



AIMMS-CPLEX/MOPTA

Optimization Modeling Competition

2009

You are employed at an OR consulting firm, and have been hired to develop an optimization model for a client company. Since you are not the final end-user, it is important to build a model that is attractive, easy-to-use, and has clear reporting on the relevant key performance indicators. The client company will base its satisfaction with your work on the following criteria:

1. Good model structure, keeping the model as simple as possible.
2. The quality of the solution found and the solution time.
3. Relevant, clear reporting.

Your project is described in the case study below. The model, the report, and the results are due by April 30, 2009, 7pm EDT, which is 4 pm PDT. Good luck!

Maintenance Scheduling

Problem Statement

The trucks of the transportation company “Move Efficiently” have to undergo periodic maintenance of different types ranging from changing the oil to a complete engine overhaul. The time intervals between consecutive maintenance checks of each type are pre-described based on experience and information from the truck manufacturer. The trucks become unusable if they are behind on the required maintenance. However, maintenance is expensive and trucks should not be over-maintained. The problem, therefore, is to schedule maintenance so that it minimizes costs while making sure that trucks can be used. The problem needs to be solved over a 2-year time-horizon on a weekly basis, From July 1, 2009 till June 30, 2011. There are constraints on the number of trucks that are required to be active, and capacity constraints at the single maintenance location.

Parameter Values

Number of trucks: 425

Number of truck types: 3 (Small, Medium, Large)

Different Types of Maintenance:

- Routine Maintenance
- Transmission Maintenance
- Engine overhaul

Maximum interval between “Routine Maintenance”: 15 weeks

Maximum interval between “Transmission Maintenance”: 50 weeks

Maximum interval between “Engine overhaul”: 90 weeks

During an “Engine overhaul” the “Routine Maintenance” and “Transmission Maintenance” are also performed. During “Transmission Maintenance” the “Routine Maintenance” is also performed

The cost of a “Routine Maintenance” for any truck type at any time: \$250

The cost of a “Transmission Maintenance” for any truck type at any time: \$2,000

The cost of an “Engine overhaul” for any truck type at any time: \$7,500

Duration of “Routine Maintenance”: 0.5 week

Duration of “Transmission Maintenance”: 1 week

Duration of “Engine overhaul”: 3 weeks

(The vehicle is out of order for the duration of the service)

At the beginning of the time period the maintenance level of the trucks is roughly uniformly distributed. See the exact data in the appendix. As expected, this part of the data is very likely to change. The total number of trucks, the minimum number of trucks in service and the maintenance capacities are:

	All trucks	Small	Medium	Large
Total number of trucks	425	85	295	45
In-service minimum number of trucks	400	75	280	40
Capacity of “Routine Maintenance”	11	3	8	2
Capacity of “Transmission Maintenance”	4	1	3	1
Capacity of “Engine overhaul”	15	3	11	2

The company also considers expanding the maintenance facility. They would like to have answers for the following questions:

- Expenses aside, how many trucks can they keep on the road continuously, given the current capacity of the maintenance facility?
- Where are the bottlenecks in the current system? How should the maintenance station be extended?

If you need values for any other parameters, or have any questions, comments or concerns, please contact Imre Pólik at imre.polik@lehigh.edu. Otherwise, you should clearly document any assumptions you make about the problem setup. If you have problems with the software (installation, licenses, etc.), contact MOPTA2009@aimms.com.

Deliverables

You have been commissioned to develop an optimization model using AIMMS to help the scheduling of the maintenance. In addition, the numbers presented above were collected through preliminary studies and are likely to change as further studies are performed. As the end users of the system will not have knowledge of model development, the model should be set up to take inputs and display results through a dialog and spreadsheet-based interface wherever possible. Make an end-user dashboard that can be used by the truck maintenance planner of “Moving Efficiently” where (s)he can run the model and get inside in the availability of the trucks. A detailed project report (in PDF format) should also be included. This should include information on what the model does, what assumptions were made, how the results are to be interpreted, any limitations of the model, and the general impact on business profitability that can be expected as a result of implementing the consultant’s recommendations.

Suggestions and hints

Start with a smaller number of trucks to see if your formulation works. Try a shorter time horizon or a longer time unit. The complete model may take up to 10 hours to solve. If possible use a computer with multiple CPU cores to speed up the computations.

