

Optimization of Pooled Log Transport



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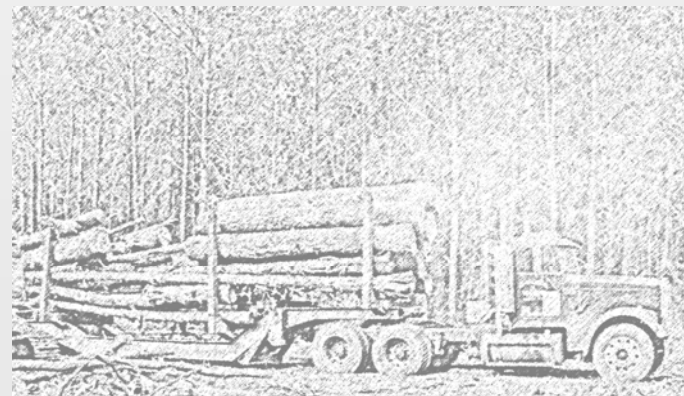
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Pooled Log Transport Logistics

- Optimization Model
- Route Generation
 - Comparison to existing
 - Large, small delivery systems



Optimization of Tree-Length Delivery

- Numerous system models developed
- Very efficient solution techniques



Optimization Benefits

- Glen Murphy (2003, *SJAF*) 25 - 50% reduction in fleet size to haul the same amount of wood
 - Tactical analysis tool for small problems
- Weintraub and others (1996, *Interfaces*) 32% reduction in fleet size, 31% increase in productive hours



Tree-Length Transport

- Pooled systems beginning to be implemented
- Human dispatch accepted
 - Improvements seen
 - Reliable, flexible
- Optimal allocation – not so much



System Model

- Treated as a combinatorial routing problem
- Minimize unloaded mileage
 - Subject to constraints
- Time not explicitly accounted for

$$\text{Min } F = \sum_{i=1}^T \sum_{l=1}^L \sum_{m=1}^M \sum_{j=1}^N Y_{ilmj} D_{lm}$$

$$\sum_{l=1}^L \sum_{m=1}^M X_{ilmj} \leq 1 \quad i = 1 \dots T, j = 1 \dots N$$

$$\sum_{l=1}^L \sum_{m=1}^M Y_{ilmj} \leq 1 \quad i = 1 \dots T, j = 1 \dots N$$

$$\sum_{k=1}^L Y_{imkj} \leq \sum_{k=1}^L X_{ikmj} \quad i = 1 \dots T, m = 1 \dots M, j = 1 \dots N$$

$$\sum_{k=1}^M X_{ilkj+1} \leq \sum_{k=1}^M Y_{iklj} \quad i = 1 \dots T, l = 1 \dots L, j = 1 \dots N - 1$$

$$\sum_{i=1}^T \sum_{j=1}^N X_{ilmj} = S_{lm} \quad l = 1 \dots L, m = 1 \dots M$$

$$\sum_{l=1}^L \sum_{m=1}^M \sum_{j=1}^N (X_{ilmj} + Y_{ilmj}) d_{lm} \leq 360 \quad i = 1 \dots T$$

$$X_{ilmj}, Y_{ilmj} \in (0,1)$$

Constraints

$$\sum_{l=1}^L \sum_{m=1}^M X_{ilmj} \leq 1 \quad i = 1 \dots T, j = 1 \dots N$$

One trip at a time to a mill

$$\sum_{l=1}^L \sum_{m=1}^M Y_{ilmj} \leq 1 \quad i = 1 \dots T, j = 1 \dots N$$

One trip at a time to a logger

$$\sum_{k=1}^L Y_{imkj} \leq \sum_{k=1}^L X_{ikmj} \quad i = 1 \dots T, m = 1 \dots M, j = 1 \dots N$$

Go to mill m , leave mill m and go to a logger

$$\sum_{k=1}^M X_{ilkj+1} \leq \sum_{k=1}^M Y_{iklj} \quad i = 1 \dots T, l = 1 \dots L, j = 1 \dots N - 1$$

Trip taken to logger, then next trip must be to mill

$$\sum_{i=1}^T \sum_{j=1}^N X_{ilmj} = S_{lm} \quad l = 1 \dots L, m = 1 \dots M$$

Load conservation

$$\sum_{l=1}^L \sum_{m=1}^M \sum_{j=1}^N (X_{ilmj} + Y_{ilmj}) d_{lm} \leq 360 \quad i = 1 \dots T$$

Speed, trip limit for trucks

$$X_{ilmj}, Y_{ilmj} \in (0,1)$$

0,1 decision variables

Model Solution – Simulated Annealing

- Give any feasible solution, generate new one based on rules
 - Evaluate ‘fitness’ of new one, and replace old if better

$$Z = K_1 M_u + K_2 L_u + K_3 L_o + K_4 T_w + K_5 N$$

where :

