A simulated annealing algorithm to solve the log-truck scheduling problem

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Overview

- Overview of transport planning
- Truck scheduling
- Modelling approach & SA algorithm
- Case studies: small and real-life examples
- Modelling & implementation challenges

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Need of DSS for transport planning

Transportation is most costly aspect of forestry supply chains –

- 25-27 million tons/year wood transported in Australia
- Transport costs $1.2 million/day or 40% of total costs

Decision support systems for better transport planning reduces these costs by providing:

- Stronger decision support in company
- Appropriately sized transport fleet
- Higher utilization of trucks with fewer: delays, idling, queues and under capacity deliveries

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Daily truck scheduling problem

Source: Skogforsk

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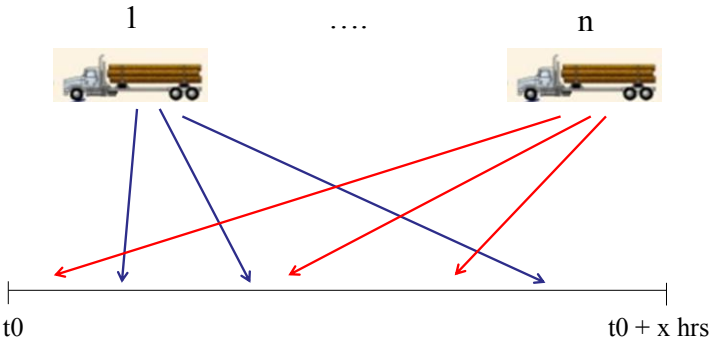
Truck scheduling – FastTRUCK approach



The whole day is scheduled for each truck at a time

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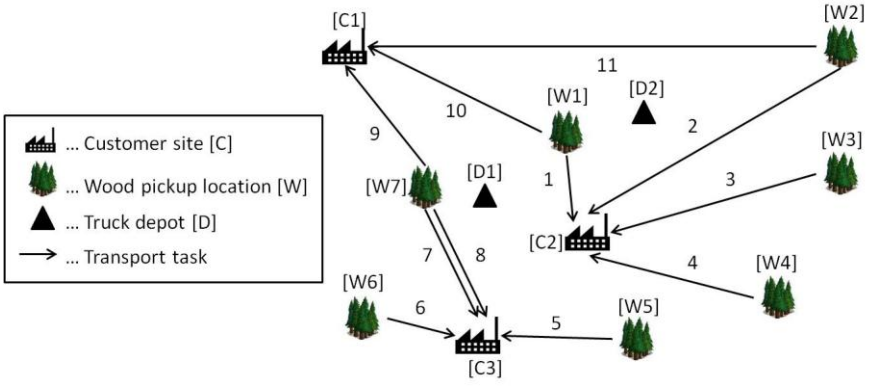
Modelling approach
Transport tasks



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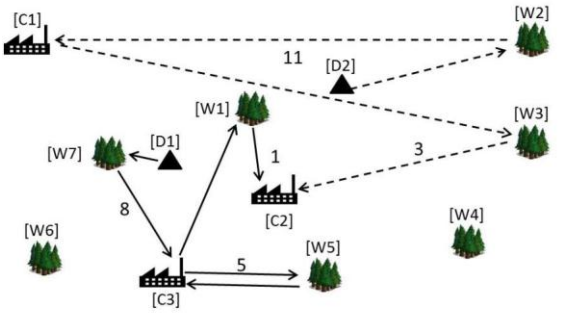
Modelling approach

- Several transport tasks are predefined. Each task is defined by a coupe, mill, and product (wood grade).

