Querying Large Vehicular Networks:

How to Balance On-Board Workload and Queries Response Time?

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Vincenzo Gulisano [1] Marina Papatriantafilou [1]

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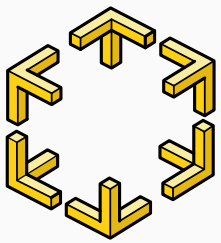
IEEE Intelligent Transportation Systems Conference - ITSC 2019,
Auckland, New Zealand.

[1] Chalmers University of Technology (Gothenburg, Sweden), [2] Volvo Cars.

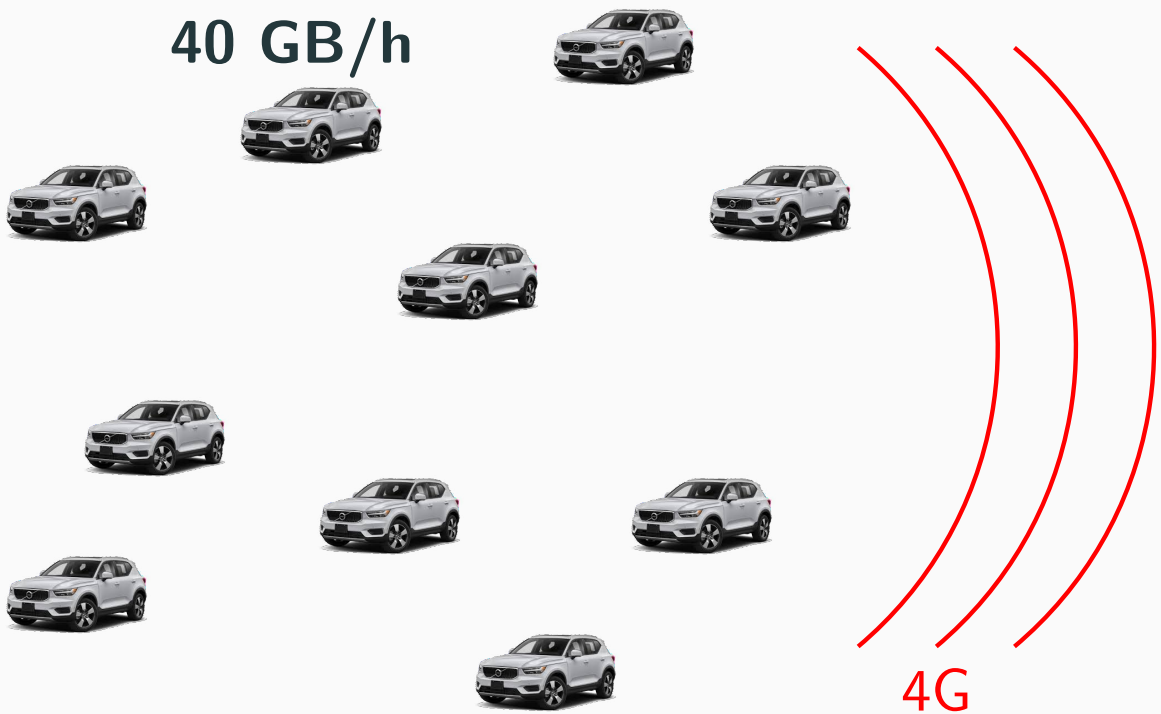
CHALMERS



Introduction

Motivation: Data Analysis On-Board Vehicles

- **Challenge:** analysis over large amount of data in a large vehicular network
- **Solution:** leverage vehicles' computing power



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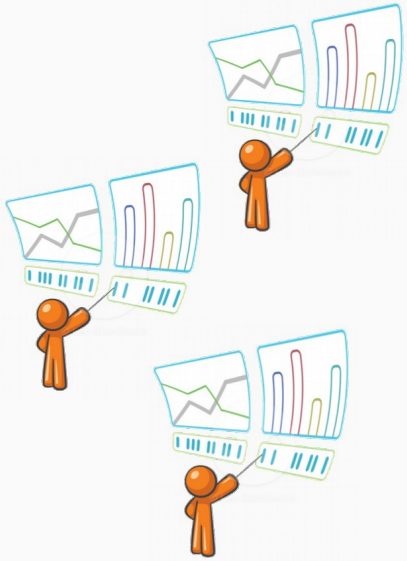
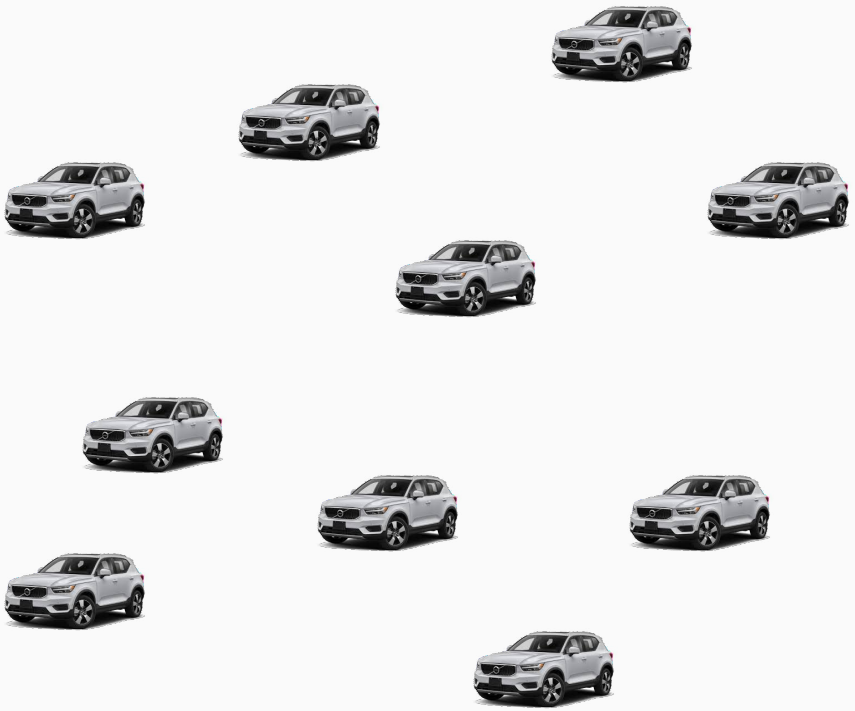


How many vehicles have driven close to a fuel station yesterday?



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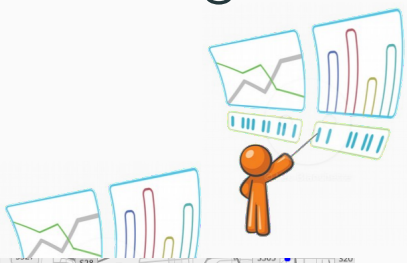
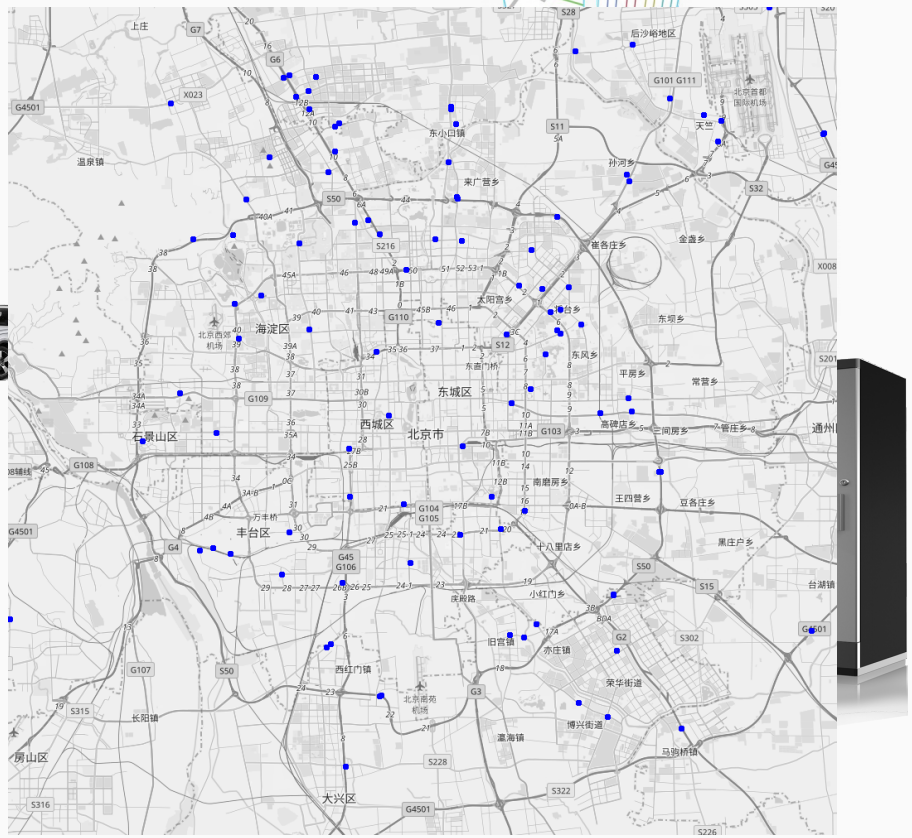


Query:

Driven close to fuel station?



from at least 2 vehicles

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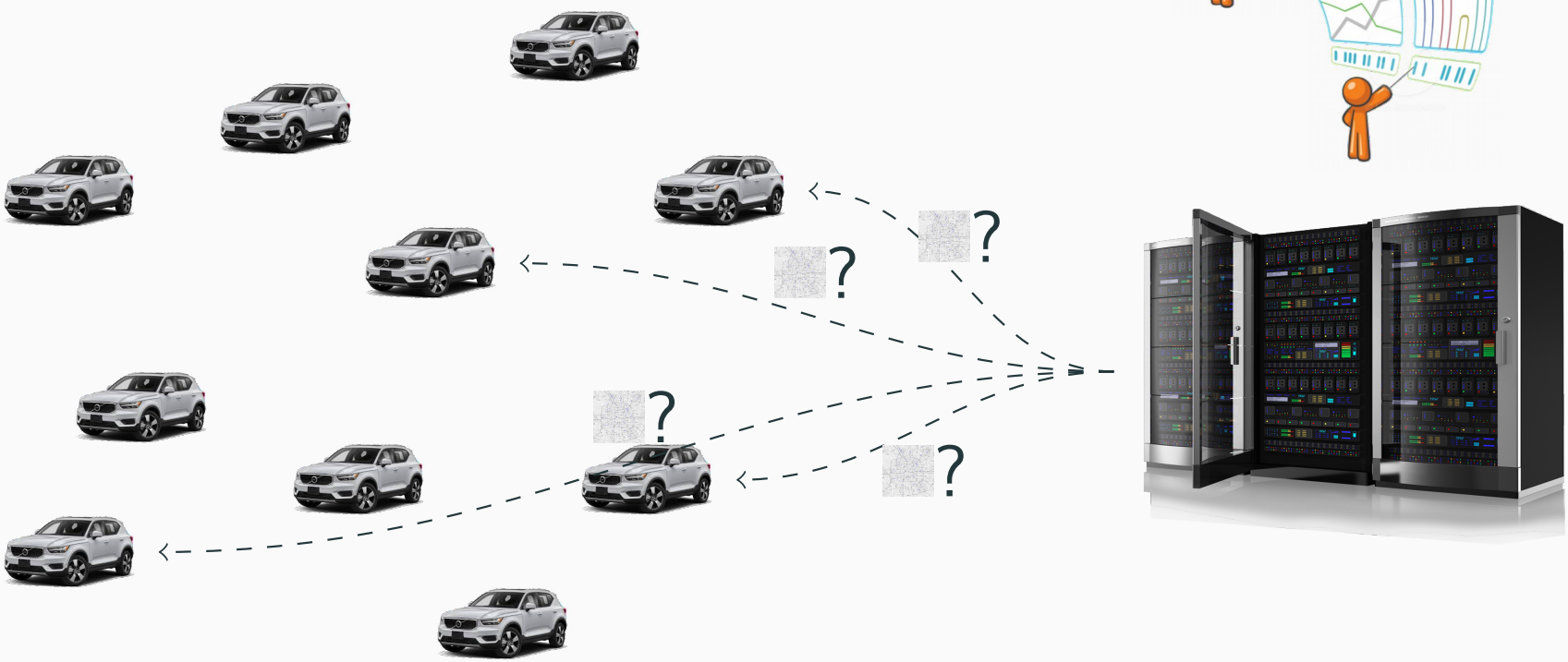

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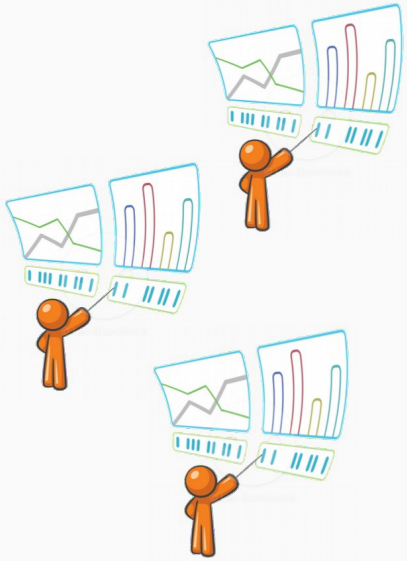