Note that the operator may have to change certain numbers in the model, so make sure your interface allows for that. Avoid hard-wiring numbers in your model.

Use the information that is provided above to build this model in AIMMS and use CPLEX (called from within AIMMS) as the solver. Make sure you select the appropriate solver options and settings to improve execution time and solution quality. However, do not overtune CPLEX to the actual problem instance you are solving, as the model will also be tested with different data.

Ensure that your model is flexible enough so that it can be easily configured to model different scenarios. If there are data items that are unclear or unavailable make an assumption. Include any assumptions you have made in your submission.

If the problem turns out to be infeasible for a certain dataset (i.e., the required number of trucks can not be guaranteed for some weeks), make sure your model still returns something that can be implemented, such as maximize the number of available trucks, while keeping the cost minimal.

Appendix

Initial maintenance levels of the trucks. The spreadsheet can also be downloaded in several formats from the competition homepage.

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
1	small	1	1	1
2	small	1	1	1
3	small	2	2	2
4	small	2	2	2
5	small	3	3	3
6	small	3	3	3
7	small	4	4	4
8	small	5	5	5
9	small	6	6	6
10	small	7	7	7
11	small	8	8	8
12	small	9	9	9
13	small	10	10	10
14	small	11	11	11
15	small	12	12	12
16	small	13	13	13
17	small	14	14	1
18	small	15	15	1
19	small	16	16	1
20	small	17	17	1
21	small	18	18	2
22	small	19	19	2
23	small	20	20	3
24	small	21	21	3
25	small	22	22	4
26	small	23	23	5
27	small	24	24	6
28	small	25	25	7
29	small	26	26	8
30	small	27	27	9
31	small	28	28	10
32	small	29	29	11
33	small	30	30	12
34	small	31	31	13

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
35	small	32	32	14
36	small	33	33	1
37	small	34	34	1
38	small	35	35	1
39	small	36	36	2
40	small	37	37	2
41	small	38	38	3
42	small	39	39	3
43	small	40	40	4
44	small	41	41	5
45	small	42	42	6
46	small	43	43	7
47	small	44	44	8
48	small	45	45	9
49	small	46	46	10
50	small	47	47	11
51	small	48	48	12
52	small	49	13	13
53	small	50	14	14
54	small	51	1	1
55	small	52	1	1
56	small	53	2	2
57	small	54	2	2
58	small	55	3	3
59	small	56	3	3
60	small	57	4	4
61	small	58	5	5
62	small	59	6	6
63	small	60	7	7
64	small	61	8	8
65	small	62	9	9
66	small	63	10	10
67	small	64	11	11
68	small	65	12	12
69	small	66	13	13
70	small	67	14	14
71	small	68	15	15
72	small	69	16	1
73	small	70	17	1
74	small	71	18	2

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
75	small	72	19	2
76	small	73	20	3
77	small	74	21	3
78	small	76	22	4
79	small	78	23	5
80	small	80	24	6
81	small	82	25	7
82	small	84	26	8
83	small	85	27	9
84	small	87	28	10
85	small	88	29	11
86	medium	1	1	1
87	medium	1	1	1
88	medium	2	2	2
89	medium	2	2	2
90	medium	3	3	3
91	medium	3	3	3
92	medium	4	4	4
93	medium	5	5	5
94	medium	6	6	6
95	medium	7	7	7
96	medium	8	8	8
97	medium	9	9	9
98	medium	10	10	10
99	medium	11	11	11
100	medium	12	12	12
101	medium	13	13	13
102	medium	14	14	1
103	medium	15	15	1
104	medium	16	16	1
105	medium	17	17	2
106	medium	18	18	2
107	medium	19	19	3
108	medium	20	20	3
109	medium	21	21	4
110	medium	22	22	5
111	medium	23	23	6
112	medium	24	24	7
113	medium	25	25	8
114	medium	26	26	9