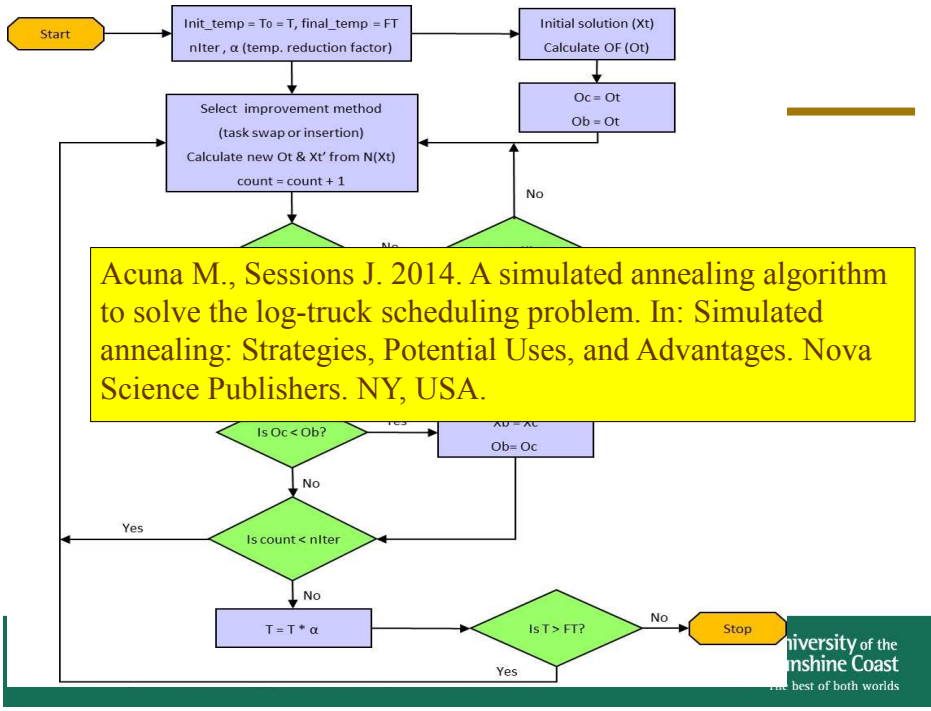
# Task Groups	15					
# Tasks	30					
Task Group	From Task	To Task	Coupe	Mill	Product	Type
1	1	2	1	1	1	1
2	3	4	1	2	1	1
3	5	6	1	3	1	1
4	7	8	2	1	1	1
5	9	10	2	2	1	1
6	11	12	2	3	1	1
7	13	14	3	1	1	1
8	15	16	3	2	1	1
9	17	18	3	3	1	1
10	19	20	4	1	1	1
11	21	22	4	2	1	1
12	23	24	4	3	1	1
13	25	26	5	1	1	1
14	27	28	5	2	1	1
15	29	30	5	3	1	1

Modelling approach

Initial feasible solution for small example (11 tasks, 4 trucks)

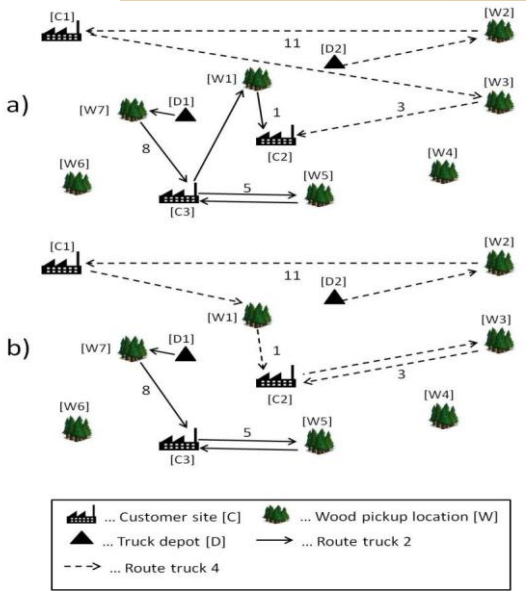


Route for truck 1	→	Task 9	Task 7	Task 6
Route for truck 2	→	Task 8	Task 5	Task 1
Route for truck 3	→	Task 10	Task 2	Task 4
Route for truck 4	→	Task 11	Task 3	



Acuna M., Sessions J. 2014. A simulated annealing algorithm to solve the log-truck scheduling problem. In: Simulated annealing: Strategies, Potential Uses, and Advantages. Nova Science Publishers. NY, USA.