M_u = Unloaded miles

L_u = Unserved loads

L_o = Over - served loads

T_w = Waiting time

N = Number of routes not finished



Generating New Solutions

- Search for solutions in the feasible range – feasibility evaluated using a simulator
- Changes made using ‘improvement’ operators

Stop – after random number of trips

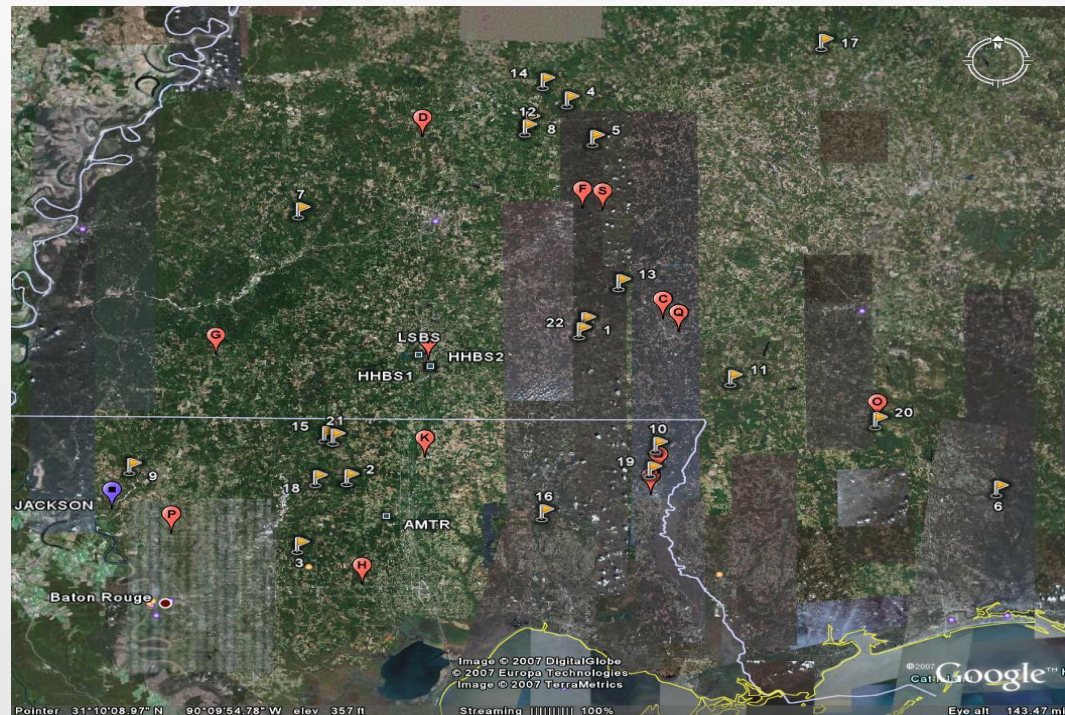
Shorten operator / lengthen operator

Transfer – trips between trucks



Case Study 1

- 68 trucks – centralized dispatch
 - Return to dispatch yard every night
- 22 loggers
- 13 mills



Truck Routing Data

- GPS records from all trucks

Microsoft Excel - report2-march22-2007

1045 Depart Time is used if the vehicles was idling on site, otherwise ignition on is used
 1046 Mile Time includes all on-site idling. Total will include first trip providing
 1047 Minimal Rounding Errors may exist

DRIVER	DATE	DEPART TIME	ARRIVE TIME	TRANSIT TIME	TOTAL TIME	IDLE TIME	MILES EXCEPT	LOCATION	PRIMARY CATEGORY
3 ONeal T	22Mar07	4:39	4:45	0:06	0:12	0:18	0:2	Hannett Haul Base	HQ
								1002 Lucy St Magnolia, MS 39652	
		4:50	9:31	1:41	9:12	1:53	9:12	1153 S MA13 (MS-13) Brooklyn, MS 39626	Prohibited
		5:49	9:51	0:02	9:14	9:16	9:14	S. N. 302007	Prohibited
		7:06	7:07	0:02	9:10	9:12	9:10	1153 S MA13 (MS-13) Brooklyn, MS 39626	Prohibited
		7:17	9:18	2:01	0:02	2:03	0:02	Amite Truck Shop 30214 LA-16	HQ
		9:30	9:22	0:02	0:02	0:04	0:02	Amite, LA, 70422 30214 LA-16	HQ
		9:34	9:32	0:08	0:02	0:10	0:02	Amite, LA, 70422	
		9:34	10:13	0:38	0:02	0:40	0:02	Hadden Mill 30277 Edna Vothsen Rd Holliston, LA, 70744	LOGGERS
		10:14	10:28	0:16	0:14	0:28	0:14	1153 S MA13 (MS-13) Brooklyn, MS 39626	ANTHONY 3/2
		12:43	13:47	0:04	0:16	0:16	0:16	S. N. 302007	KS LOGGING 3/2
		12:53	13:13	0:20	0:06	0:26	0:06	256 MS-13	JR LOGGING
		13:19	14:02	0:42	0:02	0:44	0:02	Lumberton, MS 39455	MC CLOUD 3/2
		14:04	14:08	0:04	0:02	0:06	0:02	63137 LA-16 Bogalusa, LA, 70427	EVANS JOB 1 3/2
		14:10	15:48	1:38	0:41	0:02	68	Hadden Mill 30277 Edna Vothsen Rd Holliston, LA, 70744	PRIEST 3/4
		15:50	17:07	1:16	0:06	1:22	0:06	L.S. Trucking Base / fuel stop Assume 304	BALLARD

