

Heuristic Algorithms for the Traveling Salesman Problem



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Most heuristics are of one of two types:

Construction Heuristics

*Add one arc after another to a tour,
until the tour includes all nodes.*

Improvement Heuristics

*Given an initial tour, find an improved
tour*

Examples

Construction Heuristics

- ☞ Nearest Neighbor Algorithm
- ☞ Nearest Insertion Algorithm
- ☞ Farthest Insertion Algorithm
- ☞ Space-filling Curve Algorithm



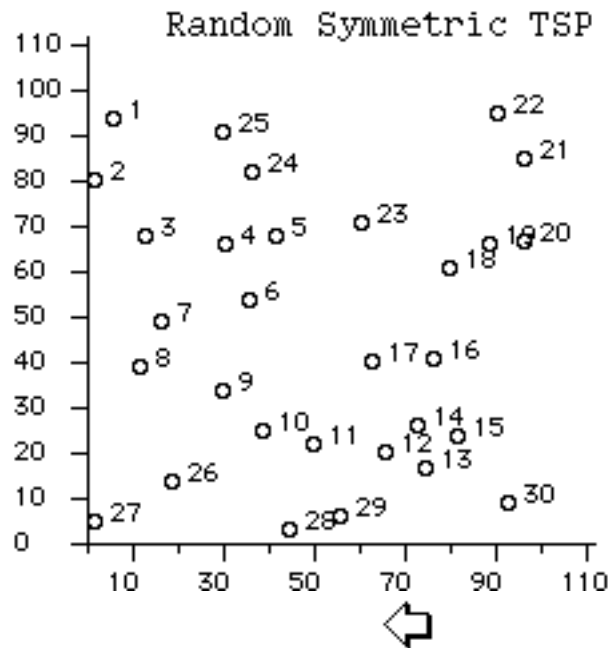
Improvement Heuristics

- ☞ Exchange Algorithm
- ☞ Simulated Annealing



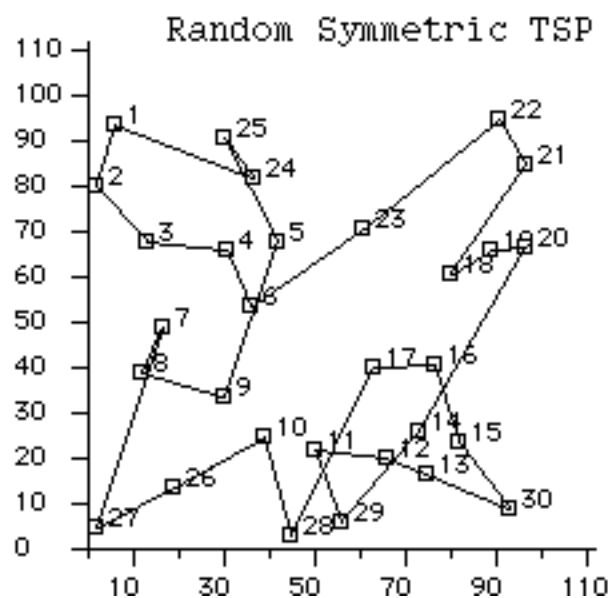
Example

30 CITIES



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Spacefilling Curve Heuristic

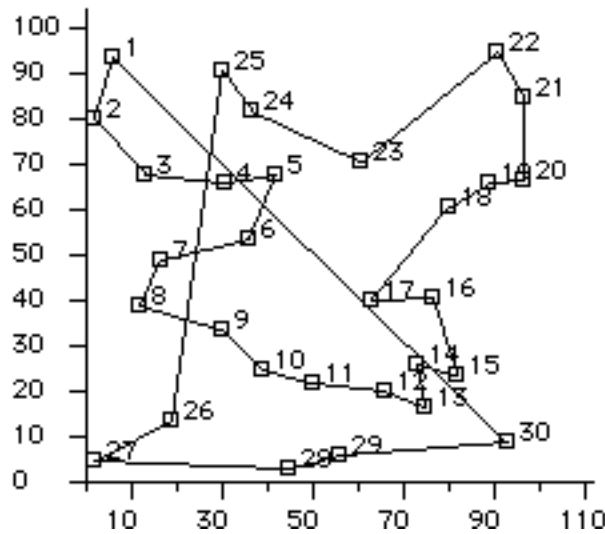


Length: 664

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Nearest Neighbor Heuristic

Random Symmetric TSP (seed= 185204)