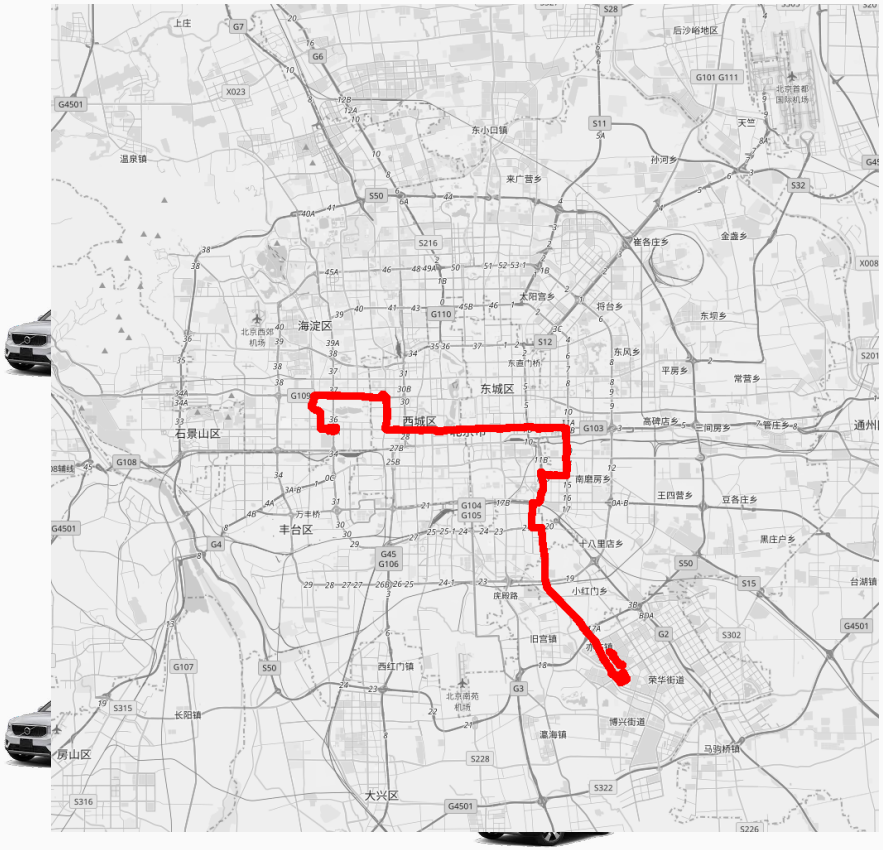

Vehicle's Onboard Data

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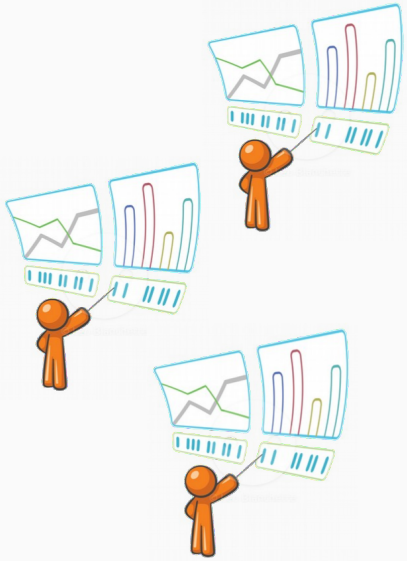

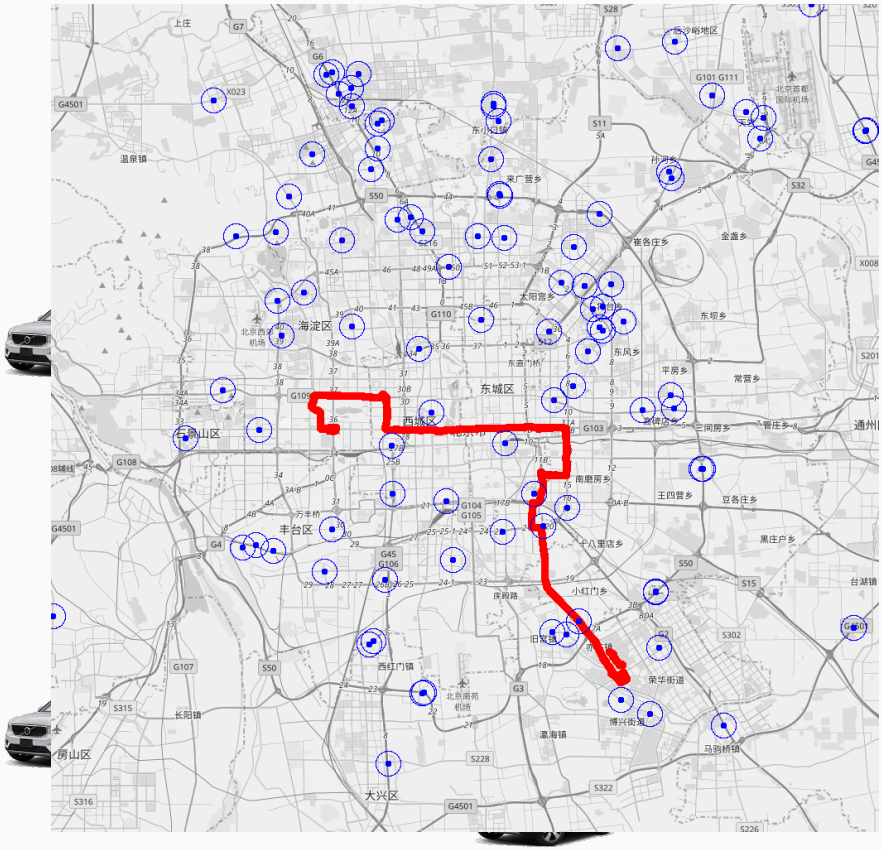

Query Execution

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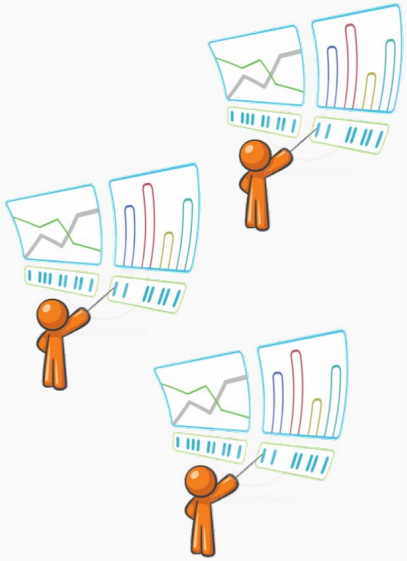

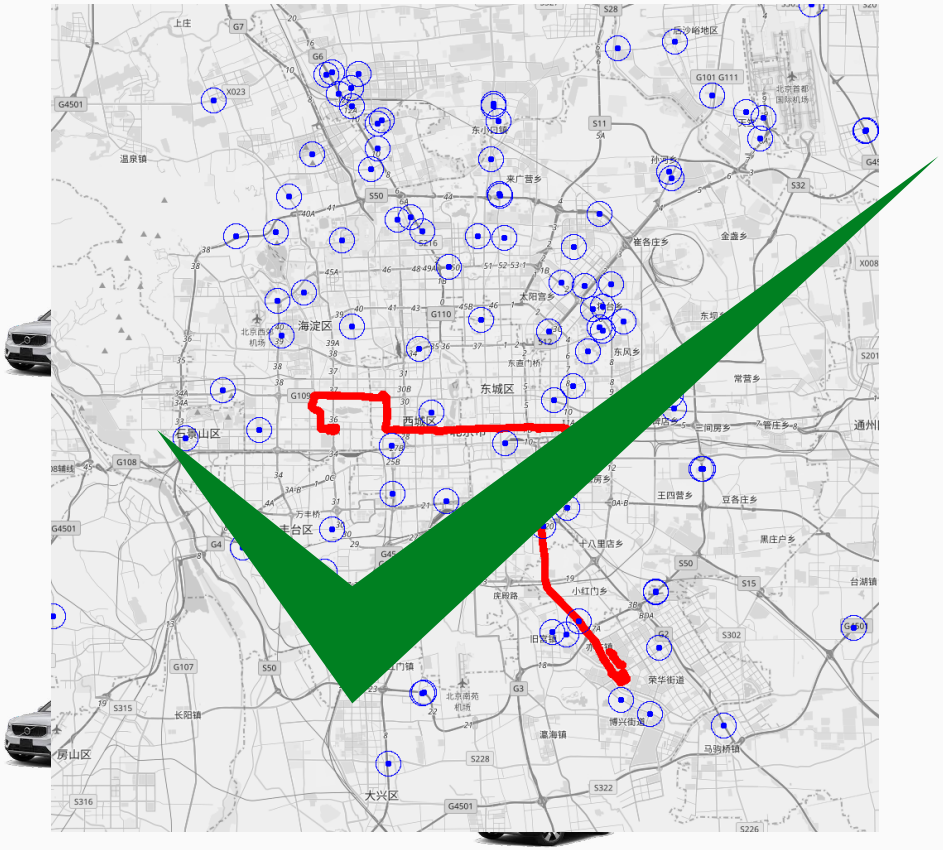

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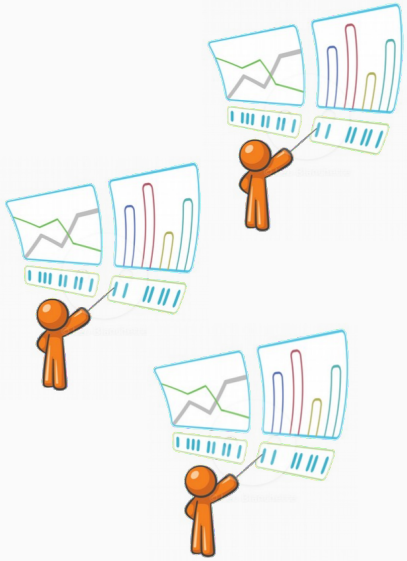

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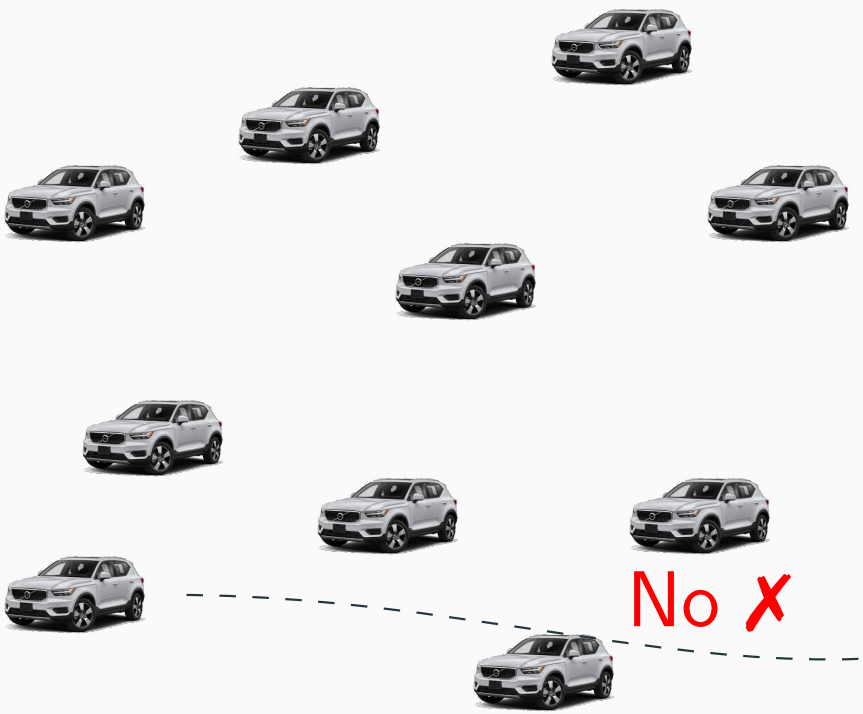

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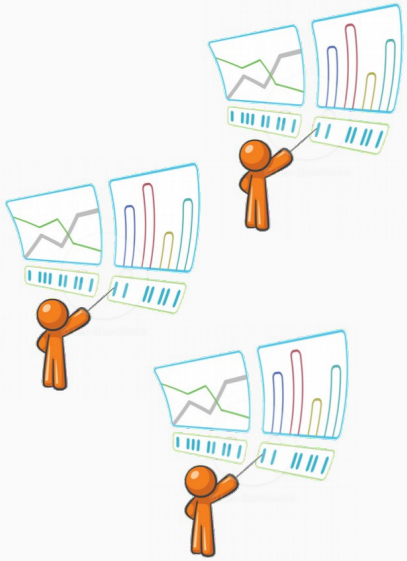

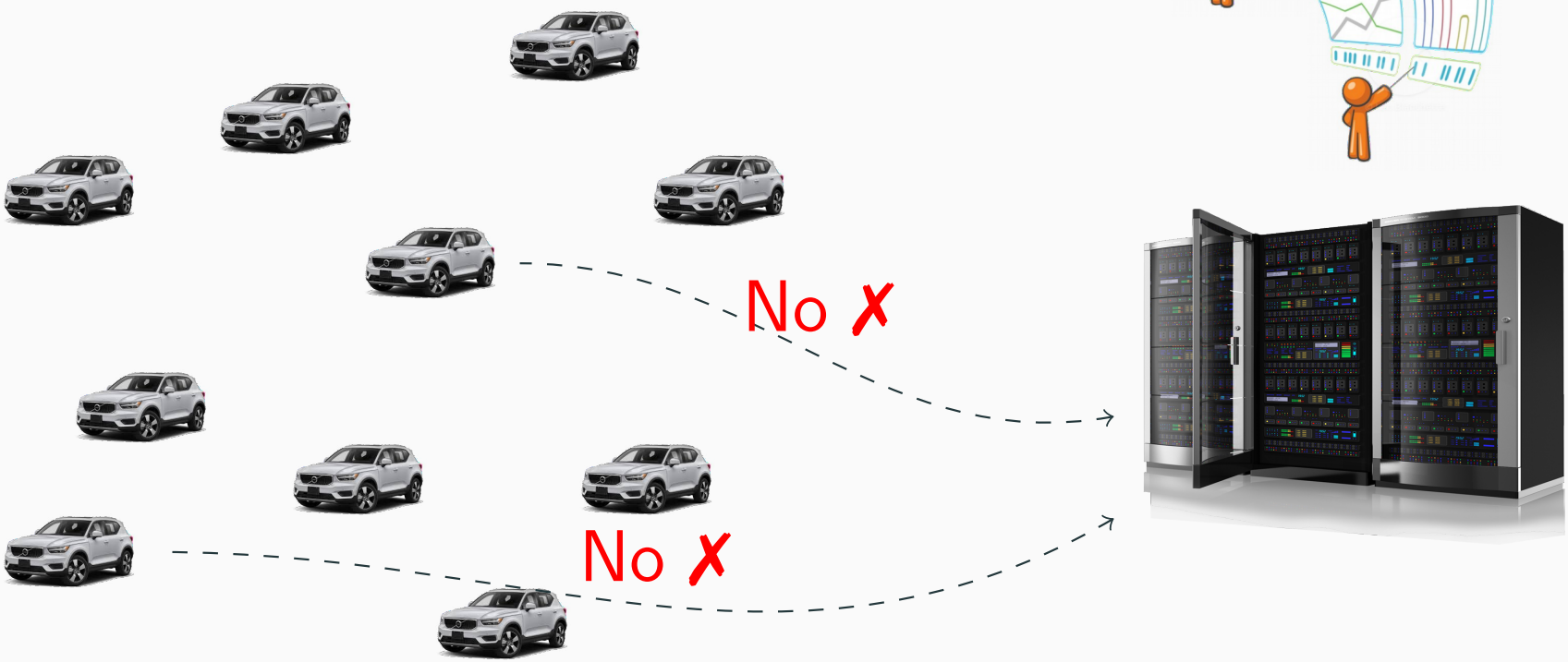

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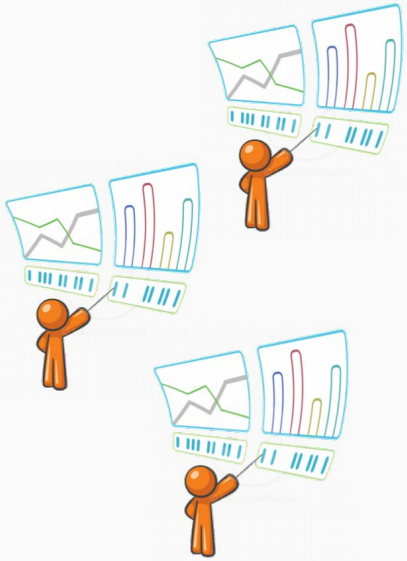