20,630 miles driven,
 10,602 unloaded miles =
 48.6% loaded

	MILES	KENTWOOD	McCOMB	MILES BOGALUSA	COLUMBIA	SILVERCREEK	TEMPLE BOGALUSA	HOLDEN	ONEAL	CHARLES DONALD	GOLDEN CHIPS	GEORGIA PACIFIC, MS	GEORGIA PACIFIC, LA	MONTICELLO
ANTHONY 3/2		1			3		2							
KS LOGGING 3/2		4							3					
JR LOGGING			9							2				
MC CLOUD 3/2			4		9			1						
EVANS JOB 1 3/2				1		3	1							
PRIEST 3/4									3					
BALLARD											4			
STERLING 3/2			4											1
CWENS			4		2									6
RANDY CARTER					2									
WALL JOB 2			2			3	9			4				
RUTHLAND			4		2		7							
BALLARD 3/1			1								1			
CHARLES AVANTS									1					
PAUL STEWART			2		4				3	4				
STUART BROS JOB			1				2							
WALL PRIVATE 3/1			6											
HARRELSON 3/26					9				2	4				
J&K 3/27 7					4					10				
WALL JOB 1			1							2				
S&S											2		1	

Results of Optimization

	EXISTING SYSTEM	OPTIMAL SYSTEM	PERCENTAGE IMPROVEMENT
Total Miles	20630	17127	17%
Loaded Miles	10028	9509	5.17%
Unloaded Miles	10602	7618	28.14%
% Loaded Miles (Loaded Miles/ Total Miles)	49	56	14.28%
% Unloaded Miles	51	44	13.72%
Total Waiting time (hours)	21	13.88	33.9%

Changing 'K' Factors Changes Solution

- Waiting time factor

PARAMETERS	USING SIMULATOR	SIMULATED ANNEALING K=0.01	SIMULATED ANNEALING K=1	SIMULATED ANNEALING K=50	SIMULATED ANNEALING K=1000	SIMULATED ANNEALING K=5000	SIMULATED ANNEALING K=10000
UNLOADED MILES	10602	10346	10359	10461	11484	11713	12101
WAITING TIME	10.5 hr	9.52 hr	9.68 hr	9.56 hr	4.84 hr	4.12 hr	2.54 hr

Case 2

- 13-17 trucks, 3-5 loggers, 6-9 mills
 - GPS data – 6 days worth
- No central dispatch yard
 - ‘Intra-day’ routing only
 - Equipment, feed moves mixed in



