

On the Technician Routing and Scheduling Problem

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Agenda

- Motivation
- The Technician Routing and Scheduling Problem (TRSP)
- Proposed approach
- Validation and preliminary results
- Conclusions and perspectives





Motivation

- Industrial partner
 - Software solution for the operation of a crew of technicians
 - Technician crew
 - Serve a set of requests for service
 - Distributed geographically (routing)
 - Satisfying time constraints (scheduling)
 - Balance workload and minimize working hours
 - Clients from different sectors
 - Maintenance operations
 - Telecoms
 - Public services





The TRSP

• Technician Routing and Scheduling Problem







The TRSP - Definition

- Set of requests
 - Location
 - Required skills, tools, spare parts
 - Time window and service time
- Crew of technicians
 - Starting/ending location (*home*)
 - Set of skills, initial tools, spare parts
 - Working day length
- Main depot
 - Technicians can pickup tools and spare parts
 - Unlimited tools and spare parts





The TRSP - Definition

- Design one tour per technician
 - Service all requests
 - Satisfy skills, tools, and spare parts constraints
 - Satisfy time windows
 - Respect working regulations
- Objectives
 - Minimize total working time
 - Balance tours
 - Minimize maximum tour duration (working time)





The TRSP - Related problems

- Technician scheduling
 - Routing is ignored
 - Team forming
 - ROADEF Challenge 2007, Cordeau et al. (2010), Hashimoto et al. (2009)
- Home care routing and scheduling
 - No tools, no spare parts
 - Eveborn et al. (2006)
- Technician routing
 - No tools, no spare parts
 - Cluster first, route second
 - Boreinsten et al. (2010)





Proposed approach

- Constructive heuristic
 - Feasible tours
 - Minimize working time
 - Balance tours
- Local search
 - Optimize each tour
- Adaptive Large Neighborhood Search (ALNS)
 - Minimize working time
 - (Balance tours)







Constructive heuristic

- Start with 1 empty tour per technician
- Do
 - Evaluate insertion cost (tour duration) of all pending requests in all tours
 - If one request cannot be inserted: backtrack
 - Solve an assignment problem
 - Assign one request per technician
 - Until
 - Feasible solution
 - Given number of failures
- Apply local search (2-opt, shift)
- Return the feasible solution, or the one servicing most requests





Adaptive Large Neighborhood Search

- Algorithm [Pisinger and Ropke, 2007]
 - Select a *destroy* and *repair* operator
 - Destroy and repair current solution
 - Update operator scores
- Destroy
 - Random, Related, Critical
- Repair
 - Best insertion, 2-Regret





Adaptive Large Neighborhood Search

- Why an ALNS
 - Flexible
 - Experiment with different objectives
 - Account for various constraints
 - Good results on other routing problems
- Specificities
 - Parallelization of repair methods
 - New relatedness measure accounting for skills, tools, and spare parts





Validation of the approach

- Solomon CVRPTW instances
 - 100 customers, 56 instances
 - CVRPTW → TRSP
 - Technician homes = central depot
 - No tools, no required skills
 - The demand is modeled as spare part requirements
 - Objective: minimize total distance





Validation of the approach

Instance group	Avg. best gap*	Avg. gap*
C1	0.20%	0.20%
C2	0.40%	0.40%
R1	0.27%	0.63%
R2	0.87%	1.52%
RC1	0.81%	1.59%
RC2	1.01%	1.63%
Overall	0.58%	0.98%
Pisinger and Ropke (2007)	0.36%	-

*Setting: 10 runs per instance, 25k iterations





Test instances

- Collection of real world data in progress
- Adaptation of Solomon size 100 instances
 - 13 or 25 technicians (avg. 8 or 4 requests per tech.)
 - Homes randomly generated
 - 5 tools, 5 skills, 5 types of spare parts
 - Technicians
 - On average: 3 skills, 2.5 tools, and 3.5 spare part types
 - Requests
 - 1 skill, on average 1 tool and 1 spare part type





Preliminary results

13 technicians

25 technicians

Group	Gain: total time	Gain: Iongest tour	Time (s)	# solved	Gain: total time	Gain: Iongest tour	Time (s)	# solved
C1	8.70%	-5.57%	42	69	44.80%	-11.38%	62	90
C2	67.43%	-5.51%	44	80	81.73%	-6.97%	63	80
R1	-0.10%	-2.90%	76	1	34.67%	0.29%	82	116
R2	69.55%	-15.12%	49	110	82.58%	-14.53%	66	110
RC1	-	-	-	0	34.48%	-0.66%	79	80
RC2	65.56%	-13.50%	46	80	80.20%	-12.90%	63	80
Average	55.56%	-10.51%	46	340	59.08%	-7.61%	70	556

*Setting: 10 runs per instance, 10k iterations





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Group

C1

C2

R1

R2

RC1

RC2

Average



Preliminary results

13 technicians			25	25 technicians			
Gain: longest tour	Time (s)	# solved	Gain: Iongest tour	Time (s)	# solved		
-5.57%	42	69	-11.38%	62	9		
-5.51%	44	80	-6.97%	63	8		
-2.90%	76	1	0.29%	82	11		
-15.12%	49	110	-14.53%	66	11		
-	-	0	-0.66%	79	8		

-12.90%

-7.61%

*Setting: 10 runs per instance, 10k iterations

-13.50%

-10.51%

80

340

46

46

90

80

116

110

80

80

556

63

70









Conclusions

- The TRSP
 - Numerous applications
 - Generalization of existing problems
 - Challenging applications
 - Embedded systems
 - Real time reoptimization of the routing





Perspectives

- Generate a testbed
 - Ensure instance feasibility
- Bi-objective
 - Minimize total duration
 - Balance tours
- Dynamic case
 - Arrival of new requests
 - Unexpected delays



Thank you for your attention

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