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
115	medium	27	27	10
116	medium	28	28	11
117	medium	29	29	12
118	medium	30	30	13
119	medium	31	31	1
120	medium	32	32	1
121	medium	33	33	2
122	medium	34	34	2
123	medium	35	35	3
124	medium	36	36	3
125	medium	37	37	4
126	medium	38	38	5
127	medium	39	39	6
128	medium	40	40	7
129	medium	41	41	8
130	medium	42	42	9
131	medium	43	43	10
132	medium	44	44	11
133	medium	45	45	12
134	medium	46	46	13
135	medium	47	47	1
136	medium	48	48	1
137	medium	49	49	2
138	medium	50	2	2
139	medium	51	1	1
140	medium	52	1	1
141	medium	53	2	2
142	medium	54	2	2
143	medium	55	3	3
144	medium	56	3	3
145	medium	57	4	4
146	medium	58	5	5
147	medium	59	6	6
148	medium	60	7	7
149	medium	61	8	8
150	medium	62	9	9
151	medium	63	10	10
152	medium	64	11	11
153	medium	65	12	12
154	medium	66	13	13

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
155	medium	67	14	1
156	medium	68	15	1
157	medium	69	16	2
158	medium	70	17	2
159	medium	71	18	3
160	medium	72	19	3
161	medium	73	20	4
162	medium	74	21	5
163	medium	76	22	6
164	medium	78	23	7
165	medium	80	24	8
166	medium	82	25	9
167	medium	84	26	10
168	medium	85	27	11
169	medium	80	28	12
170	medium	89	29	13
171	medium	1	1	1
172	medium	1	1	1
173	medium	2	2	2
174	medium	2	2	2
175	medium	3	3	3
176	medium	3	3	3
177	medium	4	4	4
178	medium	5	5	5
179	medium	6	6	6
180	medium	7	7	7
181	medium	8	8	8
182	medium	9	9	9
183	medium	10	10	10
184	medium	11	11	11
185	medium	12	12	12
186	medium	13	13	13
187	medium	14	14	1
188	medium	15	15	1
189	medium	16	16	2
190	medium	17	17	2
191	medium	18	18	3
192	medium	19	19	3
193	medium	20	20	4
194	medium	21	21	5

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
195	medium	22	22	6
196	medium	23	23	7
197	medium	24	24	8
198	medium	25	25	9
199	medium	26	26	10
200	medium	27	27	11
201	medium	28	28	12
202	medium	29	29	13
203	medium	30	30	1
204	medium	31	31	1
205	medium	32	32	2
206	medium	33	33	2
207	medium	34	34	3
208	medium	35	35	3
209	medium	36	36	4
210	medium	37	37	5
211	medium	38	38	6
212	medium	39	39	7
213	medium	40	40	8
214	medium	41	41	9
215	medium	42	42	10
216	medium	43	43	11
217	medium	44	44	12
218	medium	45	45	13
219	medium	46	46	1
220	medium	47	47	1
221	medium	48	48	2
222	medium	49	49	2
223	medium	50	3	3
224	medium	51	30	3
225	medium	52	31	4
226	medium	53	32	5
227	medium	54	33	6
228	medium	55	34	7
229	medium	56	35	8
230	medium	57	36	9
231	medium	58	37	10
232	medium	59	38	11
233	medium	60	39	12
234	medium	61	40	13

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
235	medium	62	41	1
236	medium	63	42	1
237	medium	64	43	2
238	medium	65	44	2
239	medium	66	45	3
240	medium	67	46	3
241	medium	68	47	4
242	medium	69	48	5
243	medium	70	49	6
244	medium	71	50	7
245	medium	72	1	1
246	medium	73	1	1
247	medium	74	2	2
248	medium	76	2	2
249	medium	78	3	3
250	medium	80	3	3
251	medium	82	4	4
252	medium	84	5	5
253	medium	85	6	6
254	medium	87	7	7
255	medium	88	8	8
256	medium	1	1	1
257	medium	1	1	1
258	medium	2	2	2
259	medium	2	2	2
260	medium	3	3	3
261	medium	3	3	3
262	medium	4	4	4
263	medium	5	5	5
264	medium	6	6	6
265	medium	7	7	7
266	medium	8	8	8
267	medium	9	9	9
268	medium	10	10	10
269	medium	11	11	11
270	medium	12	12	12
271	medium	13	13	13
272	medium	14	14	1
273	medium	15	15	1
274	medium	16	16	2