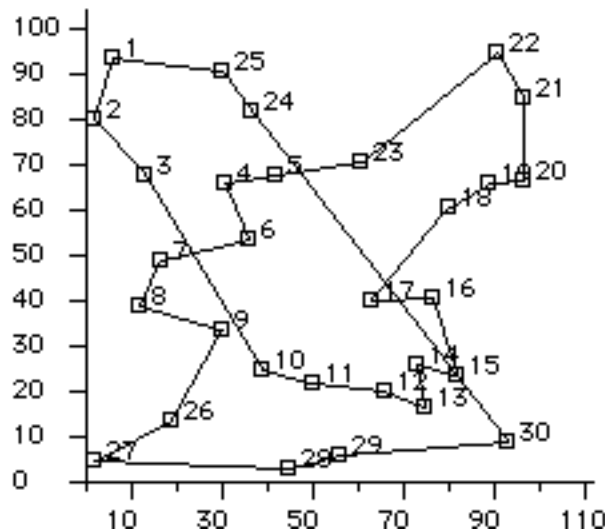
Starting Node: #1

Length: 684

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Nearest Neighbor Heuristic

Random Symmetric TSP (seed= 185204)



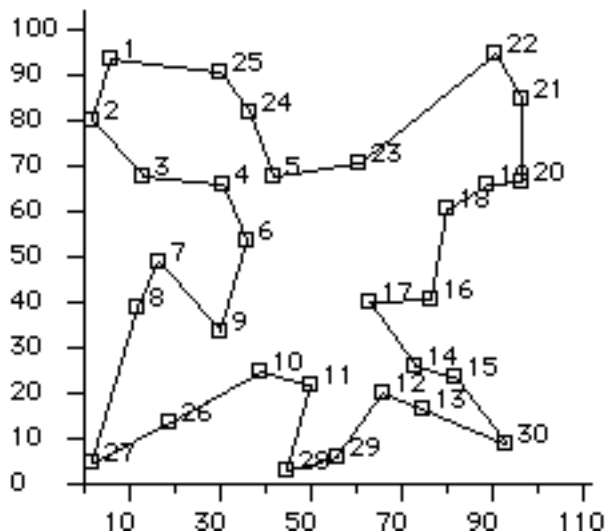
Starting Node: #10

Length: 633

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Farthest Insertion Heuristic

Random Symmetric TSP (seed= 185204)

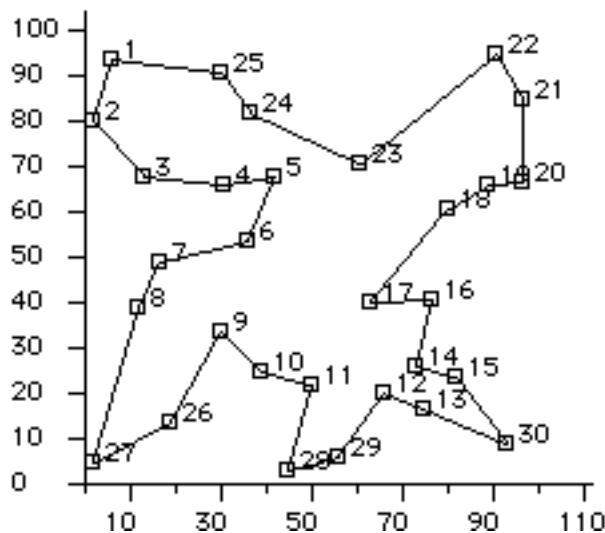


Starting Node: #1
Length: 513

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Farthest Insertion Heuristic

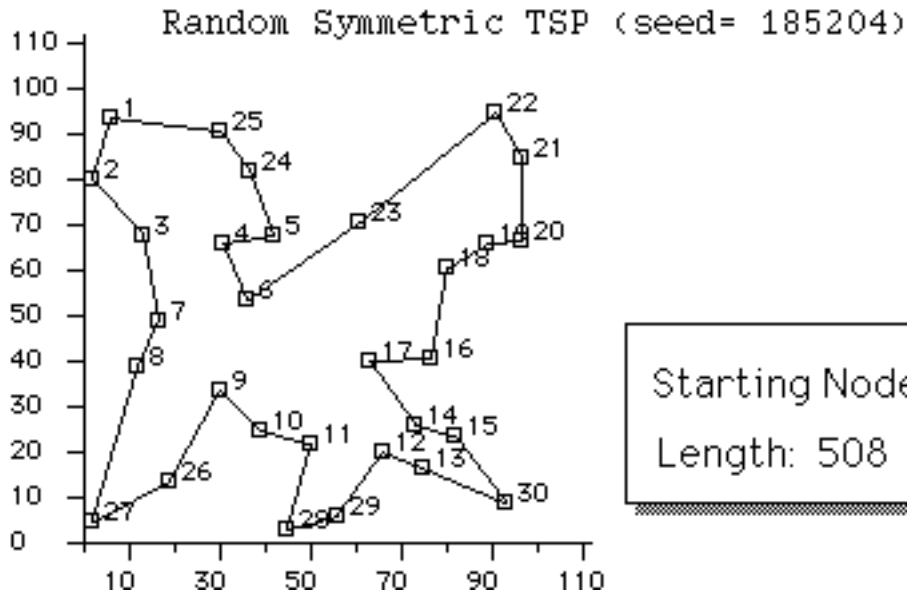
Random Symmetric TSP (seed= 185204)



