Vienna University of Technology

Mathematical Programming

Programming Exercise (Part 2)

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For our exponentially-sized model we chose cycle elimination constraints. We wrote a testbench to run the different graph instances automatically. If you want to invoke it, you can do so by calling *kmst* with the following parameters:

Calling the first 10 test instances for CEC (2 per .dat file)

```
./kmst -m 2 -t test/test.in -n 10
```

4 Cycle Elimination Constraints

4.1 Formulation

We added an artificial root node v_0 to our graph and edges $(v0, i) : i \in V$ from the root node to every other node with weight 0:

$$V' = V \cup \{v_0\}$$
$$E' = E \cup \{(v_0, i) : i \in V\}$$
$$\forall i \in V : w_{v_0 i} = 0$$

4.2 Variables

- x_e : Edge decision variable
- y_{ij} : Arc decision variable
- z_i : Vertex decision variable

4.3 Constraints

$$\forall e = \{i, j\} \in E' : x_e = y_{ij} + y_{ji} \tag{1}$$
$$\forall j \in V : \sum_{i \in V} y_{ij} \leq 1 \tag{2}$$
$$\sum_{j \in V} y_{v_0 j} = 1 \tag{3}$$
$$\sum_{i \in V} y_{i v_0} = 0 \tag{4}$$
$$\forall j \in V : \sum_{i \in V} y_{ij} * k \geq \sum_{i \in V} y_{ji} \tag{5}$$
$$\forall j \in V : z_j = \sum_{i \in V} y_{ij} \tag{6}$$
$$\sum_{i \in V} z_i = k \tag{7}$$
$$\forall (i, j) \in E' : y_{ij} \in \{0, 1\} \tag{8}$$

- (1) : Establishes the connection between arc decision variable y_{ij} and edge decision variable x_e
- (2) : Guarantees that every node can have at most one incoming arc, which is a property of a directed tree
- (3) : Guarantees that only one arc from the artificial root node v_0 to any other node is selected
- (4) : Guarantees that only no arc to the artificial root node v_0 from any other node is selected
- (5) : Guarantees that any non-root node can only have outgoing edges if it has incoming edges as well
- (6) : Establishes the connection between node decision variables and arcs
- (7) : Limits the total number of nodes in a solution
- (8) : This is the domain constraint for the binary arc decision variable y_ij

4.4 Objective

$$min \sum_{e \in E} w_e x_e$$

4.5 Results

TODO

5 Interpretation

We invested quite some time in this programming exercise and so we were very disappointed that instances $g06 - g08$ did not terminate for both SCF and MCF. The overall performance of the solutions does not seem good either. Since we didn't have any experience with CPLEX, we could not tell if this behaviour was normal or not.