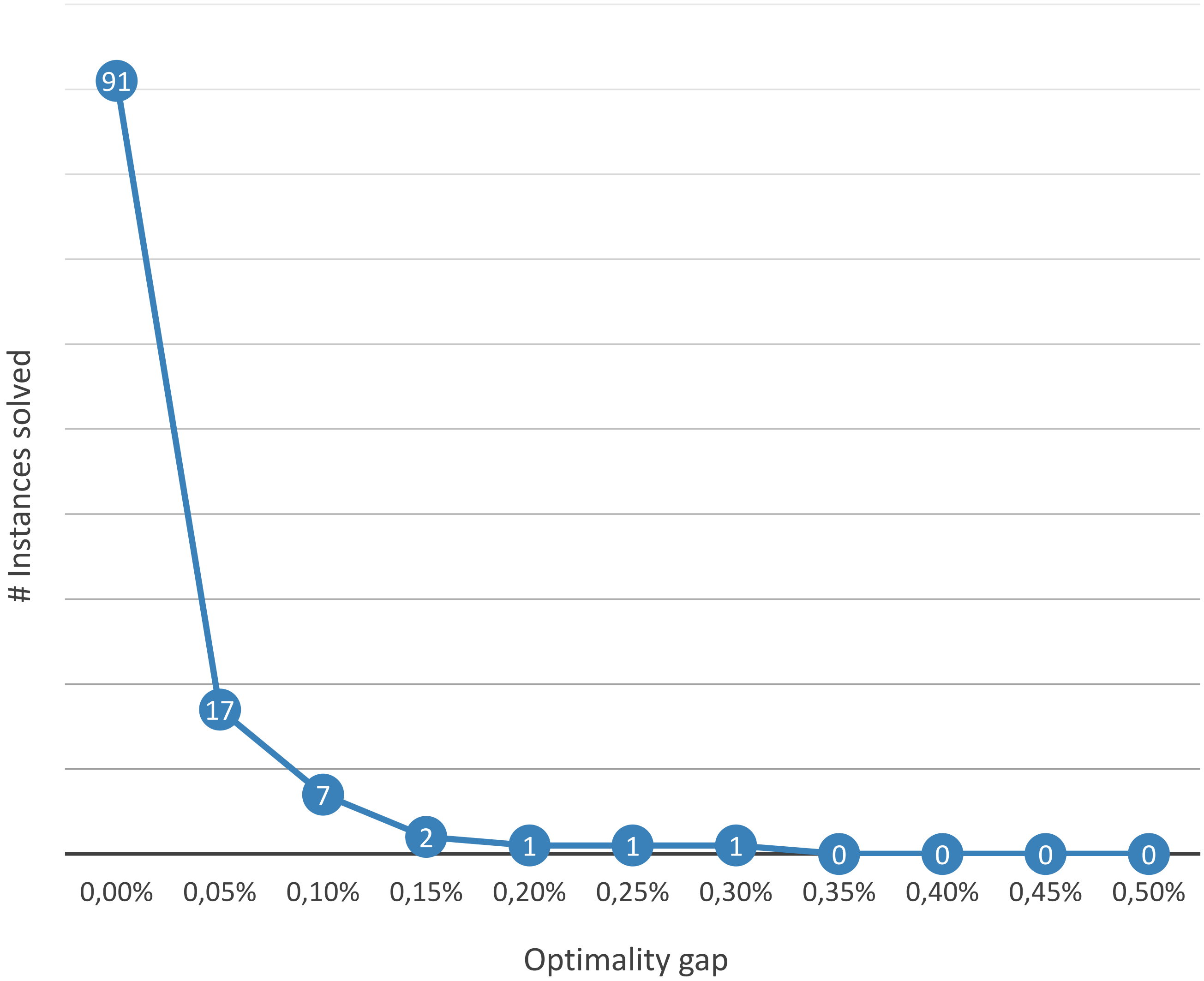
#1 i_1 m_1 t_1 $\xrightarrow{-}$ j more expensive

Overall results

INSTANCE TYPE	AVG TIME (i5 *@2.7GHz*)	AVG TIME (i7 *@2.6GHz*)	AVG OPTIMALITY GAP
30_1	0,348 s	0,345 s	**0,01 %**
30_20	0,188 s	0,151 s	**0,00 %**
100_1	2,491 s	1,590 s	**0,05 %**
100_20	0,880 s	0,732 s	**0,00 %**
300_20	2,348 s	2,525 s	**0,01 %**

- The program finds an **optimal solution** for more than the **75%** of the instances
- **Every** (non-optimal) solution has an optimality gap below 0.3%

Gaps frequency distribution



Overall results (hard instances)

- The program is also capable of solving the **hard** instances with very good gaps (always below 2%)

HARD INSTANCE	TIME	OPTIMALITY GAP
30_1_ST_0	0,246 s	**0,00 %**
30_1_TL_0	0,325 s	**0,07 %**
30_1_TT_0	0,309 s	**1,72 %**
30_20_ST_0	0,438 s	**1,89 %**
30_20_TL_0	0,166 s	**0,40 %**
30_20_TT_0	0,201 s	**1,49 %**
100_1_ST_0	0,861 s	**1,93 %**
100_1_TL_0	1,971 s	**0,38 %**
100_1_TT_0	1,646 s	**0,42 %**
100_20_TL_0	0,684 s	**0,12 %**
100_20_TT_0	1,050 s	**0,75 %**

Thanks for your attention

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