Starting Node: #10
Length: 516

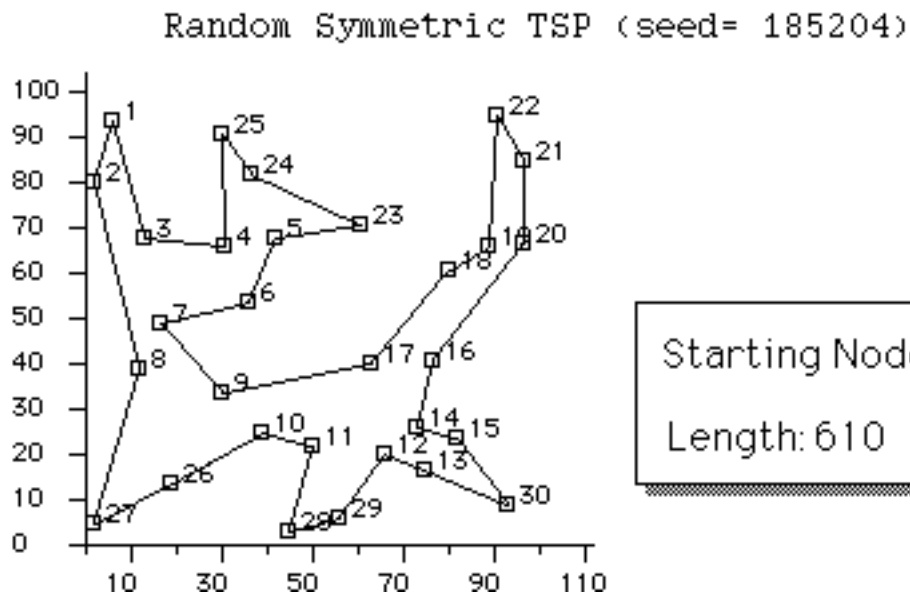
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Farthest Insertion Heuristic



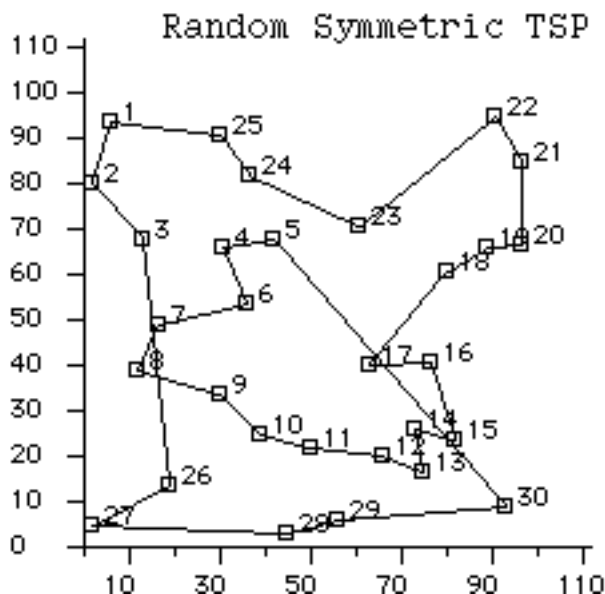
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Nearest Insertion Heuristic



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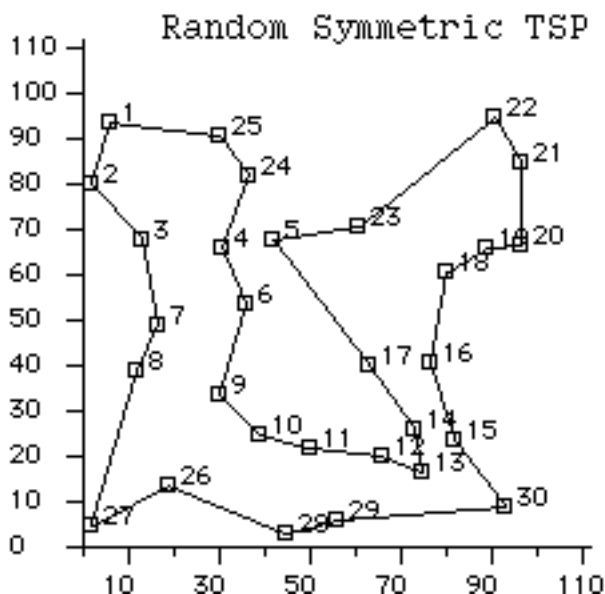
Lin's 2-Opt Heuristic



