

Upon returning to Oberlin, Cardin and Hughes realized that they could have used optimization to plan their visit to the Magic Kingdom. They discovered that the M⁷TP is very similar to what is known in the optimization field as the Selective Traveling Salesperson Problem (STSP). They purchased a guide book, [9], that contains ride durations and provides 0-to-5-star "fun factor" ratings for various age groups. For their modeling project, they decided to

1. construct an IP formulation of the M⁷TP,

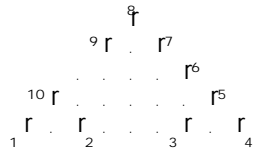


Figure 3

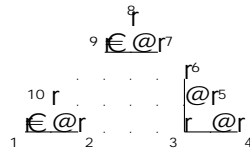


Figure 4

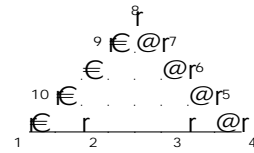


Figure 5

This constraint states that no more than two of the three “edges” $f1;2g$, $f1;10g$,

$gf12$ gf

$S = \{f1;2;10g; f3;4;5;6g; f7;8;9g\}$. Figure 5 displays the optimal solution to the second "Step 1" optimization problem. Note that in this small example, the optimal tour was obtained with the addition of only three subtour elimination constraints, although nearly one thousand possible subtours exist.

It should be noted that Dantzig, Fulkerson, and Johnson actually replaced the discrete constraints $x_{ij} \in \{0,1\}$ for each $1 \leq i < j \leq n$ with the continuous constraints $0 \leq x_{ij} \leq 1$. Applegate, Bixby, Chvátal, and Cornuejols (2006) and Cornuejols, Desautels, and Glover (2006) showed that this relaxation is tight for the subtour elimination constraints.

optimal tour of the park. With this in mind, restaurants are not considered to add to total fun, although two hours will be allotted for eating.

Data

Cardi and Hughes' IP formulation

Cardi and Hughes came up with the following IP formulation of the M⁷

found it interesting that the optimal tours have the same basic shape. Indeed, the fact that both tours visit all five "lands" that comprise the Magic Kingdom is a testament to how well planned the entire park is. But if we look at the actual rides that both groups visit, we see that the two groups only agree on 12 rides. Surely, the fact that the routes are so similar, but the attractions visited are so different could be a source of dom that comprise the Magic Kingdom

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tour? h9et	Preschool	Parent
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tour?l

tour, the preschoolers will obtain 65.5 stars (97.0% of their optimal value) and their parents will obtain 51 stars (95.3% of their optimal value).

- [7] R.M. Karp and J.M. Steele, "Probabilistic analysis of heuristics," in E.L. Lawler, J.K. Lenstra, A.H.G. Rinnooy Kan, and D.B. Shmoys, eds., *The Traveling Salesman Problem* (Wiley, New York, 1985) pp. 181-205.
- [8] G. Laporte and S. Martello, "The selective travelling salesman problem", *Discrete Applied Mathematics* 26 (1990) 193-207.
- [9] B. Selinger,

The top half of the spreadsheet contains the data: ride-to-ride distances (in

3. The next step is to make Excel aware that you would like to solve an optimization problem. To do this, choose the *Solver* from the *Tools* menu.
4. To specify the objective function, click once in the *Set Target Cell* field and type F29 (or use your mouse to select cell F29). Then make sure that *Max* is selected in the *Equal To* field.
5. To specify the decision variables, click once in the *By Changing Cells* field. Then, hold down the *Ctrl* key (if you are using a PC) or the apple key (if you are on a Macintosh), and use your mouse to select all cells that correspond to decision variables. Note: Do not select cell L15. It should remain at its current value of 1; the entrance to the park *must* be visited.
6. Now it is time to add the constraints. To add a constraint, click on the *Add* button. A window that resembles Figure 9 will appear.

Cell Reference:		Constraint:	
<input type="text"/>	<input type="text" value="<="/>	<input type="text"/>	

should not be eliminated), type

= SUM(I22, J22, J23)

in cell L26 and the number 2 in cell M26, open the *Solver* tool, and add a constraint that states that cell L26 should be less than or equal to cell M26