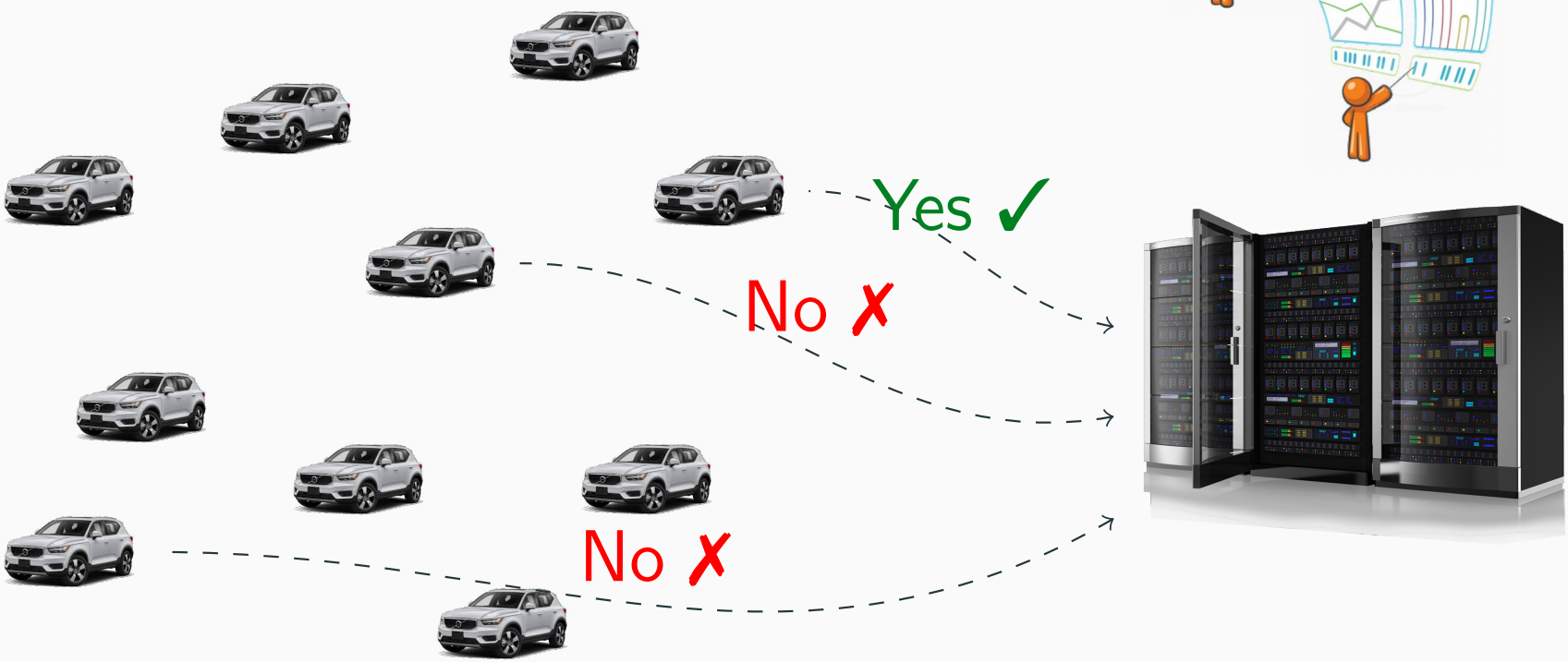

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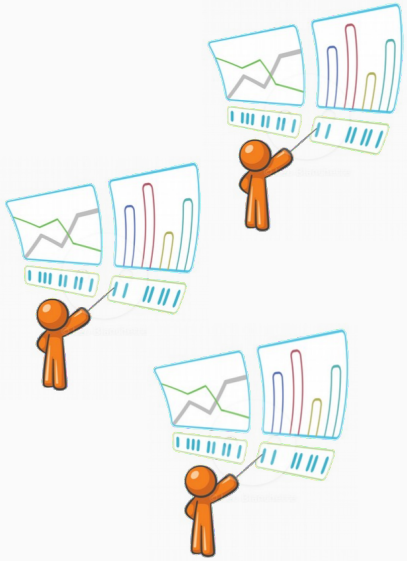

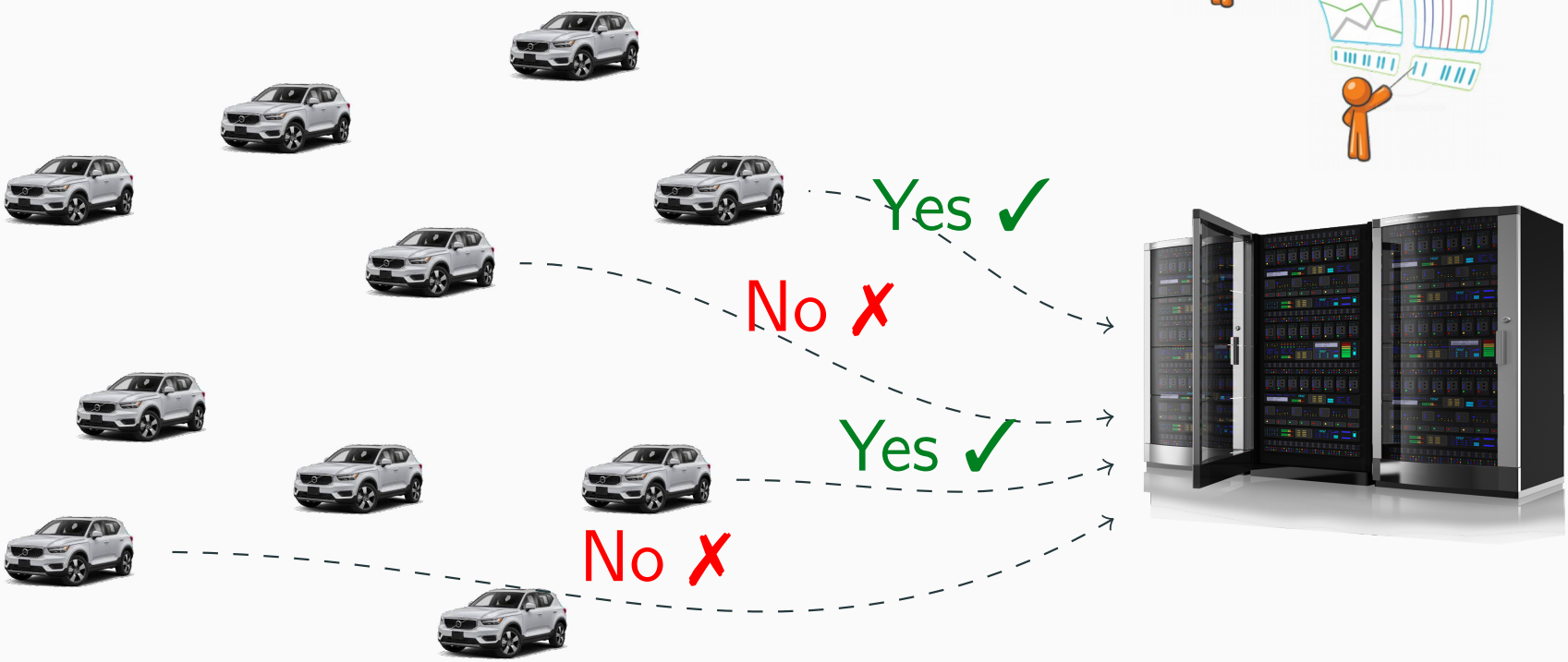

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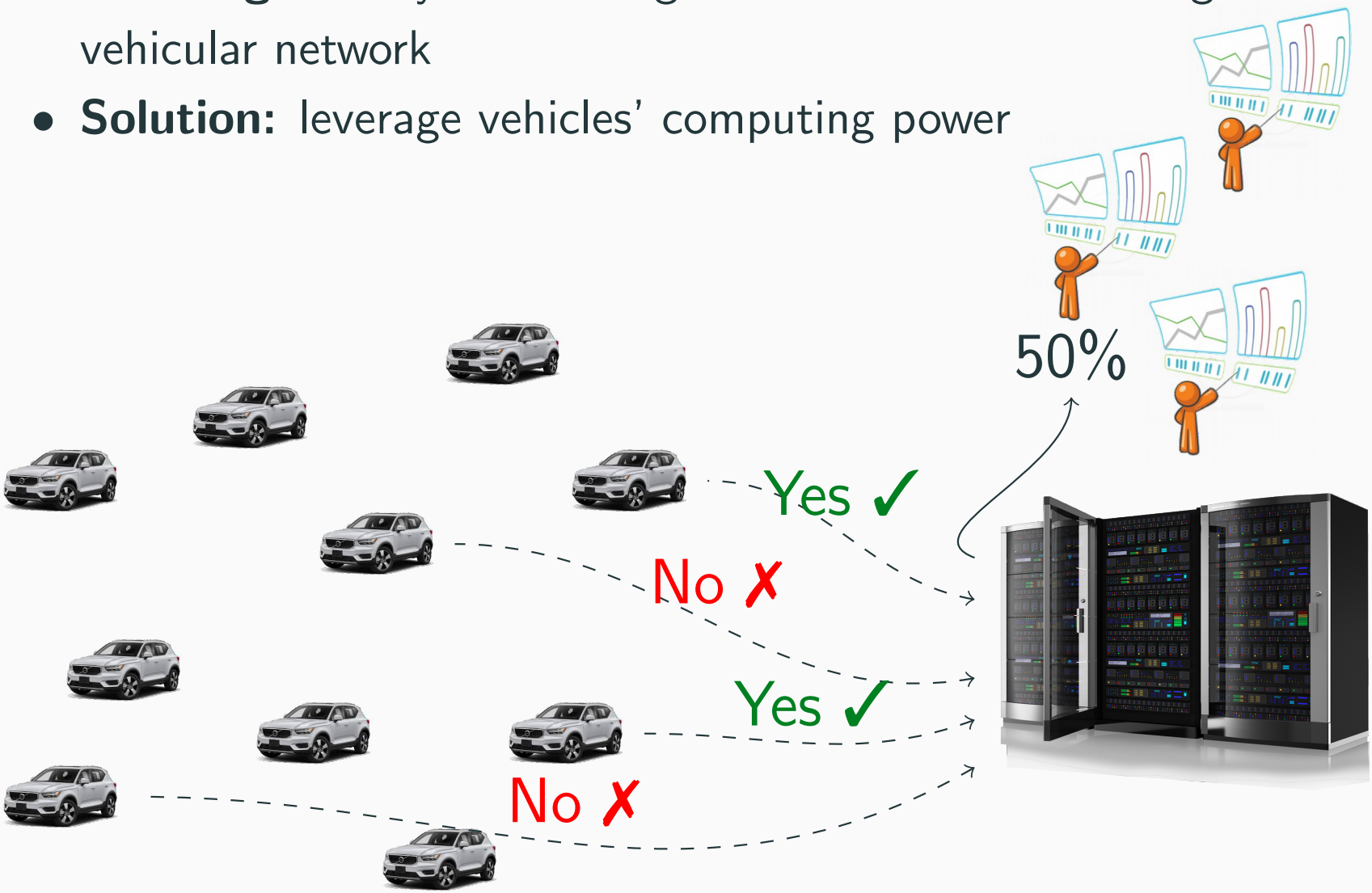

Model and Problem Definitions

Queries in Vehicular Networks: Model

Queries

- a **condition** to satisfy to answer positively
- a **minimum number** of positive answers to collect

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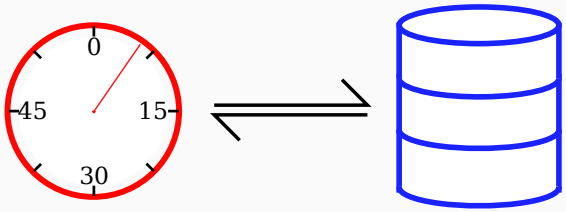

- Spread a set of queries on a fleet of Vehicles while balancing
  - **Response Time:** the time to resolve all queries
  - **Analysis Cost:** the total amount of computational work

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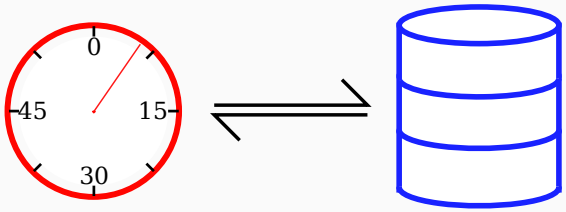