Starting Tour
 Nearest Neighbor
 Tour, Originating
 at Node #5
 Length: 620

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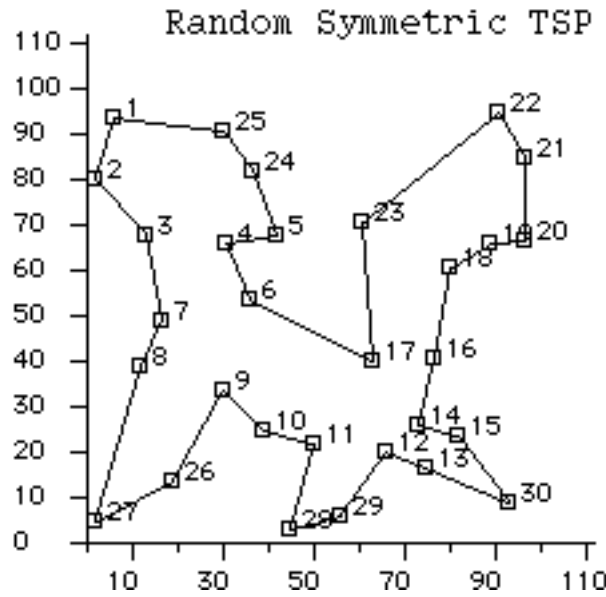
Lin's 2-Opt Heuristic



2-Optimal Tour
 Length: 549

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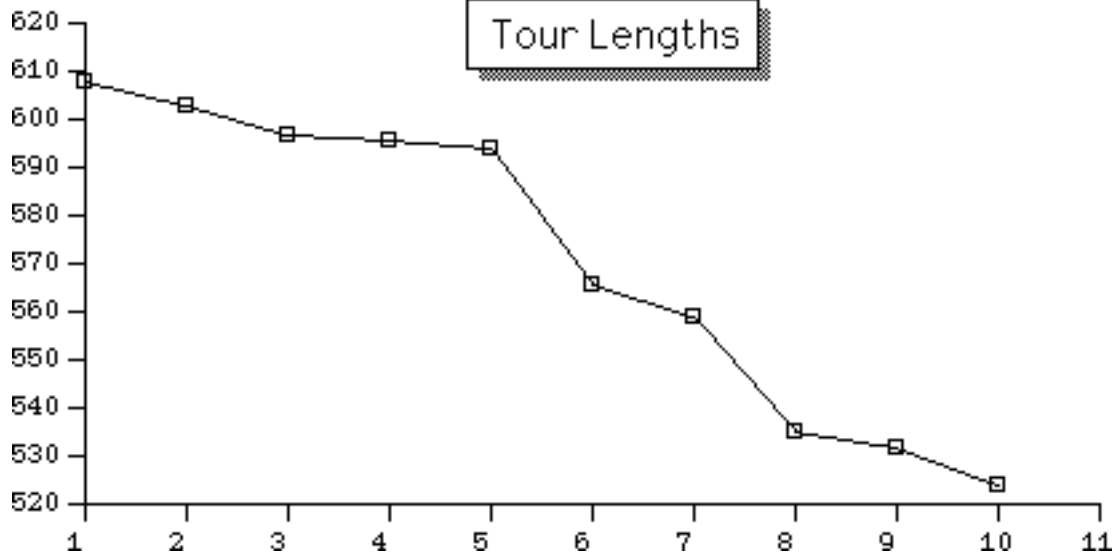
Lin's 2-Opt Heuristic



2-Optimal Tour
Length: 524

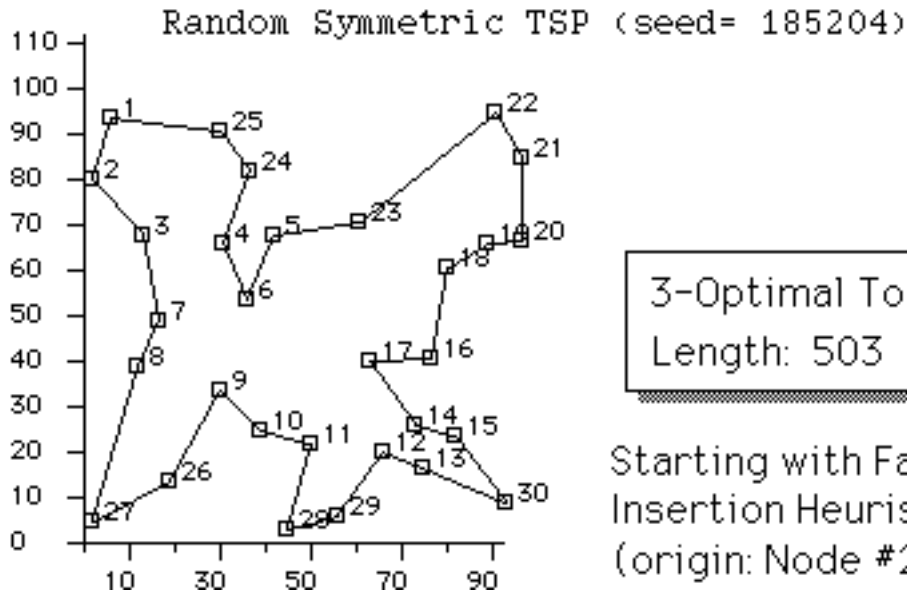
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Lin's 2-Opt Heuristic

