

# Traveling Salesmen Problem (TSP)

Your friendly salesman:  
Perrin Westrich

# Outline

- What is the TSP?
- Computational complexity
- Factoradics
- Search technique
- Experiment

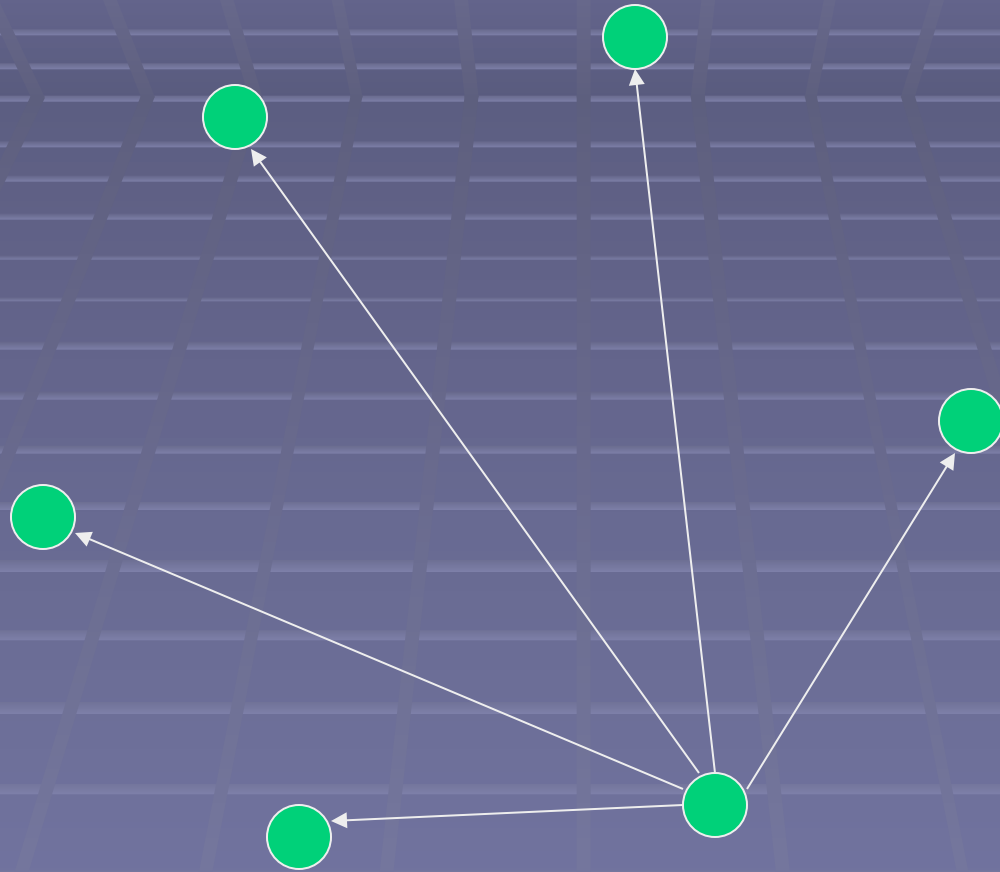
# TSP

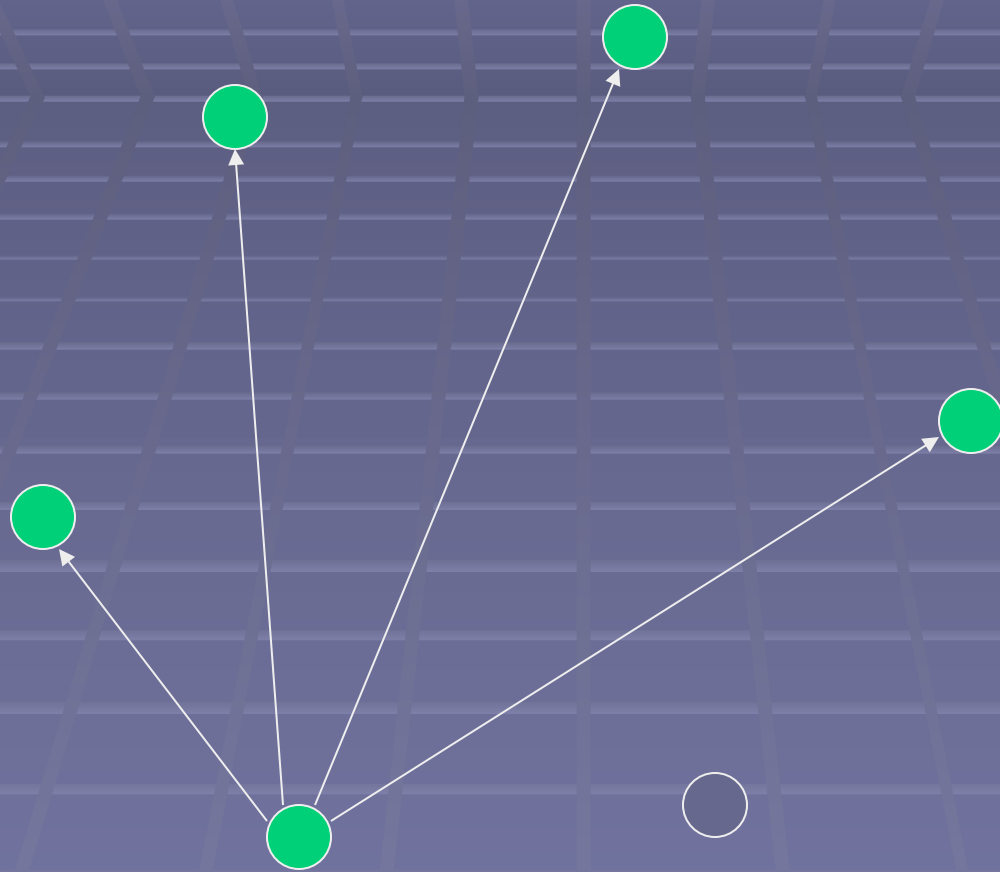
- List of cities.
- Must visit each city once
- Return to the first city
- Must take the path with the shortest length

# Computational Complexity

- $N!$  number of possible paths