SA - Improvement methods



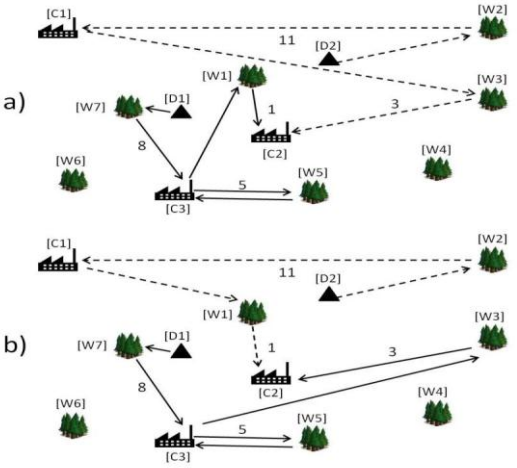
Insertion

Tasks

Truck 2	8	5	1
Truck 4	11	3	

Truck 2	8	5	
Truck 4	11	1	3

SA - Improvement methods



Swap

	Tasks		
Truck 2	8	5	1
Truck 4	11	3	

Truck 2	8	5	3
Truck 4	11	1	

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Results – small example

Neighborhood structure*	Average SA solution	Best SA solution	Deviation (%)
60 / 20 / 10 / 10	2685	2660	0.0
80 / 0 / 20 / 0	2697	2673	0.5
40 / 40 / 10 / 10	2700	2687	1.0
20 / 60 / 10 / 10	2706	2693	1.2
0 / 80 / 0 / 20	2841	2805	5.4

(*) % probability for : insertion / swap / insertion for a set of n-trials / swap for a set of n-trials

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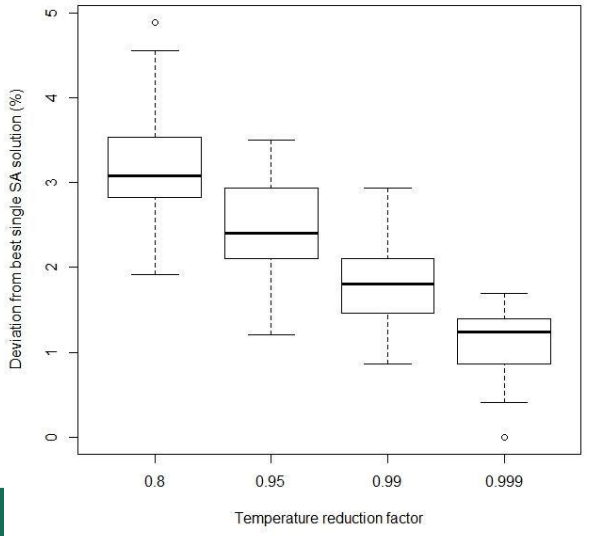
SA cooling scheme
Temperature reduction factor



The single most important SA parameter to get good solutions.

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Results – small example

Parameters SA			SA solution	
Temperature adjustment factor	**Initial temperature**	**Iterations per temperature**	**Solution value**	**Deviation (%)**
0.8	20000	1500	2711	2.4
0.95	40000	1000	2692	1.6
0.99	40000	1500	2683	1.3
0.999	20000	1000	2660	0.4

Optimal solution with GAMS® & CPLEX® = 2648

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Results – performance metrics for a real-life problem

Parameters SA	Brute	Greedy	SA
Number of trucks	64	64	64
Total daily cost ($)	95,053	95,531	94,361
Unit daily cost ($/t)	20.1	19.2	18.7
Wood delivered (t)	4,727	4,988	5,046
Truck loads	163	172	174
Unloaded time (min)	18,733	16,884	17,209
Avg. truck utilization (%)	91.3	89.0	90.2
Avg. waiting time (min)	62	76	74
Avg. loaded running (%)	47.7	52.5	52.0

Brute = random, Greedy = shortest time, SA = simulated annealing

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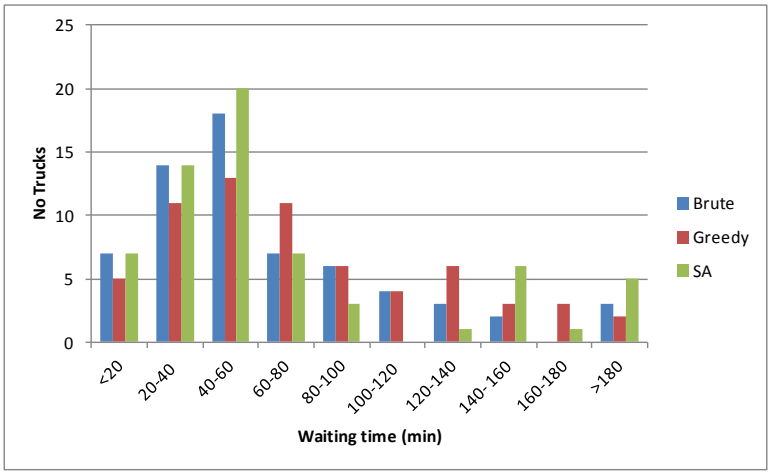
Results – waiting time