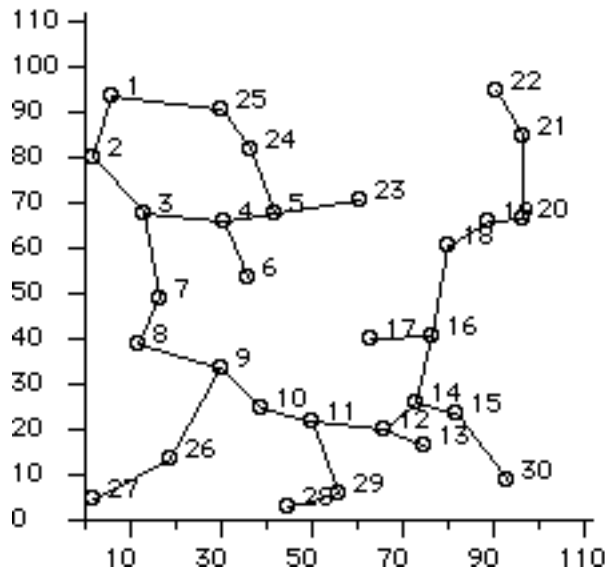


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Lin's 3-Opt Heuristic

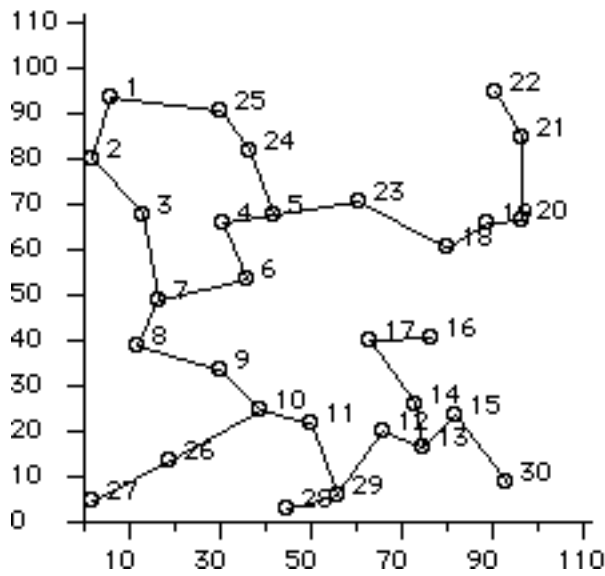


Iteration 1
Lower Bound: 445
Sum of excess degrees: 8



Vertex Penalty Method

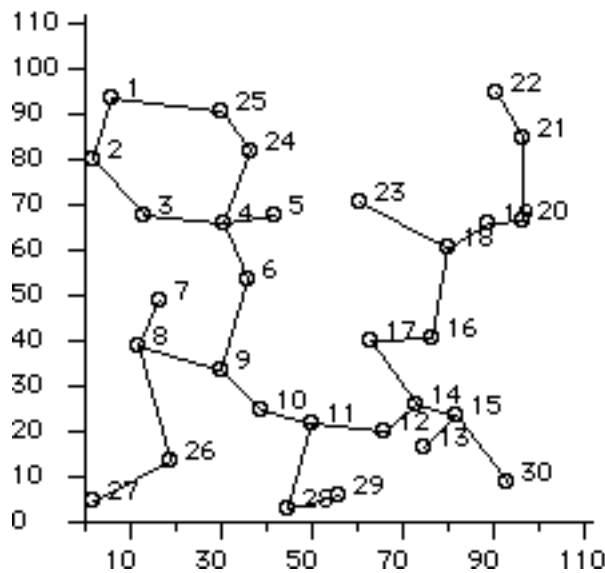
Iteration 2
 Lower Bound: 451
 Sum of excess degrees: 5



