Branch & Bound Algorithms for the Traveling Salesman Problem

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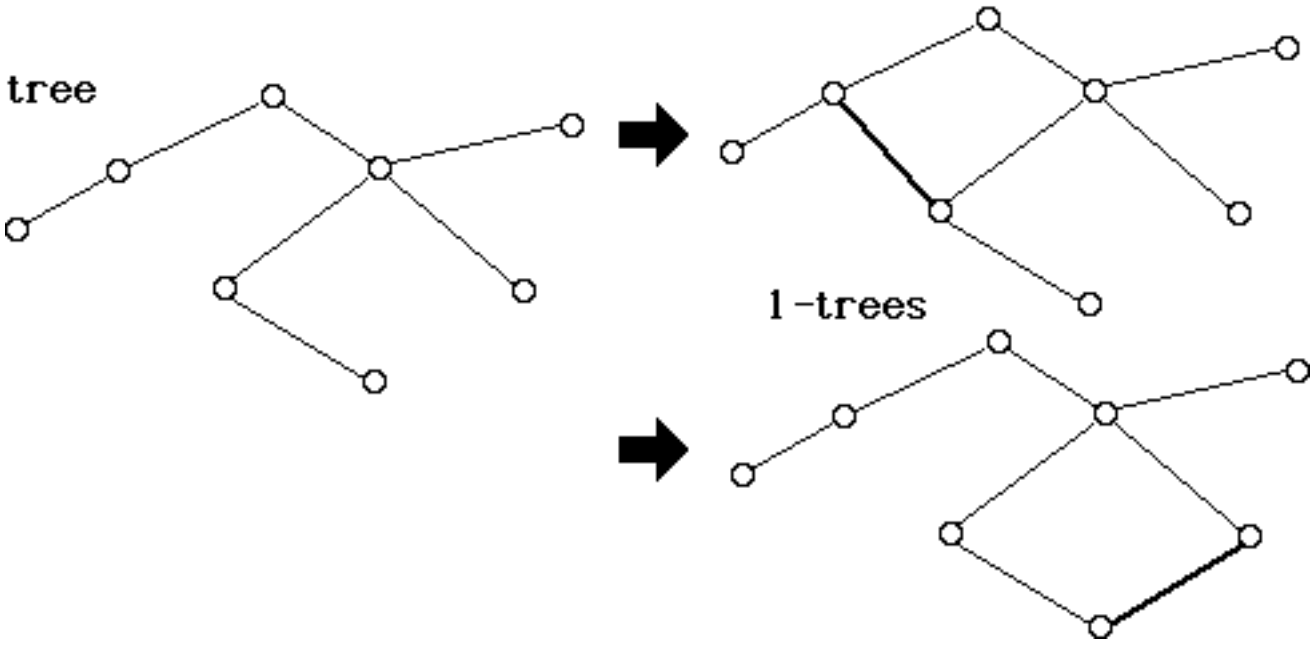
A TSP tour has the properties:

- it is a *connected* subgraph of the network
- the degree of every node is 2

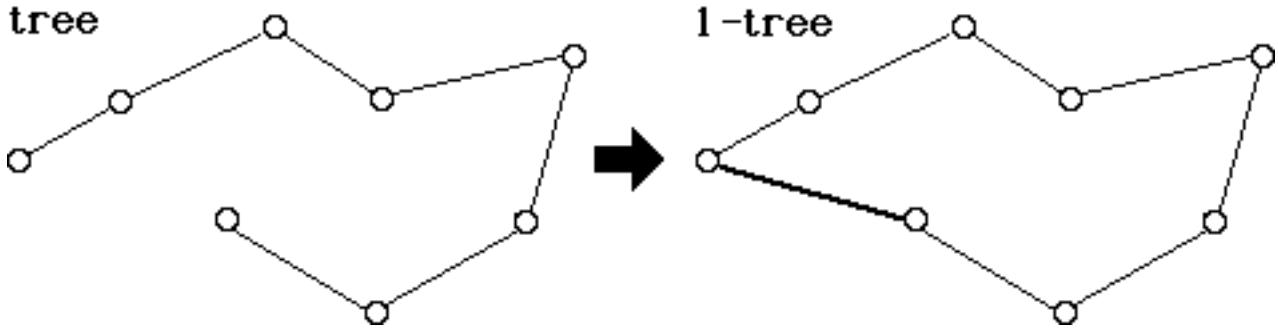
The solution of the *Assignment Problem* satisfies the second property, but not always the first.
The solution of the *minimum spanning 1-tree* problem satisfies the first property, but not always the second.

1-Tree

A 1-tree is constructed by adding a single edge to a tree.



Note that a tour is a 1-tree:



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$$\text{Minimize} \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} X_{ij}$$

subject to

$$\left.\begin{aligned} \sum_{i=1}^{n} X_{ij} &= 1 \;\forall\; j=1,\ldots n \\ \sum_{j=1}^{n} X_{ij} &= 1 \;\forall\; i=1,\ldots n \end{aligned}\right\} \textit{Assignment constraints}$$

$$X \in \mathbf{T} \qquad \textit{= set of all 1-trees}$$

If either the assignment or the 1-tree constraints are relaxed, the resulting problem (which is easy to solve) provides a lower bound on the length of the optimal tour.

 Relaxation of 1-tree constraints

 Relaxation of Assignment constraints