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  - **Response Time:** the time to resolve all queries
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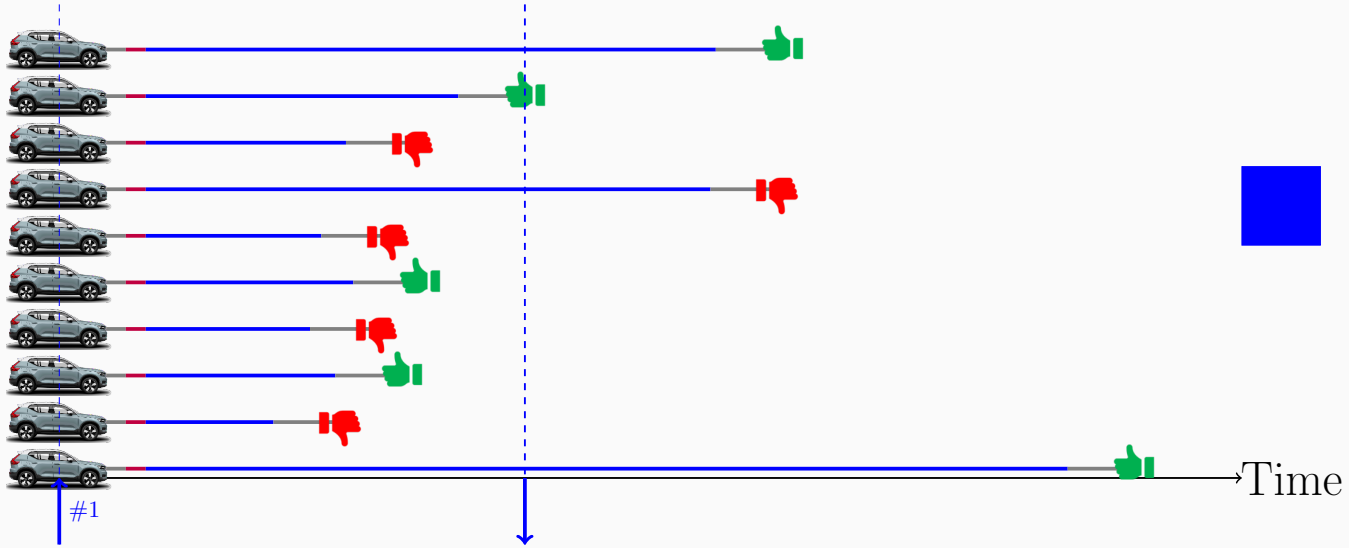
Challenges

- the 2 measures go in opposite directions
- the time to answer a particular query is **unknown**

Algorithms

Query Spreading Algorithms

Fleet Size **10**, Answers Required **3**.



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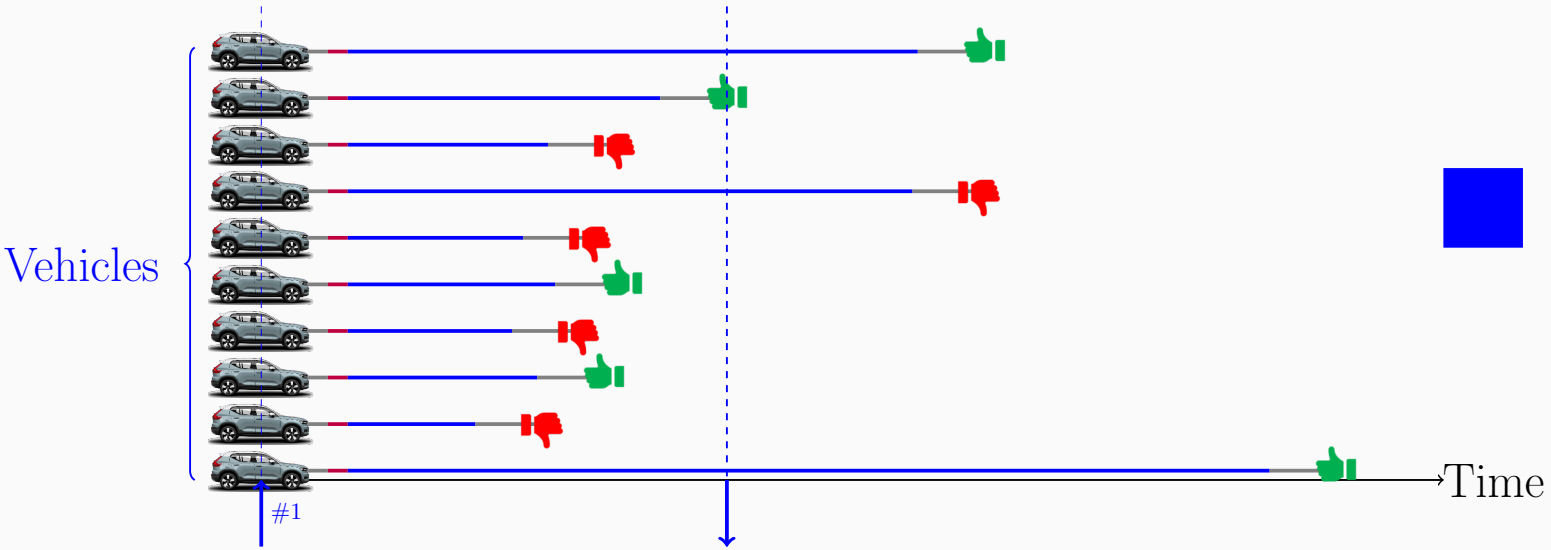

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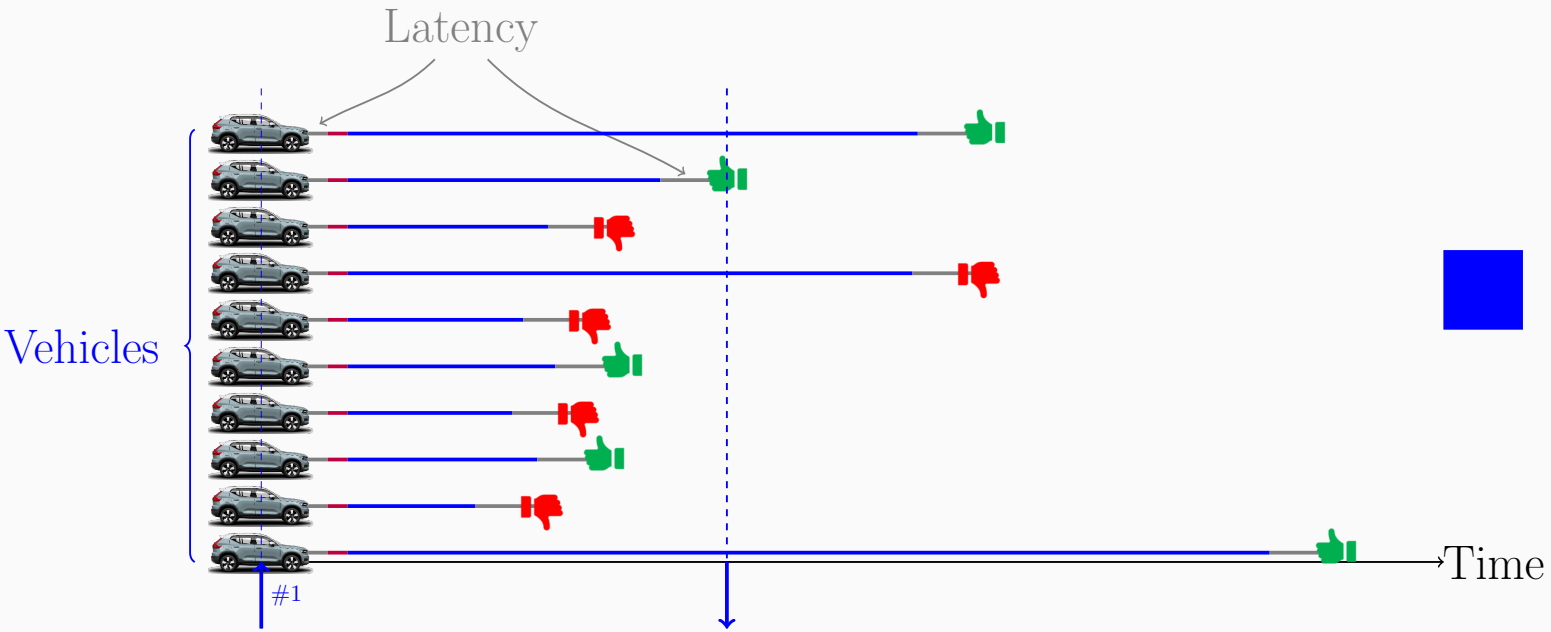

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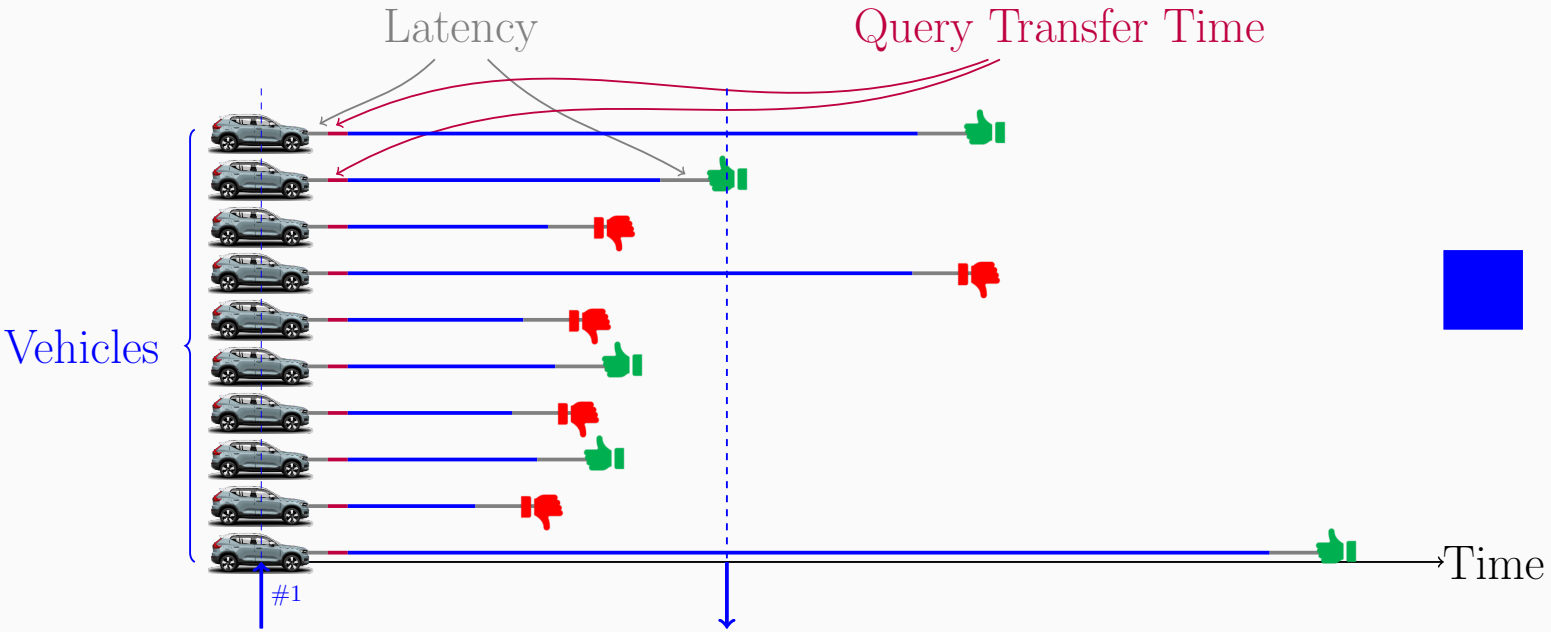

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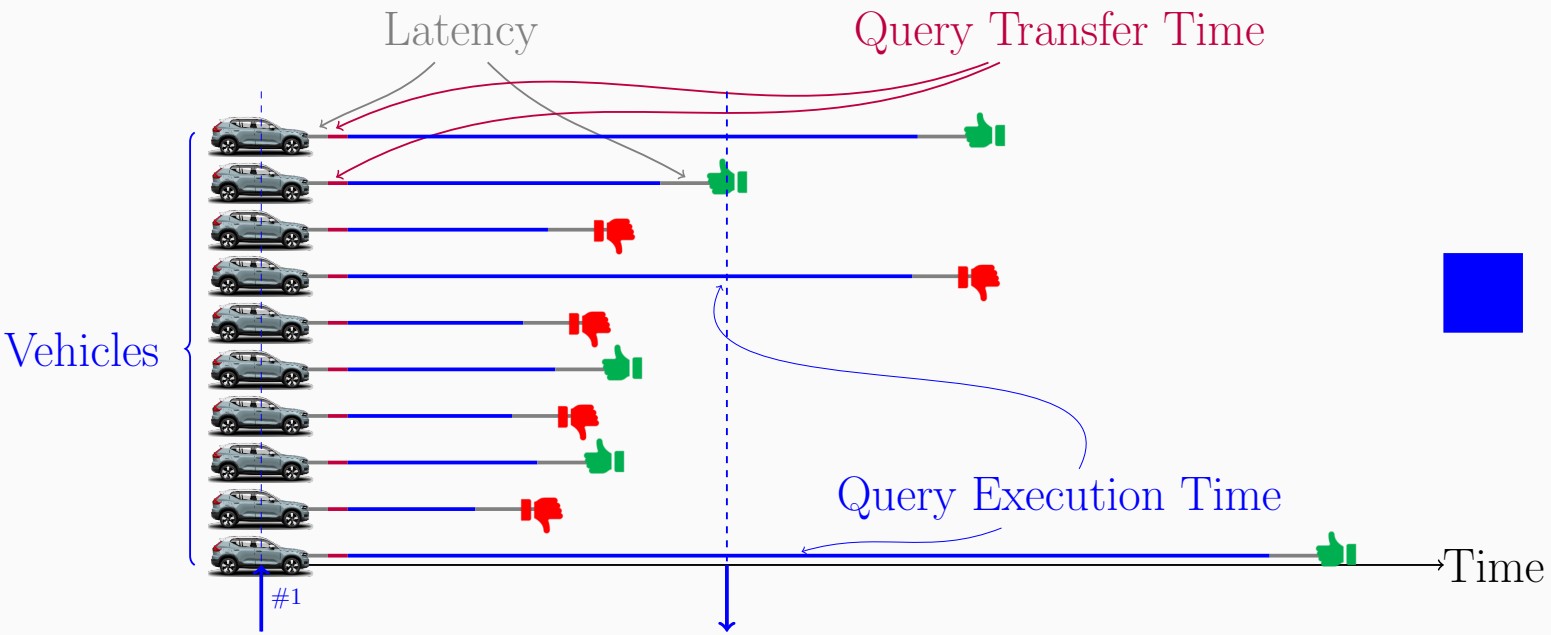