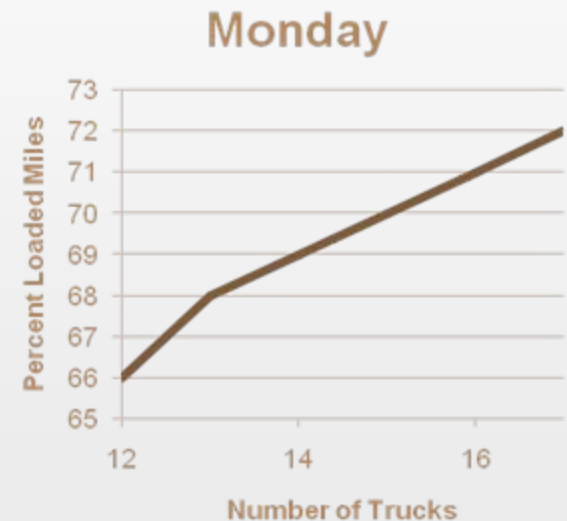
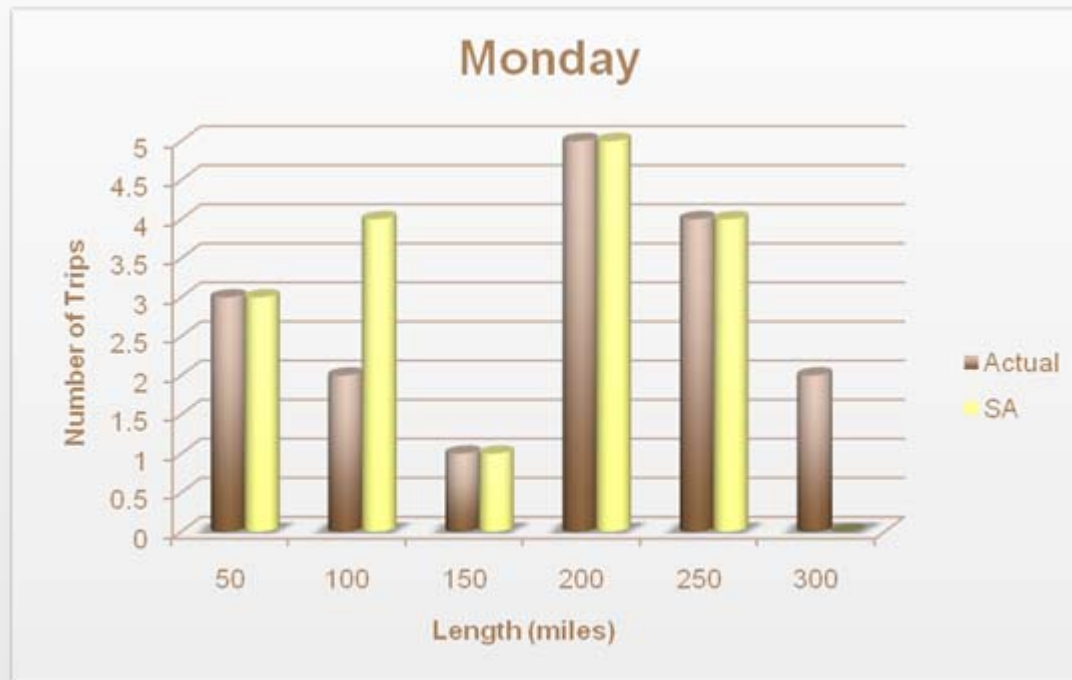
Case 2 Results

- 3 days only

Day	Percent Loaded		Total Miles	
	Actual	SA	Actual	SA
Monday	58	72	2662	2157.3
Tuesday	56	67	2544.2	2136.4
Wednesday	51	63	2639	2269.7

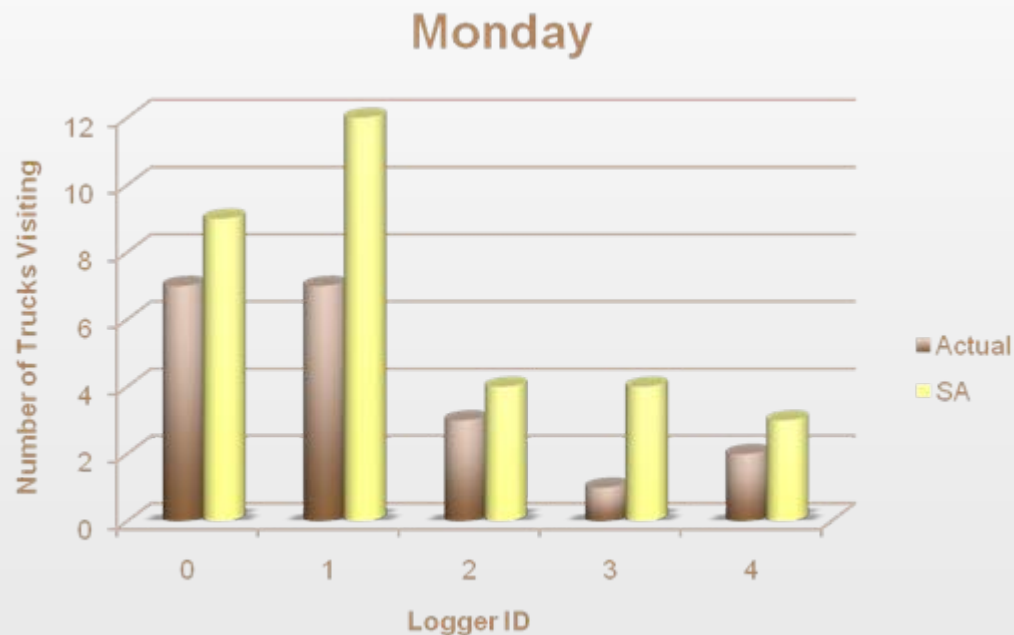
Feasible?

- Where are the savings?



Are Routes Changed?

- Route diversity – how many *different* trucks visit a single logger?



Timing Issues?

- First logger visit of the day
 - Monday: 2
 - Tuesday: 1 (8)
 - Wednesday: 1 (6)
- Beginning/End of the day
 - Take advantage of 'home' locations



Conclusions

- Dispatch optimization improvements seem significant
 - Routes are likely different from what a human might assign
- Problems with feasibility
 - Should be able to address, but testing on real data is tedious