**Vertex
 Penalty
 Method**

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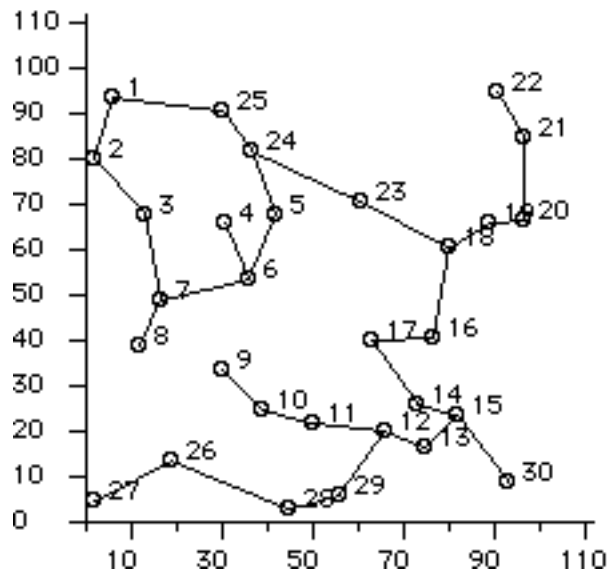
Iteration 3
 Lower Bound: 452.7
 Sum of excess degrees: 8



**Vertex
 Penalty
 Method**

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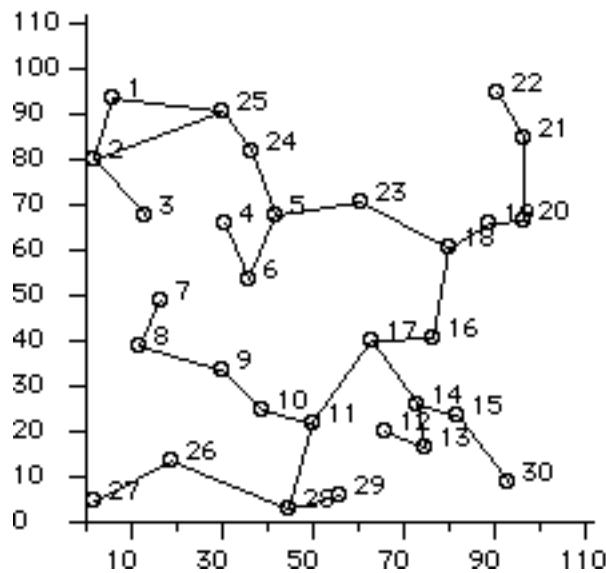
Iteration 4
Lower Bound: 463.545
Sum of excess degrees: 6



Vertex Penalty Method

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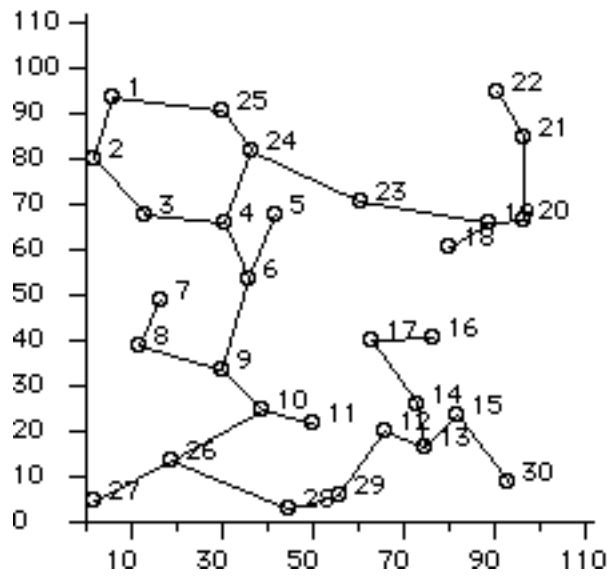
Iteration 5
Lower Bound: 472.0270833
Sum of excess degrees: 8



Vertex Penalty Method

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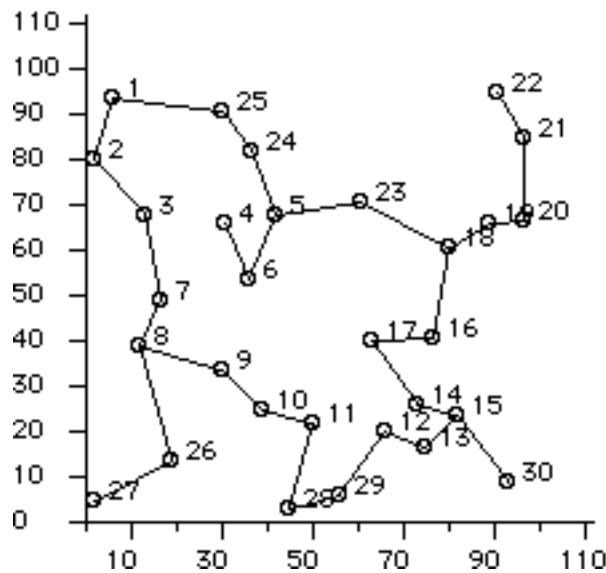
Iteration 6
 Lower Bound: 475.0825781
 Sum of excess degrees: 8