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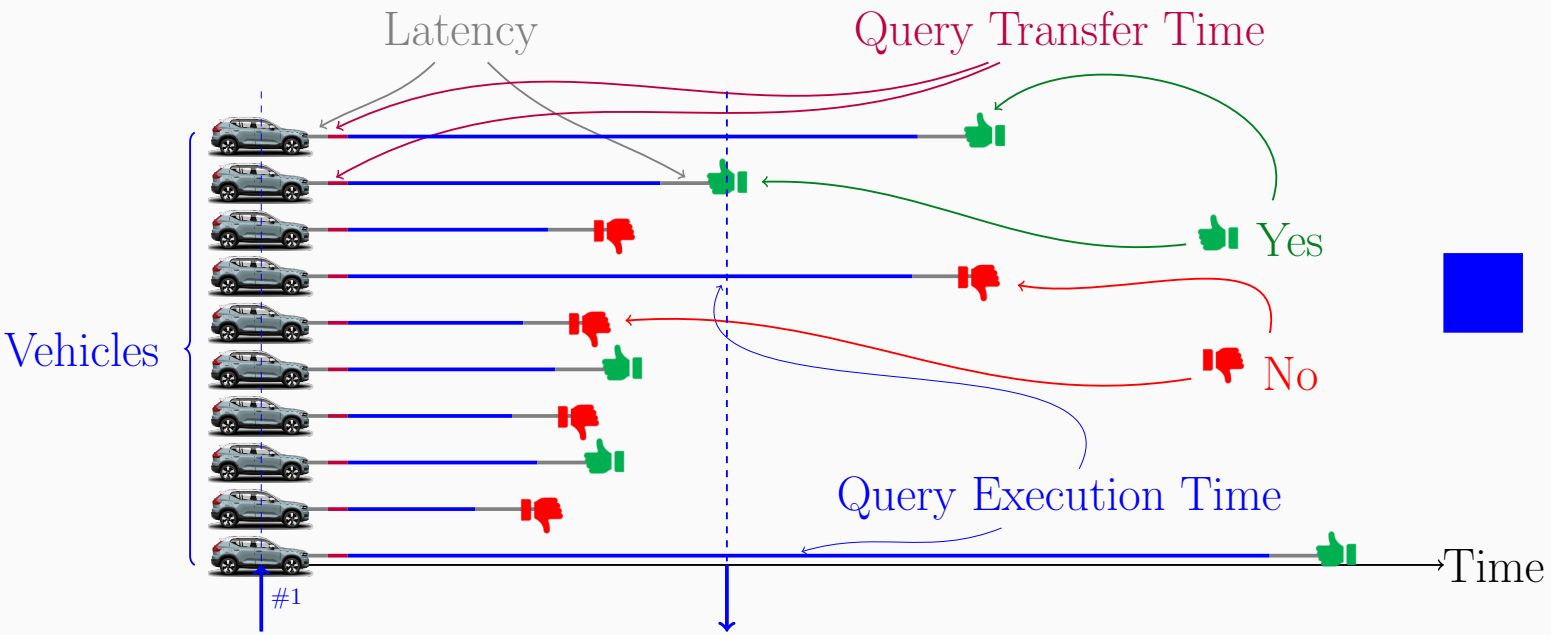

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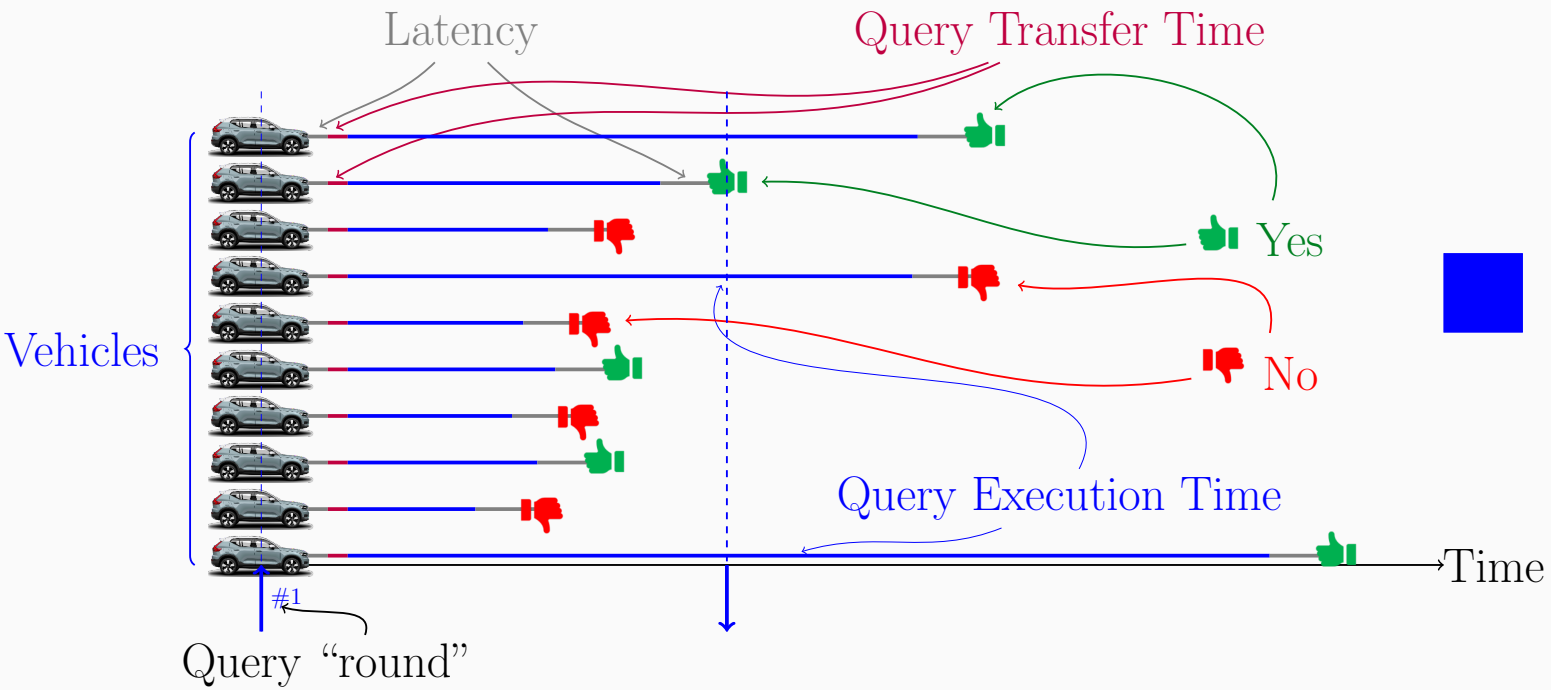

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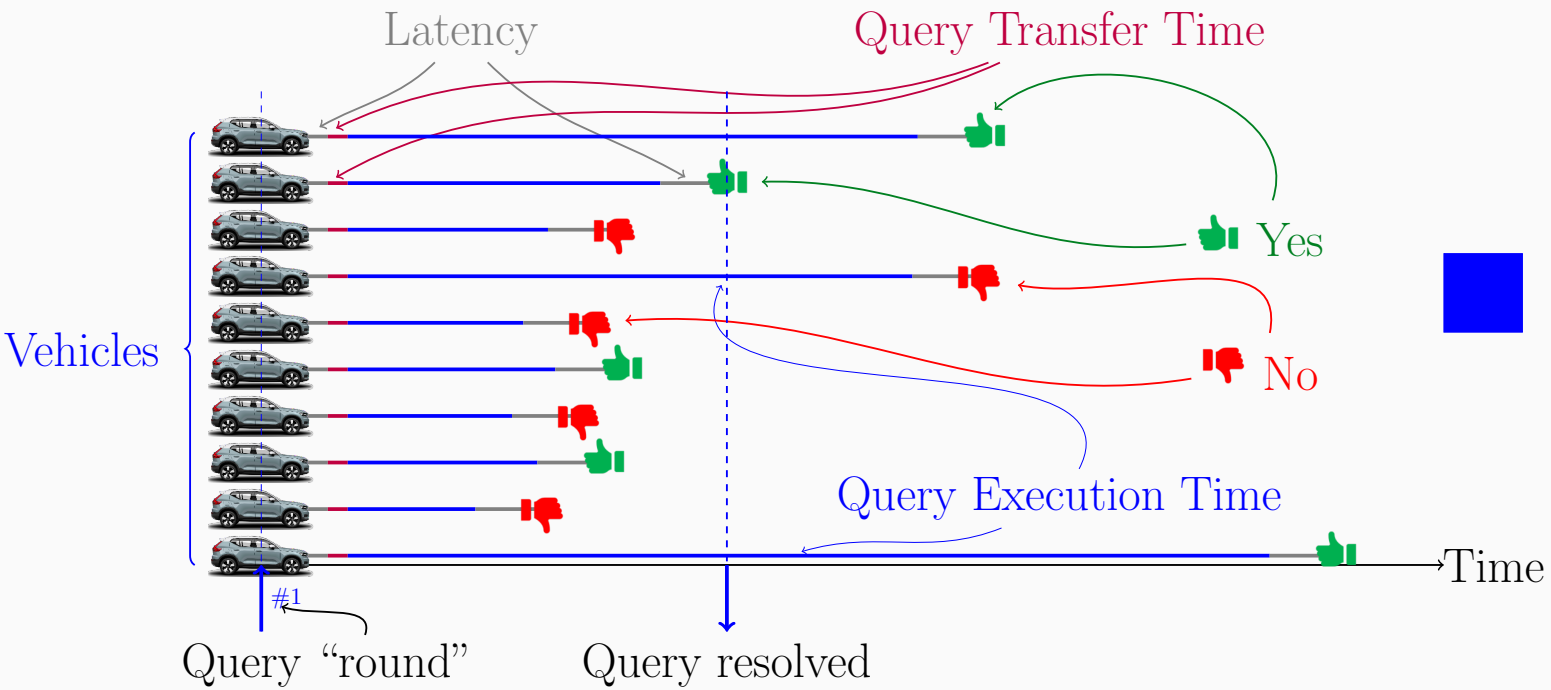

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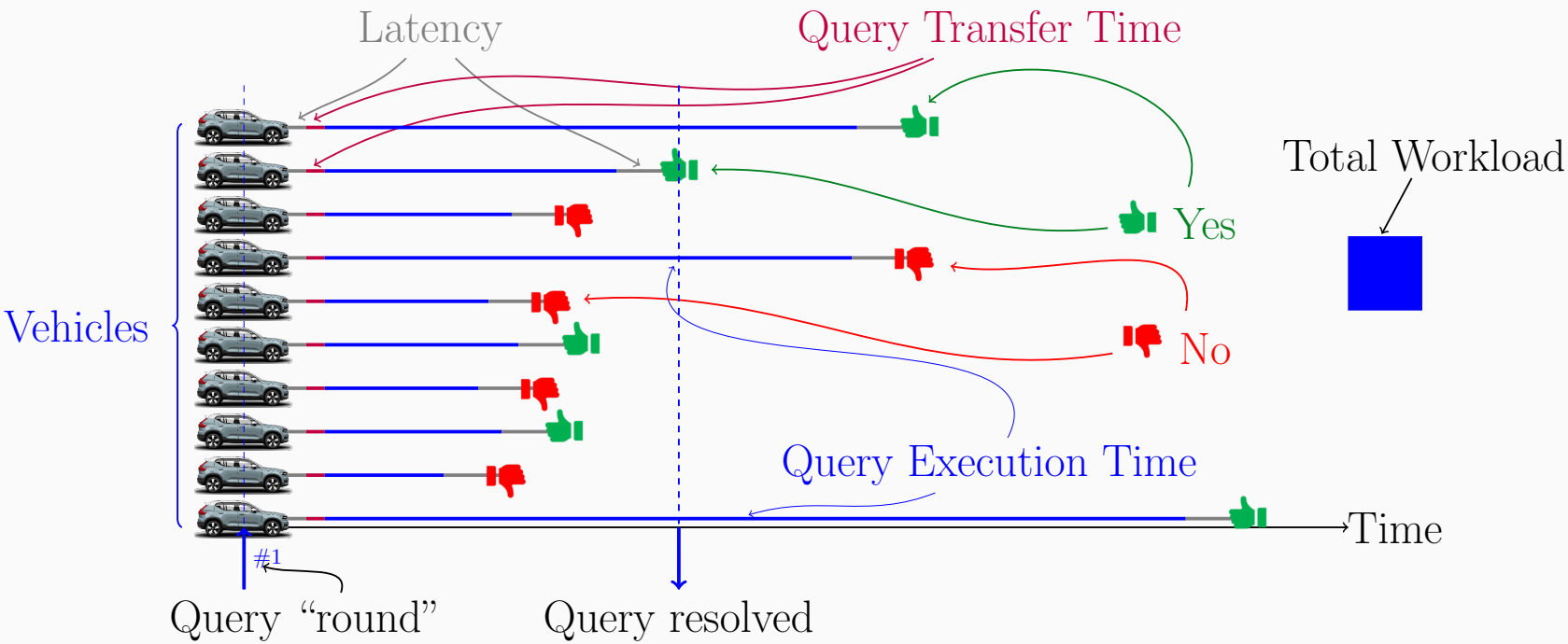

