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Application of a TSP variant to chemical shipping

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Presentation content

- Brief recap of TSP
- Characteristics of maritime shipping of chemicals
- Description of problem
- Mathematical modeling of problem
- Optimal order of loading/unloading
- References
- Homework assignment

Travelling salesman problem (TSP)

- A well-studied problem of optimization
- *What is the shortest route to take when visiting a list of points?*, i.e. minimize total distance of route.
- Other values can be optimized a well: time taken, costs, mean distance between points etc.
- Variant used today: **”Travelling salesman problem with pickups and deliveries”**

Maritime shipping of chemicals

- Bulk liquid industrial chemicals and chemicals/oils that require high standards of tank cleaning.
- Shipments are relatively small.
- Tankers can have 15 to over 50 separate tanks for different chemicals.

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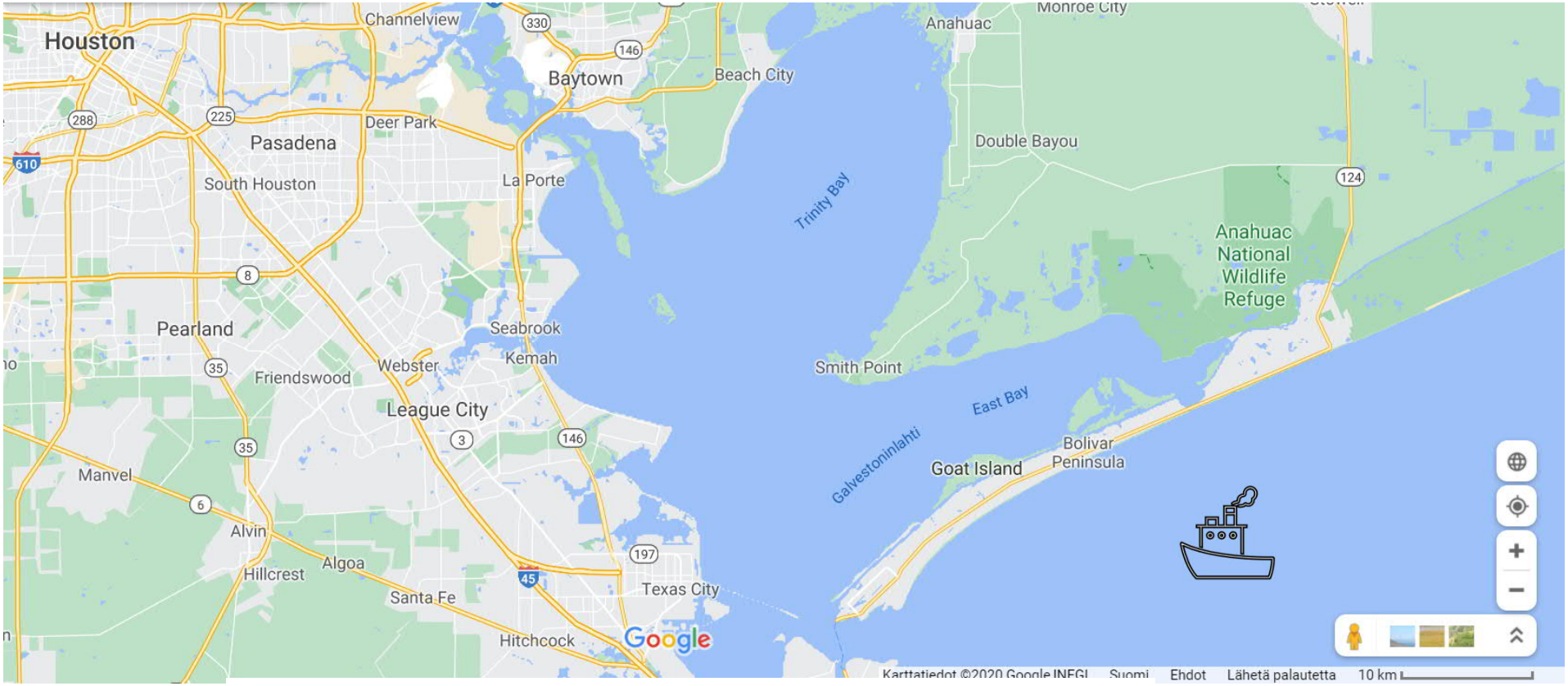
The problem

- As chemical tankers typically carry a wide range of chemicals, often for different charterers, they need many terminal calls in port, => inefficiencies => long times in port.
- Odfjell's (the studied company) ships spent 44% of their available time in port during 2013.
- Reducing time spent in port increases availability for transport.

Illustration of problem

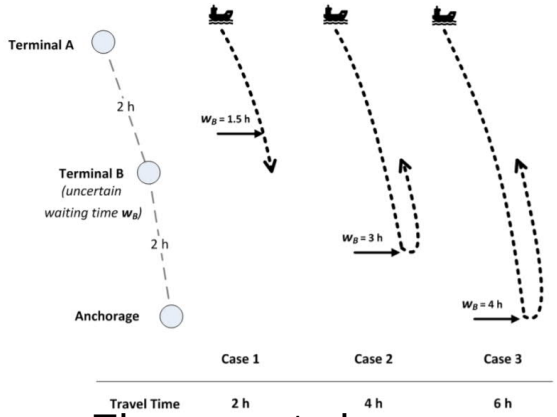


Port of Houston, screenshot from Google Maps

Mathematical modeling of problem

- Goal = Find the order of terminal calls with greatest probability for the port calls time to not exceed a threshhold.
- Stochastic travel times between terminals, distributions for the times are derived with Monte Carlo-simulations based on data provided by Odfjell.
- Draft limitations are taken into account.

$$\max \Pr\left(\sum_{(i,j)\in A} T_{ij} x_{ij} \leq H\right)$$



Elgesem et al.

Optimal order of terminal calls

- Without risk, the optimal route is obviously the shortest route.
- When considering risk, one might favour slightly increased mean for much decreased variance, DM's preference.
- Deterministic and stochastic approach had little difference in most cases, stochastic approach had greater value if the anchorage would be closer to port. (Due to lower-variance alternatives)

References

- Elgesem, A. S., Skogen, E. S., Wang, X., & Fagerholt, K. (2018). A traveling salesman problem with pickups and deliveries and stochastic travel times: An application from chemical shipping. *European Journal of Operational Research*, *269*(3), 844-859.

Homework assignment

A chemical tanker is heading to port to complete a series of pickups and deliveries. Your task is to,

A: List all feasible orders of terminal calls, such that all deliveries and pickups are completed.(4p)

B: Present the order of terminal calls with the shortest total distance. (2p)

Details are given in the excel file.

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Hints either at course tg or directly to @WalterRehn

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Thank you for your time!