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
275	medium	17	17	2
276	medium	18	18	3
277	medium	19	19	3
278	medium	20	20	4
279	medium	21	21	5
280	medium	22	22	6
281	medium	23	23	7
282	medium	24	24	8
283	medium	25	25	9
284	medium	26	26	10
285	medium	27	27	1
286	medium	28	28	1
287	medium	29	29	2
288	medium	30	30	2
289	medium	31	31	3
290	medium	32	32	3
291	medium	33	33	4
292	medium	34	34	5
293	medium	35	35	6
294	medium	36	36	7
295	medium	37	37	8
296	medium	38	38	9
297	medium	39	39	10
298	medium	40	40	1
299	medium	41	41	1
300	medium	42	1	1
301	medium	43	1	1
302	medium	44	2	2
303	medium	45	2	2
304	medium	46	3	3
305	medium	47	3	3
306	medium	48	4	4
307	medium	49	5	5
308	medium	50	1	1
309	medium	51	1	1
310	medium	52	2	2
311	medium	53	2	2
312	medium	54	3	3
313	medium	55	3	3
314	medium	56	4	4

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
315	medium	57	5	5
316	medium	58	6	6
317	medium	59	7	7
318	medium	60	8	8
319	medium	61	9	9
320	medium	62	10	10
321	medium	63	11	1
322	medium	64	12	1
323	medium	65	13	2
324	medium	66	14	2
325	medium	67	15	3
326	medium	68	16	3
327	medium	69	17	4
328	medium	70	18	5
329	medium	71	19	6
330	medium	72	20	7
331	medium	73	21	8
332	medium	74	22	9
333	medium	76	23	10
334	medium	78	24	1
335	medium	80	25	1
336	medium	82	26	2
337	medium	84	27	2
338	medium	85	28	3
339	medium	80	29	3
340	medium	89	30	4
341	medium	1	1	1
342	medium	1	1	1
343	medium	2	2	2
344	medium	2	2	2
345	medium	3	3	3
346	medium	3	3	3
347	medium	4	4	4
348	medium	5	5	5
349	medium	6	6	6
350	medium	7	7	7
351	medium	8	8	8
352	medium	9	9	9
353	medium	10	10	10
354	medium	11	11	1

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
355	medium	12	12	1
356	medium	13	13	2
357	medium	14	14	2
358	medium	15	15	3
359	medium	16	16	3
360	medium	17	17	4
361	medium	18	18	5
362	medium	19	19	6
363	medium	20	20	7
364	medium	21	21	8
365	medium	22	22	9
366	medium	23	23	10
367	medium	24	24	1
368	medium	25	25	1
369	medium	26	26	2
370	medium	27	27	2
371	medium	28	28	3
372	medium	29	29	3
373	medium	30	30	4
374	medium	31	31	5
375	medium	32	32	6
376	medium	33	33	7
377	medium	34	34	8
378	medium	35	35	9
379	medium	36	36	10
380	medium	37	37	1
381	large	80	1	1
382	large	81	1	1
383	large	2	2	2
384	large	2	2	2
385	large	3	3	3
386	large	5	3	3
387	large	8	4	4
388	large	10	5	5
389	large	12	6	6
390	large	14	7	7
391	large	16	8	8
392	large	18	9	9
393	large	20	10	10
394	large	22	11	1

Truck #	Category	Weeks since last engine	Weeks since last transmission	Weeks since last routine
395	large	24	12	1
396	large	26	13	2
397	large	28	14	2
398	large	30	15	3
399	large	32	16	3
400	large	34	17	4
401	large	36	18	5
402	large	38	19	6
403	large	40	20	7
404	large	42	21	8
405	large	44	22	9
406	large	46	23	10
407	large	48	24	1
408	large	50	25	1
409	large	52	26	2
410	large	54	27	2
411	large	56	28	3
412	large	58	29	3
413	large	60	30	4
414	large	63	31	5
415	large	64	32	6
416	large	64	33	7
417	large	65	34	8
418	large	70	35	9
419	large	71	36	10
420	large	72	37	1
421	large	73	38	1
422	large	75	39	2
423	large	80	40	2
424	large	82	41	3
425	large	42	1	1