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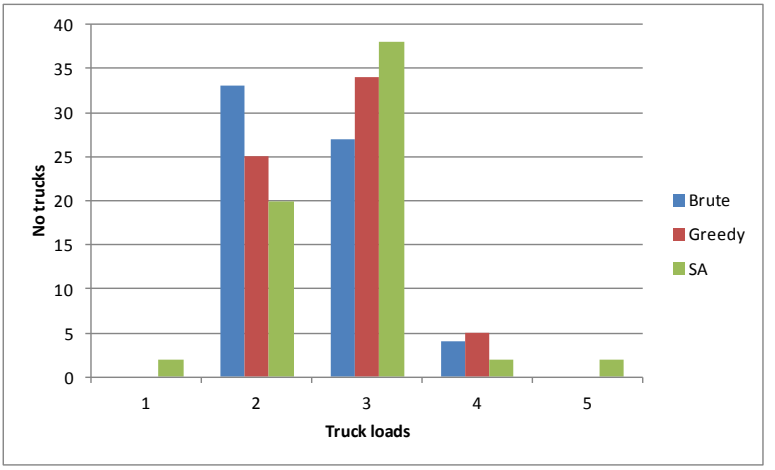
Results – truck loads



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Results – truck loads

SLOT INFORMATION FIRST TRIP

Truck	Truck ID	Task	Coupe	Slot	Slot time	Product
1	39	31	4	1	4:00	2
2	3	15	2	1	4:00	1
3	34	20	2	2	4:20	1
4	13	93	10	1	4:00	4
5	43	32	4	2	4:20	2
6	50	33	4	3	4:40	2
7	23	100	10	2	4:20	4
8	30	113	12	1	4:00	5
9	6	117	12	2	4:20	5
10	46	34	4	4	5:00	2
11	57	35	4	5	5:20	2
12	11	133	14	1	4:00	6
13	45	36	4	6	5:40	2
14	16	135	14	2	4:20	6
15	55	37	4	7	6:00	2
16	64	38	4	8	6:20	2
17	52	39	4	9	6:40	2
18	47	40	4	10	7:00	2
19	33	140	14	3	4:40	6
20	14	151	16	1	4:00	7
21	41	191	20	1	4:00	8
22	62	192	20	2	4:20	8
23	59	193	20	3	4:40	8
24	20	156	16	2	4:20	7
25	25	158	16	3	4:40	7

Truck	Truck ID	Task1	Task 2	Task 3	Task 4	Task 5	Task 6
1	39	31	11	12	13	14	
2	3	15	16	17	18	19	
3	34	20	91	92			
4	13	93	94	95			
5	43	32	96	97			
6	50	33	98	99			
7	23	100	111	112			
8	30	113	114	115	116		
9	6	117	118	119	120		
10	46	34	131	181			
11	57	35	132	182			
12	11	133	183	21			
13	45	36	134	184			
14	16	135	185	22			
15	55	37	136	186			
16	64	38	137	187			
17	52	39	138	188			
18	47	40	139	189			
19	33	140	190	23			
20	14	151	152				
21	41	191	24	153			
22	62	192	25	154			
23	59	193	26	155			
24	20	156	157				
25	25	158	159				

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Truck scheduling – Modelling challenges

- Objective function being used (e.g. Min. total costs vs Max. Truck Productivity)
- Metrics to be used and reported (loaded running, vehicle utilisation, tonne-km per vehicle, # of vehicles, total cost)
- How the algorithm captures the operational aspects of the problem
- Provide solutions in a reasonable time that are accepted by planners and dispatchers (credibility test)

Truck scheduling – Implementation challenges

- Organisational change for forest companies
- Strong initial opposition from truck drivers and contractors
- Information sharing
- Cost/effort of collecting input data (logistics platform)
- Cost/effort of developing and implementing schedule (management intensity and time scale)

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