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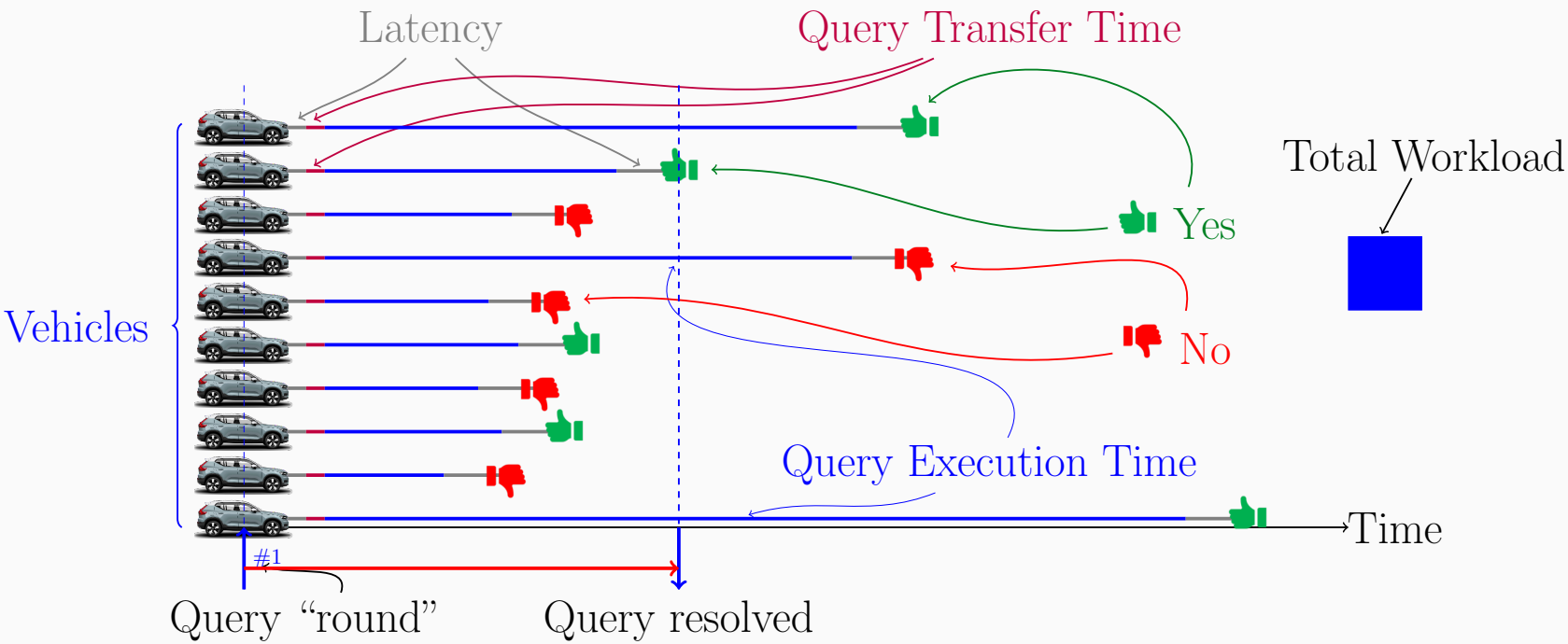

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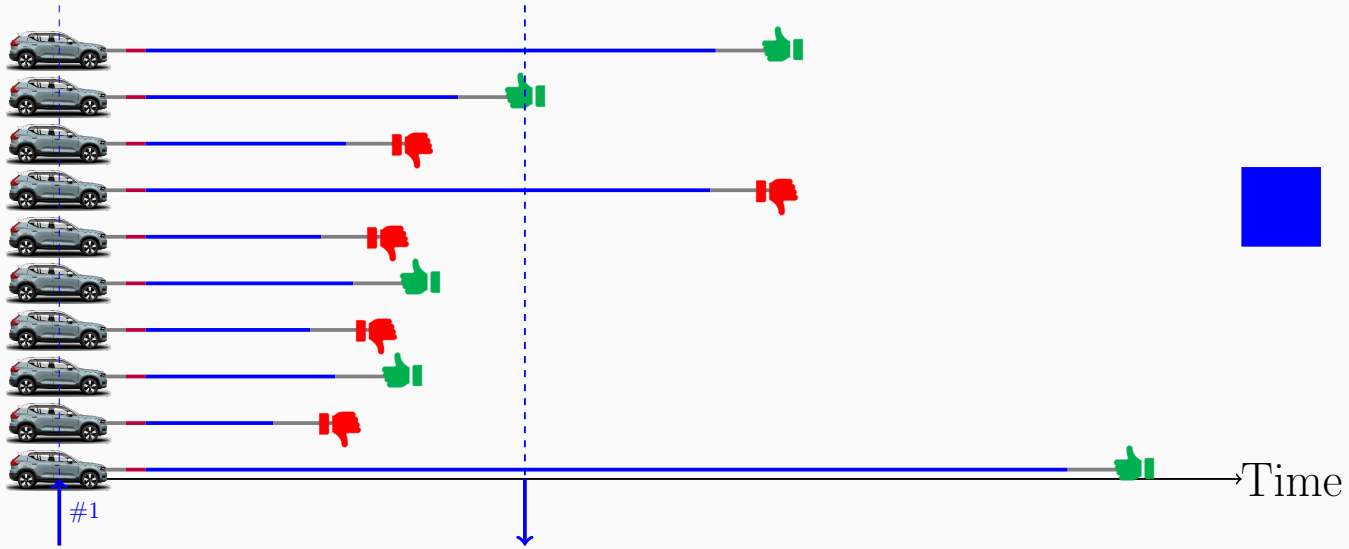
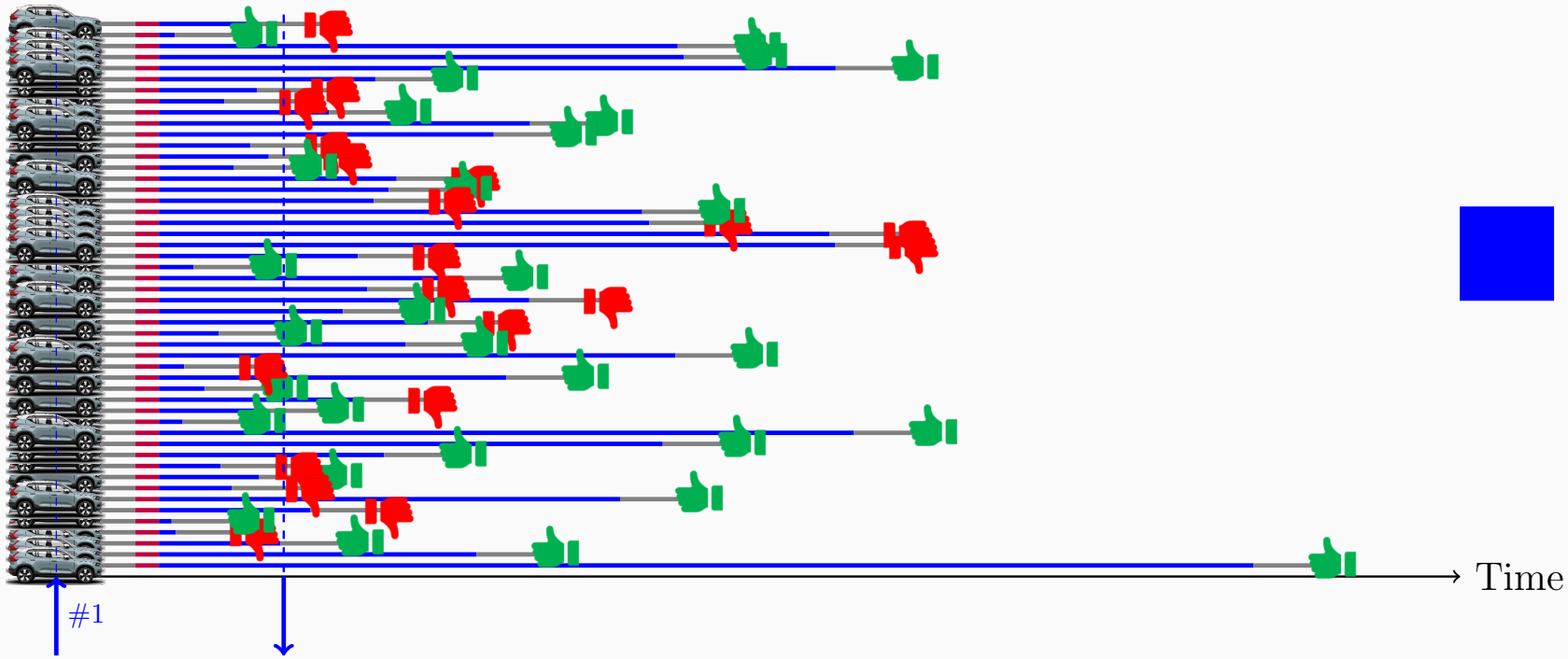


“Ask Everyone” Strategy

Fleet Size **50**, Answers Required **5**.



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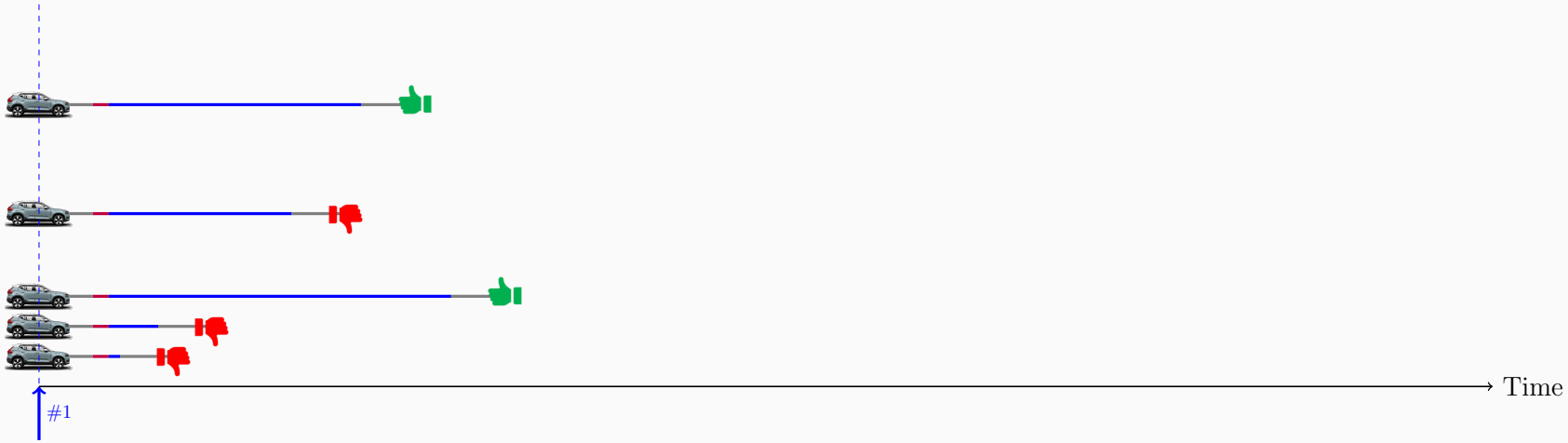

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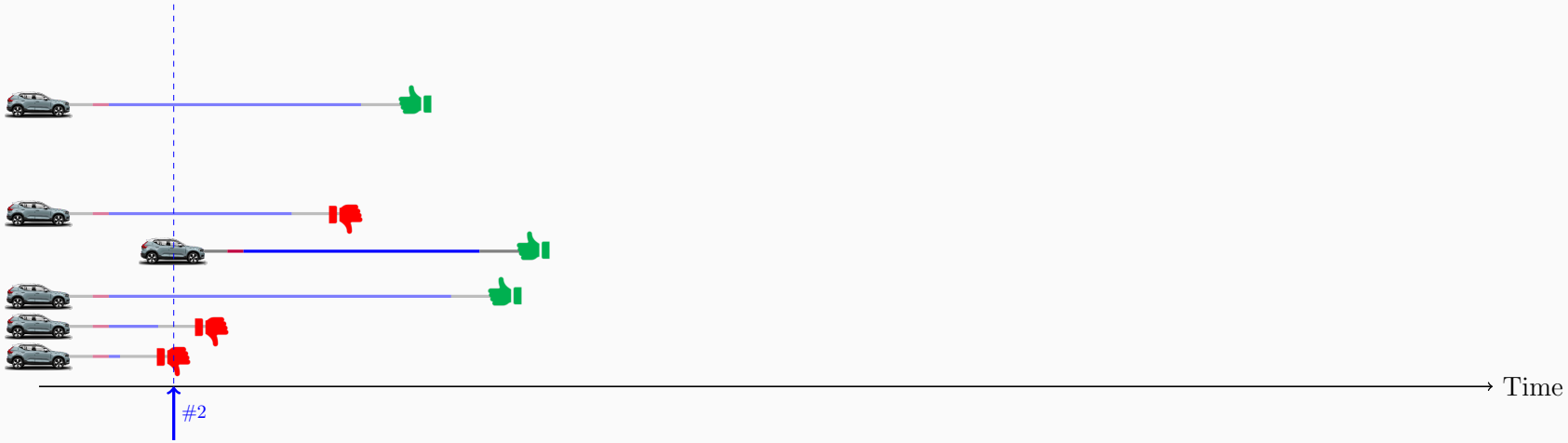

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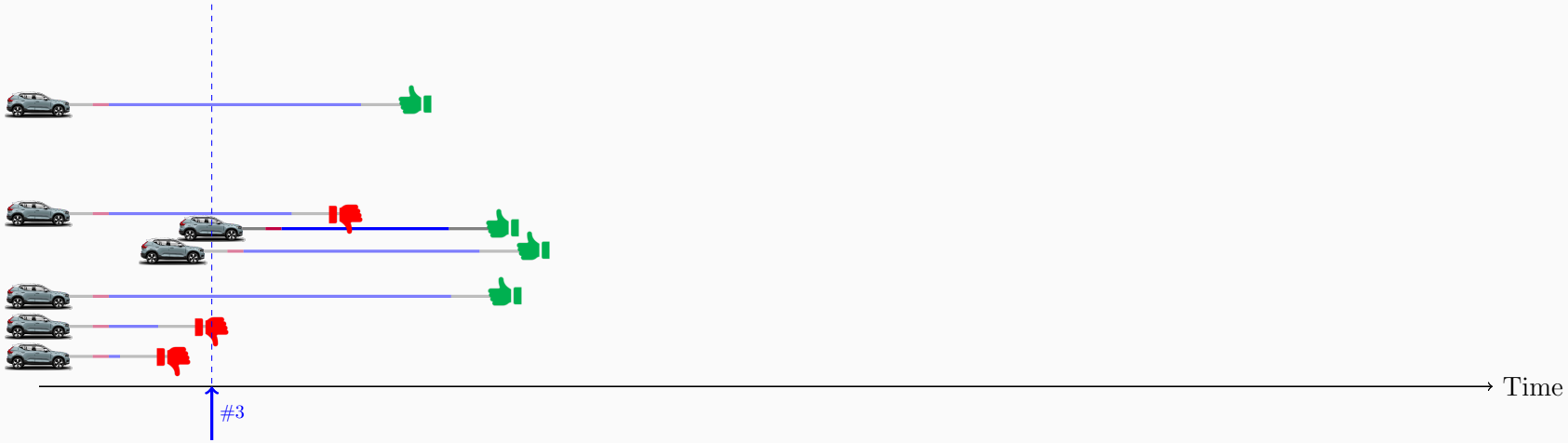