**Vertex
 Penalty
 Method**

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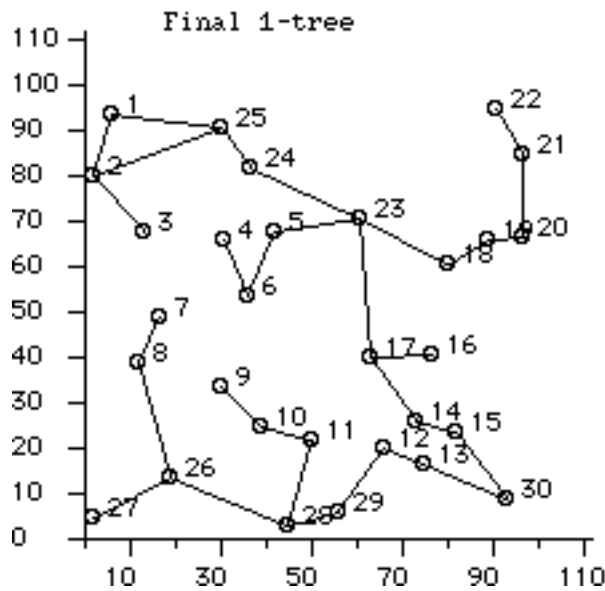
Iteration 7
 Lower Bound: 477.417609
 Sum of excess degrees: 4



**Vertex
 Penalty
 Method**

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Vertex Penalty Method

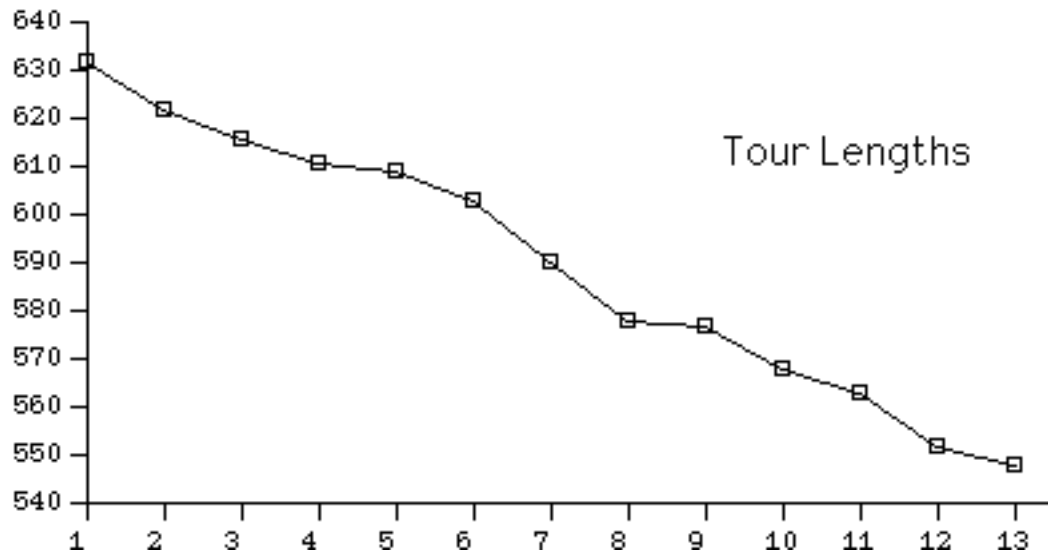


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Iteration	Lower Bound	Excess Degree	at Nodes													
1	445	8	3	4	5	9	11	12	14	16						
2	446	7	5	6	7	10	13									
3	445	10	2	8	14	15	18	24	25	26	29					
4	469	5	4	7	12	15	28									
5	462	7	9	11	13	17	23									
6	467	7	6	8	9	14	16	18	29							
7	473	8	3	5	10	11	19									
8	480	7	2	10	18	24	25	26								
9	489	6	3	4	8	19	29									
10	485	5	5	6	7	18	28									
11	485	7	2	19	20	23	24	25	29							
12	496	4	3	8	17	20										
13	498	5	5	10	12	15	16									
14	499	5	6	7	9	11	13									
15	497	5	2	23	24	25	28									
16	495	5	3	4	10	12										
17	499	3	5	11	17											
18	494	7	2	6	7	15	16	25	26							
19	496	5	8	13	23	24	29									
20	497	5	3	4	14	26										

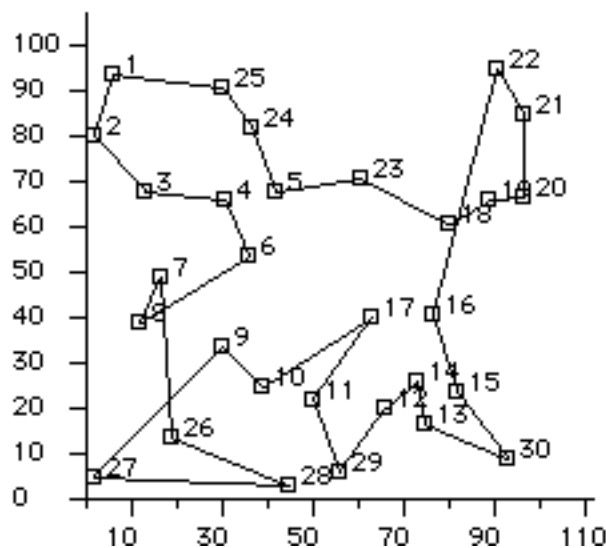
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2-Exchange Heuristic