- NP hard











ABCD

ABDC

ACBD

ACDB

ADBC

ADCB

BACD

BADC

BCAD

BCDA

BDAC

BDCA

CABD

CADB

CBAD

CBDA

CDAB

CDBA

DABC

DACB

DBAC

DBCA

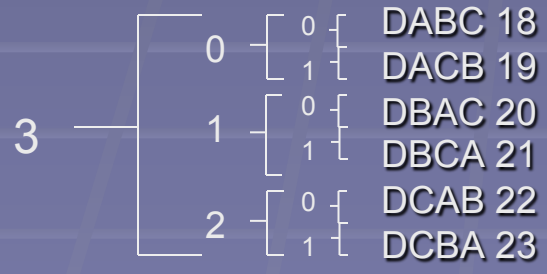
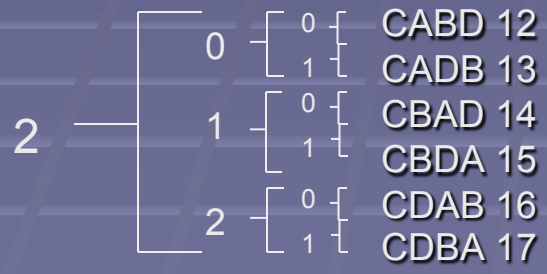
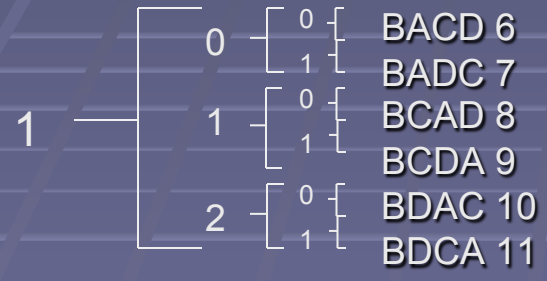
DCAB

DCBA

ABCD  
ABDC

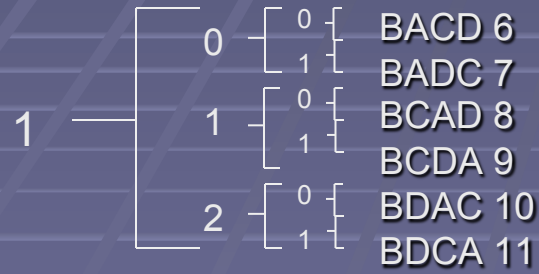
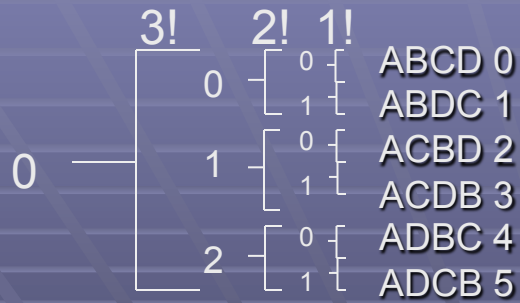
ACBD  
ACDB