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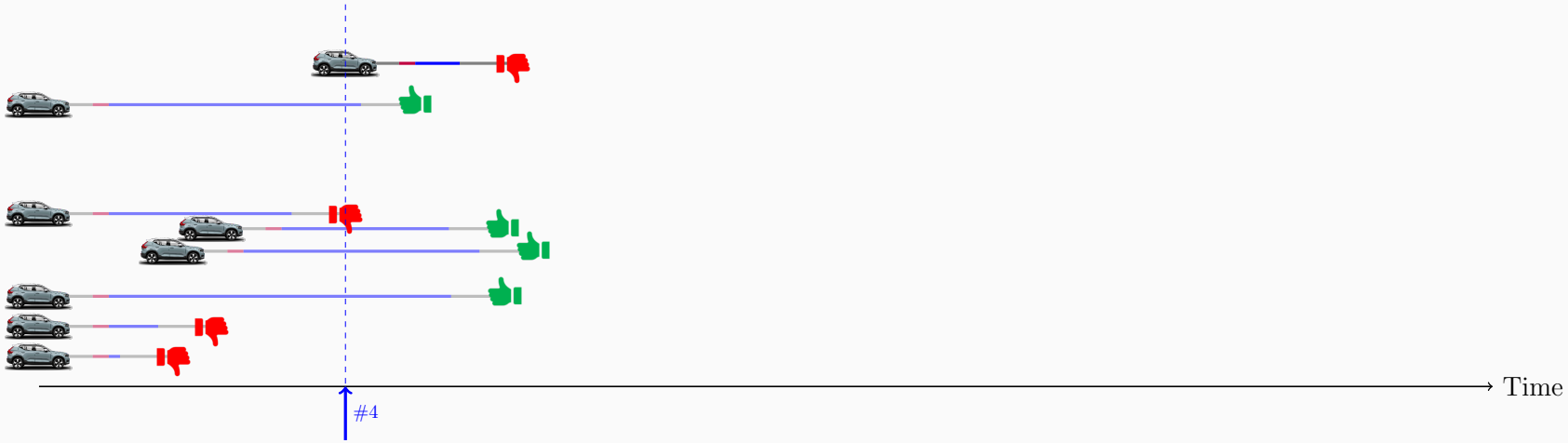

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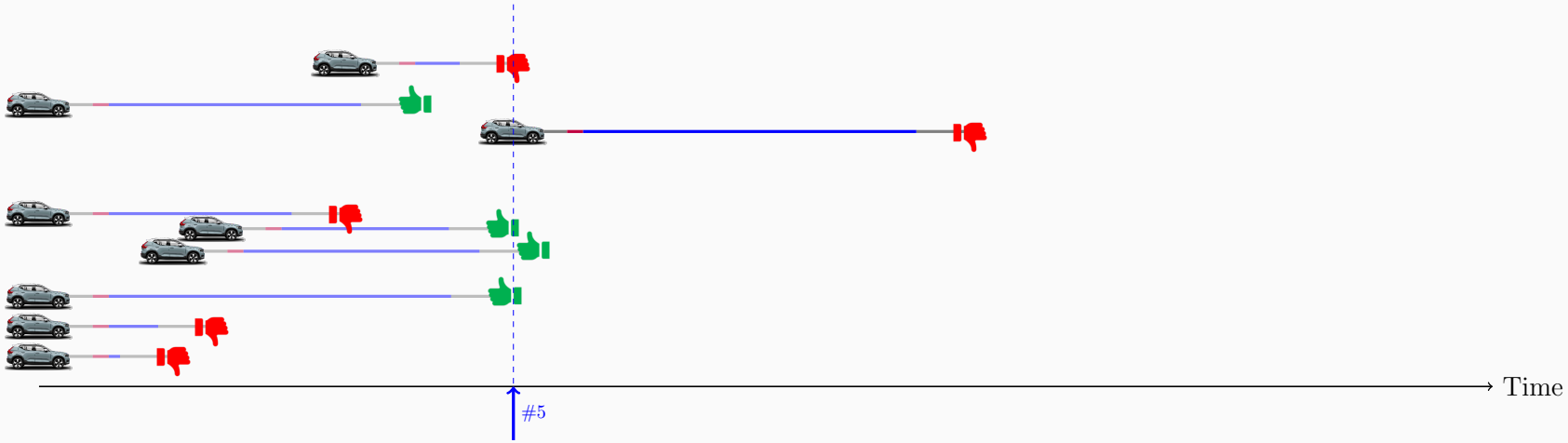

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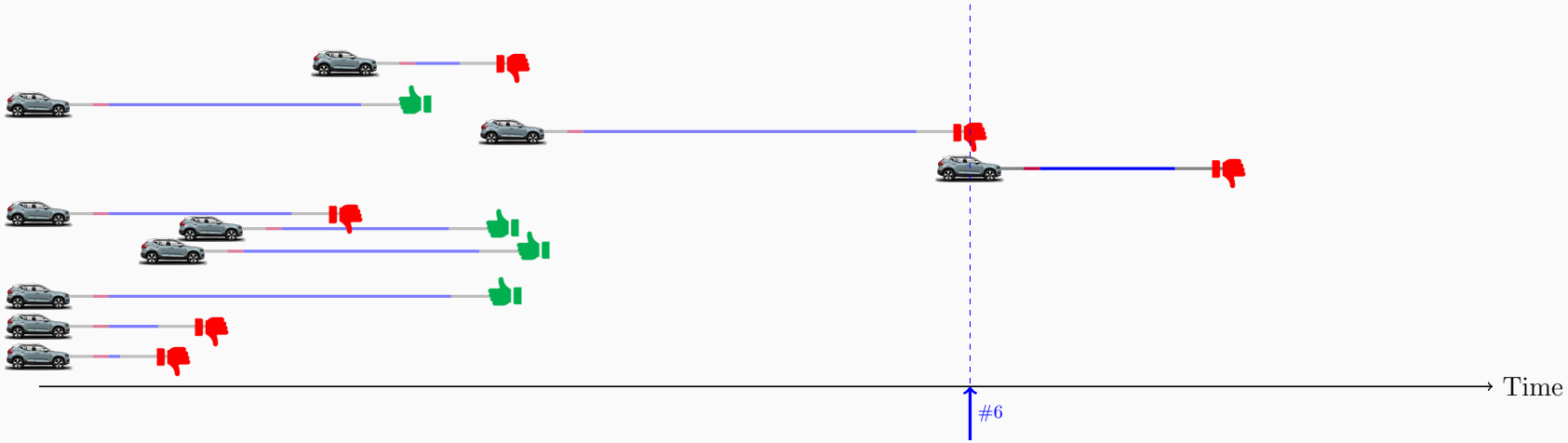

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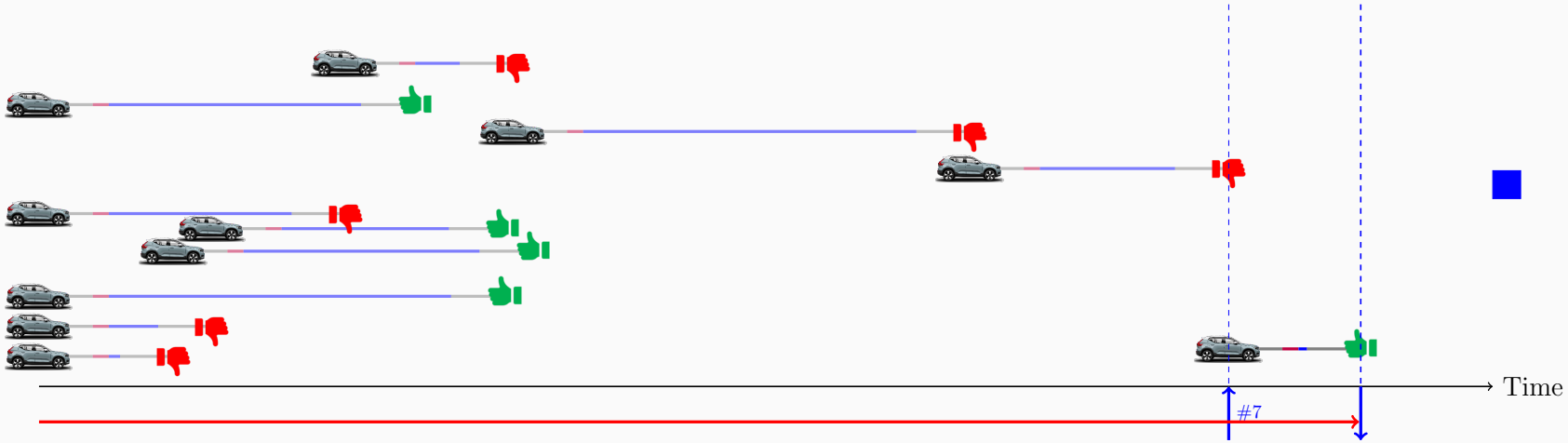

“Balanced” Strategy

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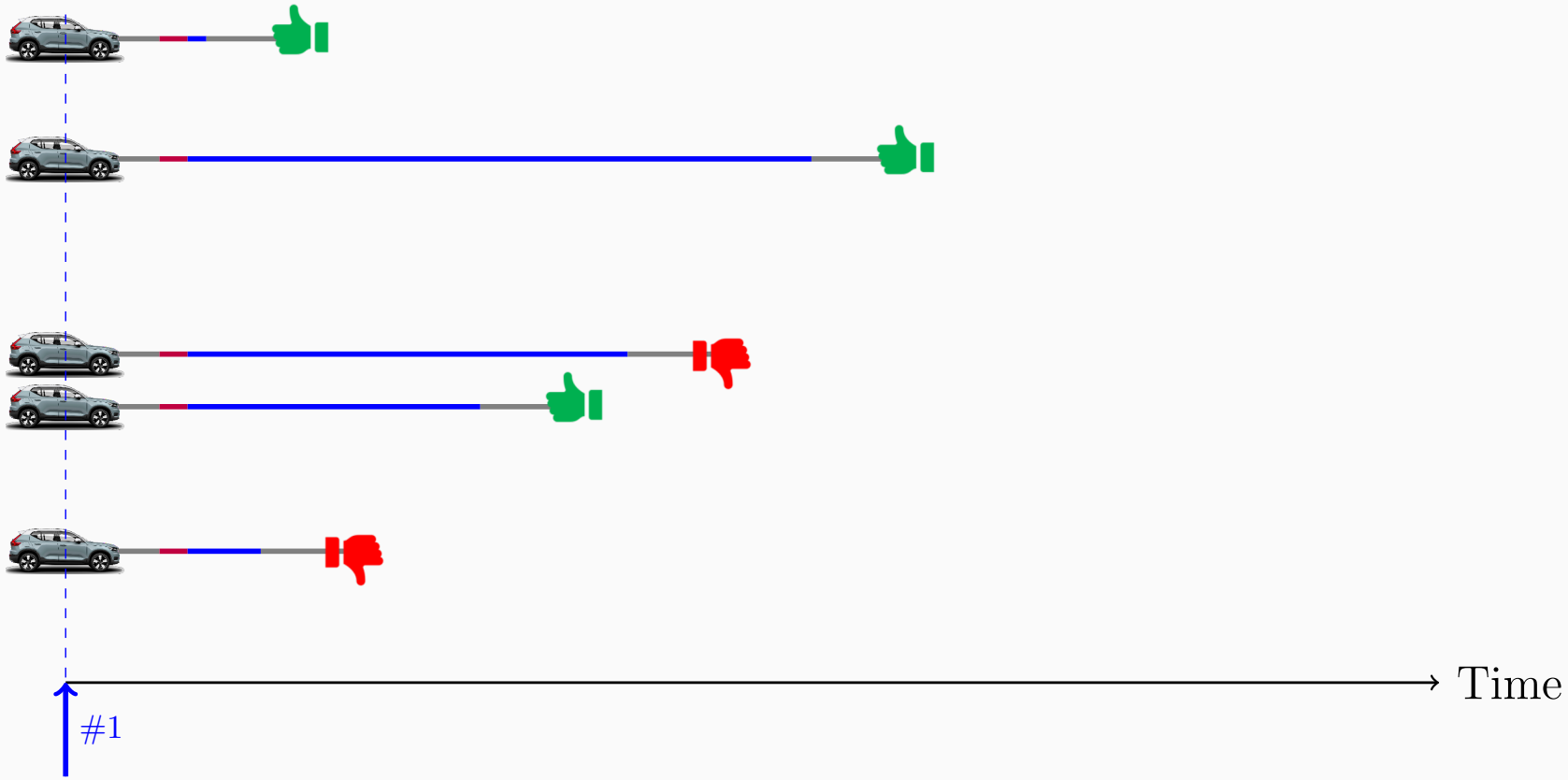
Start by asking n vehicles at random.