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Simulated Annealing

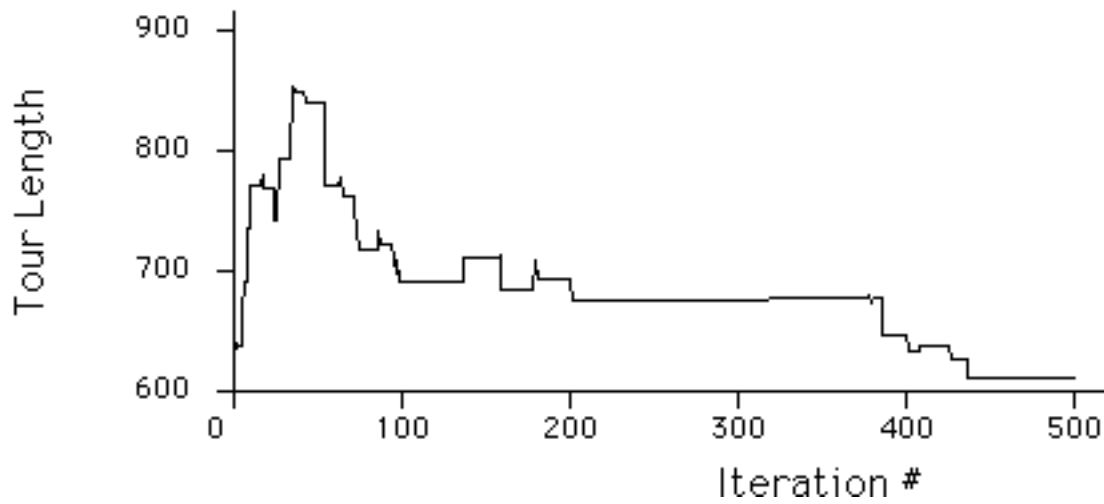


Final Tour
Length: 613

(Beginning with
tour of length 632)

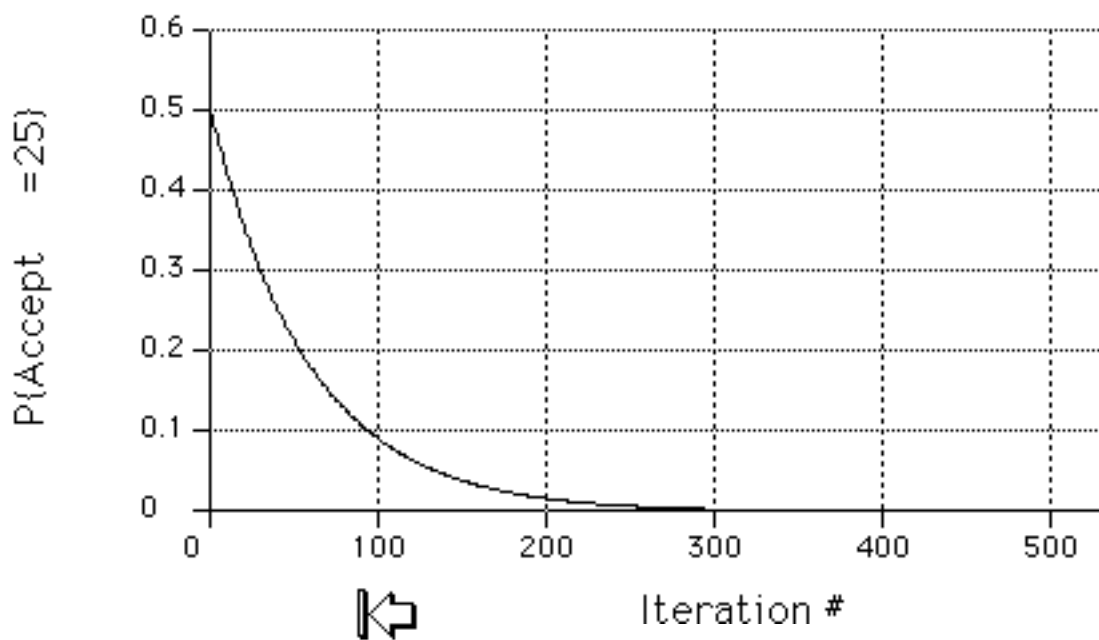
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Simulated Annealing



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Simulated Annealing



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