ADBC  
ADCB



# Factoradic Numbering System

- An unambiguous numbering system
- Directly related to permutations





0  
ABC  
ACB

1  
BAC  
BCA \*

2  
CAB \*  
CBA \*

Reflection Table

0	0	1
0	1	1

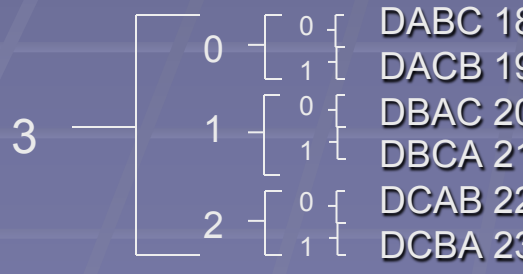
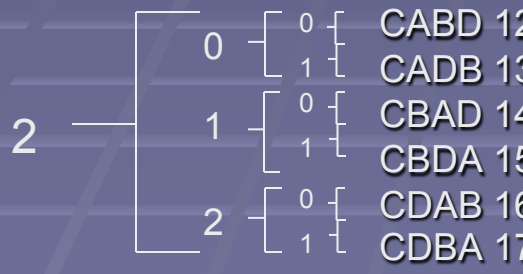
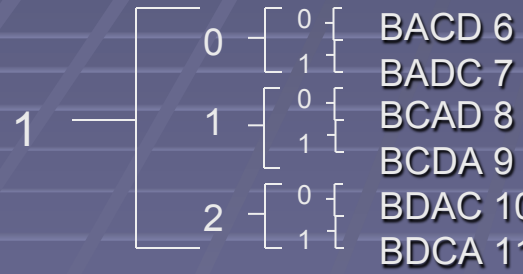
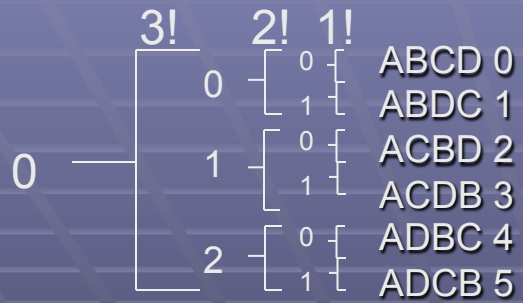
ABCD  
 ABDC  
 ACBD  
 ACDB  
 ADBC  
 ADCB  
 BACD  
 BADC  
 BCAD  
 BCDA \*  
 BDAC  
 BDCA \*

Reflection Table

0	0	1	2
0	1	1	2
0	1	2	2

CABD  
 CADB \*  
 CBAD  
 CBDA \*  
 CDAB \*  
 CDBA \*  
 DABC \*  
 DACB \*  
 DBAC \*  
 DBCA \*  
 DCAB \*  
 DCBA \*





### Reflection Table

0	0	1	2
0	1	1	2
0	1	2	2

# Experiment

- Run a brute search
- Run the modified brute force search
- Compare times
- See if there is any benefit to the second approach

# Results

## 11 City TSP

- Brute force: 100 seconds
- Modified Brute Force: 50 seconds
- Problems...

# Results

## 11 City TSP

- After modifications
- Brute force: 5 seconds
- Modified brute force search: 4 seconds

# Results

## 12 City TSP

- Prediction: BF-60 seconds, MBF-48 seconds
- Brute force search: 60 seconds
- Modified brute force search: 47 seconds

# Conclusion

- Modified brute force search takes 78.4% of the amount of time as the brute force search

# Summary

- What is the TSP?
- Computational complexity
- Factoradics
- Search technique
- Experiment

# References

- Traveling Salesmen Problem. Retrieved November 12, 2006, from [http://en.wikipedia.org/wiki/Travelling\\_salesman\\_problem](http://en.wikipedia.org/wiki/Travelling_salesman_problem)
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- Zbigniew Michalewicz, and David B. Fogel. How to Solve It: Modern Heuristics. Springer-Verlag Berlin Heidelberg 2000