How to Schedule Meetings with a Traveling Salesman Q & D, and Why We Didn't

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Periodically scheduled meetings between managers and their employees are often used to monitor progress. Unfortunately, people attending two or more of these meetings in one day may find their time cut up into pieces too small to be useful. This problem can be solved as a traveling salesman problem. The efficient solution found by this method was not implemented because of factors not incorporated into the objective function.

Meetings, meetings everywhere, nor any time to think.

Mr. Jensen was the manager of development projects at the plant. Every fortnight he spent all day Monday talking to each of his 12 employees. Starting with small talk, he went on to review the progress of each project the employee would be involved in during the next two weeks. Since he spent 40 minutes with each person, the entire process took eight hours. "This is exhausting," Mr. Jensen complained to Tom, a young management trainee who had been following him around as part of his introduction to the company. "There must be another way to organize these meetings." Tom did not reply but realized that while he had enjoyed most of the morning sessions, the afternoon sessions had been boring. Because the employees usually worked in teams on various projects, the discussions in the afternoon repeated much of what had been covered in the morning.

That night, still thinking about his day's work, Tom told the story to his wife. She said, "Why don't you just hold one meeting for all the employees on each proj-

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ect?" The next morning, Tom excitedly announced to Mr. Jensen that he had found the solution to his problem: "Let's have sessions in which all employees involved in a given project are present at the same time. That saves time for you and your employees because you won't have to go over the same material two or three times." Mr. Jensen rejected his proposal with the reason that few projects involved the same team of employees.

		Employees											
		A	B	C	D	E	F	G	H	I	J	K	L
Projects.	1	X	X										
	2	X	X										
	3	X	X										
	4			X	X								
	5			X	X								
	6				X								
	7		X			X							
	8						X	X					
	9		X				X	X					
	10				X	X							
	11			X									
	12											X	
	13							X		X			
	14								X	X			X
	15			X	X								
	16							X				X	
	17										X	X	X
	18								X			X	
	19										X	X	
	20									X			
	21							X					X
	22			X	X								
	23					X							X
	24				X								X
	25									X			
	26						X						
	27			X	X								
	28												X
	29				X							X	
	30			X									

Table 1: The relationship between the projects and the employees in Mr. Jensen's department. An X indicates that the employee is involved in the project.

Most employees would therefore attend more than one meeting, which would break their day into small unusable pieces. In addition, as Mr. Jensen said: "All that traffic in and out would make my office look like the railway station on a holiday weekend. Forget it!" But Tom didn't forget it!

Problem Formulation

Rollup! The Magical Mystery Tour

Tom thought of the operations research courses he had taken. Did the situation fit a standard problem? He soon saw what to do!

Given the distribution of employees over the projects (Table 1), it is relatively easy to deduce the number of people (C_{ij}) that have to enter or leave Mr Jensen's office if project j is discussed after project i.

$$C_{ij} = N_i + N_j - N_{ij}$$

in which N_i = number of employees in project i.

N_{ij} = number of employees both in project i and in project j.

This way, Tom computed the "setup cost" incurred by having a discussion of project i followed by a discussion of project j. These "costs" are shown in Table 2. He noted that the matrix was symmetric. Projects involving the same employees were combined into one "big project."

Now, the problem became sequencing the projects so as to minimize the total traffic in and out of Mr. Jensen's office. Introducing dummy projects in which no employees were involved as the first and the last projects to be discussed completed the modeling of the problem as a traveling salesman problem. But modeling the problem was not enough; Tom had to present the solution to Mr. Jensen.

Project i	Project j																					Equivalent Projects	New Project Number
	1	4	6	7	8	9	10	11	12	13	14	16	17	18	19	20	21	23	24	26	28	29	
0	2	2	1	2	2	3	2	1	1	2	3	2	3	2	2	1	2	2	2	1	1	2	1
1	—	4	3	2	4	3	4	3	3	4	5	4	5	4	4	3	4	4	4	3	3	4	2,3	2
4		—	1	4	4	5	2	1	3	4	5	4	5	4	4	3	4	4	2	3	3	2	5,15,22,27	3
6			—	3	3	4	1	2	2	3	4	3	4	3	3	2	3	3	1	2	2	1		4
7				—	4	1	2	3	3	4	5	4	5	4	4	3	4	2	4	3	3	4		5
8					—	1	4	3	3	2	5	2	5	4	4	3	2	4	4	1	3	4		6
9						—	5	4	4	3	6	3	6	5	5	4	3	5	5	2	4	5		7
10							—	3	3	4	5	4	5	4	4	3	4	2	2	3	3	2		8
11								—	2	3	4	3	4	3	3	2	3	3	3	2	2	3	30	9
12									—	3	4	1	2	1	1	2	3	3	3	2	2	1		10
13										—	3	2	5	4	4	1	2	4	4	1	3	4		11
14											—	5	4	3	5	2	3	3	3	4	2	5		12
16												—	3	2	2	3	2	4	4	3	3	2		13
17													—	3	1	4	3	3	3	4	2	3		14
18														—	2	3	4	4	4	3	3	2		15
19															—	3	4	4	4	3	3	1		16
20																—	3	3	3	2	2	3	25	17
21																	—	2	2	3	1	4		18
23																		—	2	3	1	4		19
24																			—	3	1	2		20
26																				—	2	3		21
28																					—	3		22
29																						—		23

Table 2: The number of employees going in and out of Mr. Jensen's office if project j is discussed right after project i (or vice versa). Project 0 is the start (and end) of all discussions.

The Solution

Taking Q & D on the Road

From his textbook [Lawler 1976] Tom saw that the traveling salesman problem was NP-hard, but he was young and eager. No old schoolmaster's textbook would frighten him. He remembered the LINDO [Schrage 1981] LP and IP package from his university days and was happy that his firm had the same software. After an hour of concentrated typing, Tom had input only the following portion of the problem:

$$\text{Minimize} \quad \sum_i \sum_j C_{ij} x_{ij}$$

$$\text{subject to} \quad \sum_i x_{ij} = 1 \qquad \forall j,$$

$$\sum_j x_{ij} = 1 \qquad \forall i,$$

$$x_{ij} \text{ integer.}$$

He groaned when he realized how long it would take him to enter all of the subtour elimination constraints. He decided to see what a Q & D (quick and dirty) approach would do. With the courage of a Viking, he typed "GO," launching his computer into the solution of the partial model. Q & D strikes again!

The solution contained only eight subtours. Tom eliminated the smaller subtours by inserting the relevant constraints and typed "GO" again. Just before lunch, after a few such iterations, the final solution emerged (Table 3).

Tom spent his lunch break working up a presentation of the solution in a form that Mr. Jensen would understand (Table 4). When he finished he felt sure he had solved Mr. Jensen's problem.

very good mood, knowing that his proposal would change a situation that had troubled Mr. Jensen for years.

At five he went to Mr. Jensen's office and sat down. Mr. Jensen shook his head and said: "Tom, you still have a long way to go as a trainee. If I were to follow your proposal there would be no opportunity to meet and talk with each of my employees informally. You'll have to learn that that is the most important task of a manager."

"Thor and Wotan!" thought Tom. "I should have remembered that the traveling salesman route would bring me right back to where I began."

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