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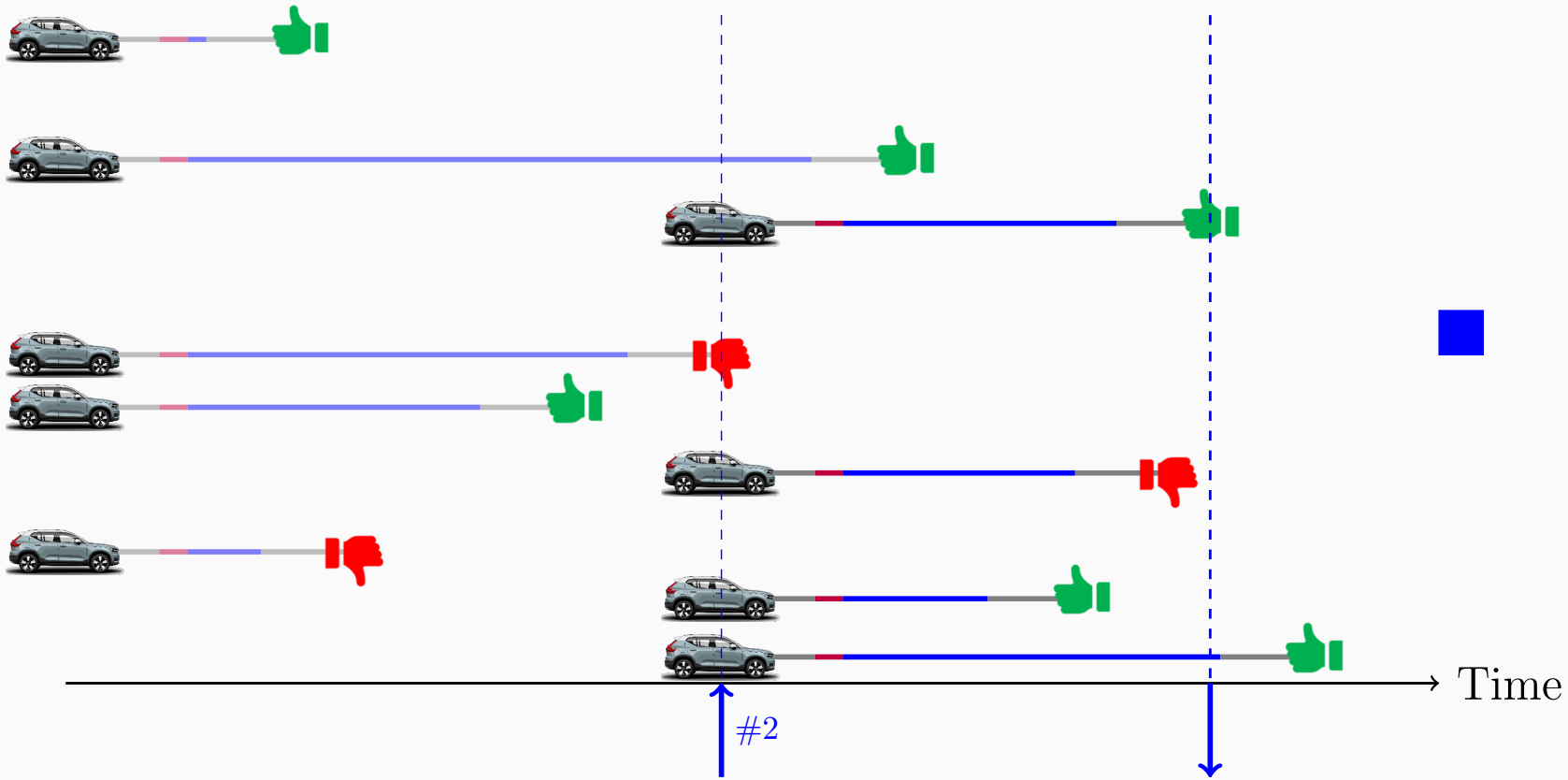
Fleet Size **50**, Answers Required **5**. here $\alpha = 1$, $\beta = 0.8$, $p_q = 0.5$.

When β of them have answered, start a "new round".

Ask then $\approx \alpha / p_q$ new vehicles based on estimating p_q.



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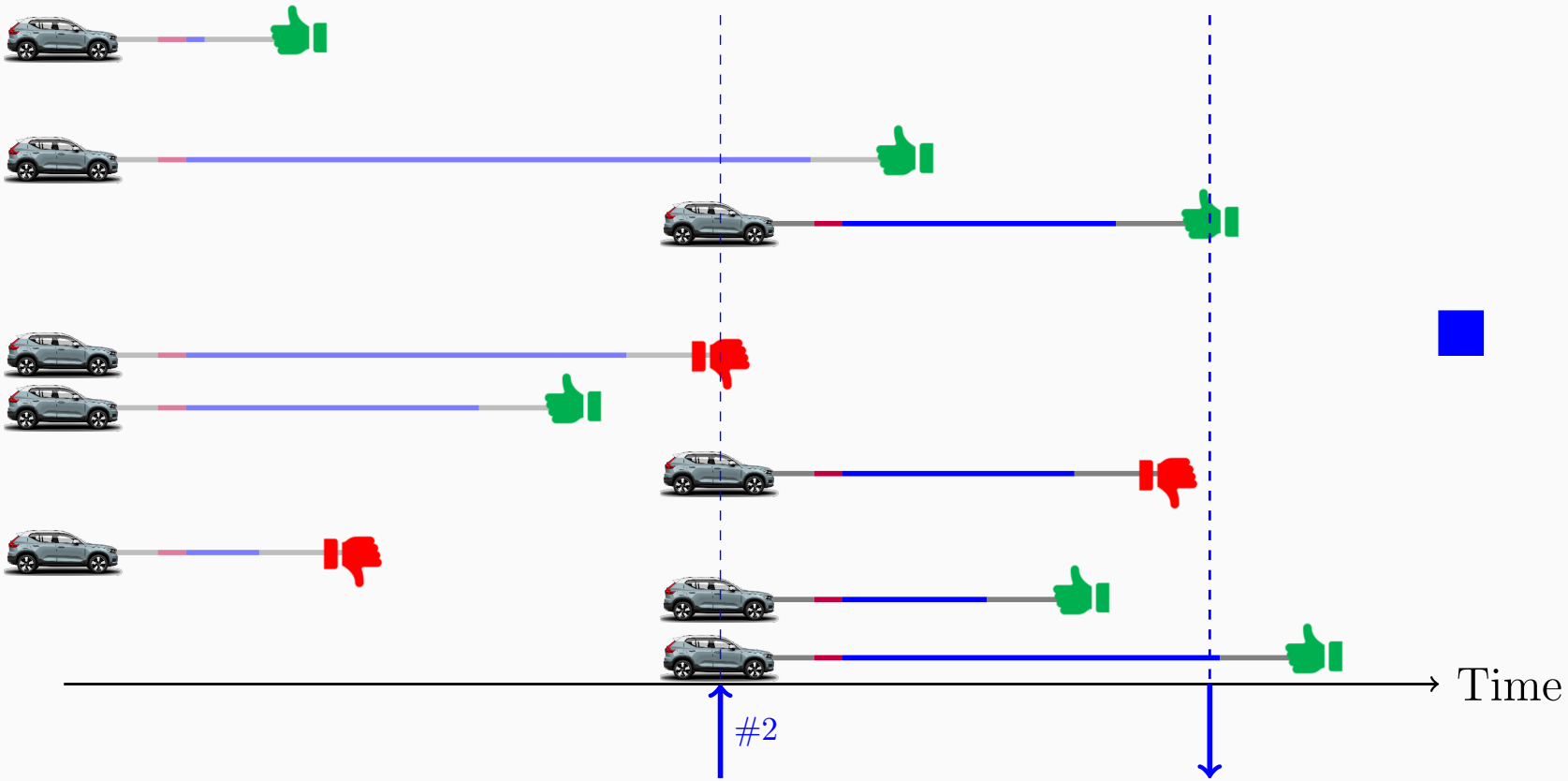
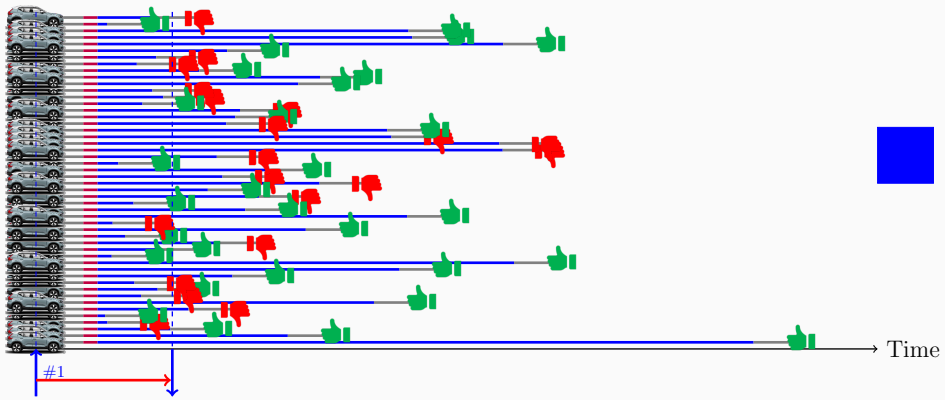


- FairAlgo: pick first vehicles with lowest work so far.

Different Query Spreading Algorithms: Trade-offs



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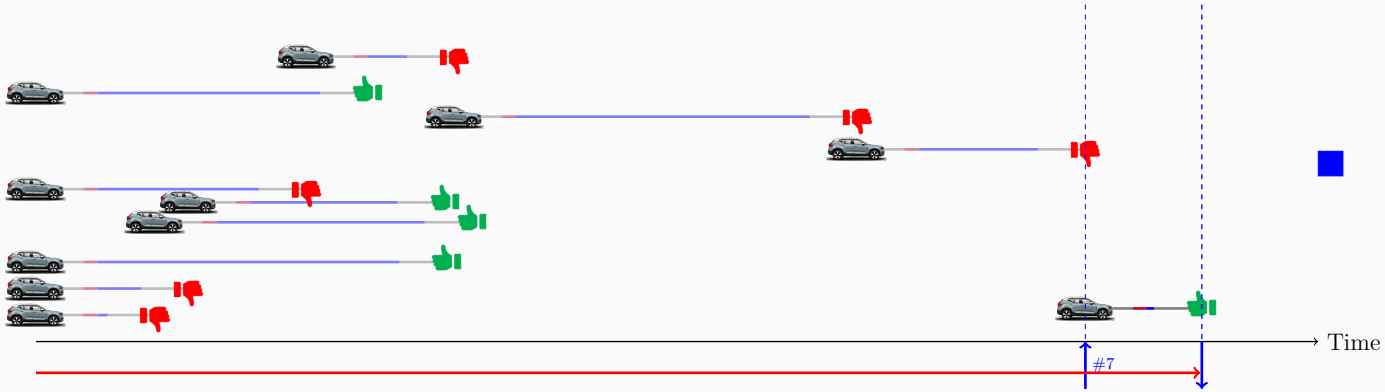
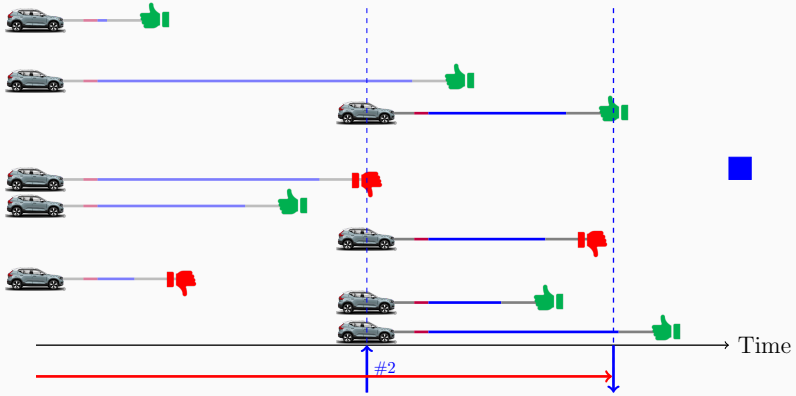


BASELINE2



BALANCEDALGO

Evaluation

Evaluation

Setup

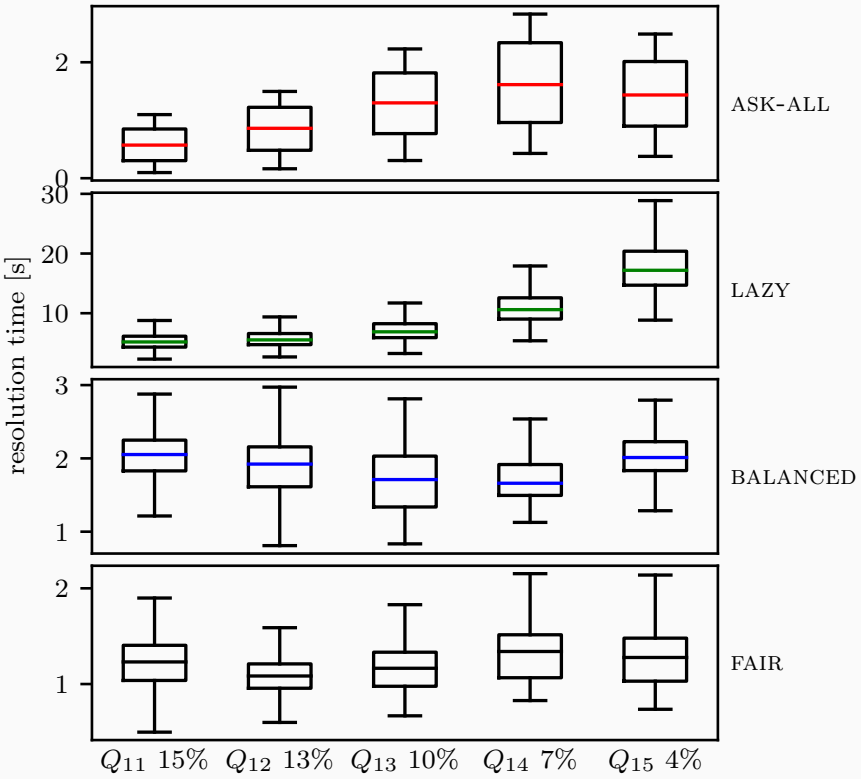
- **Datasets**: *Beijing* (GPS) and *Volvo* (GPS & CAN signals)
- **Queries**: 10-15 queries (with 1 to 50% positive answer rate)

Evaluation in a Simulated environment

- *Response Time* is estimated by running the query on an odroid
- *4G Connection*: 50ms latency, 10Mb/s transfer rate
- *Task Queue*: queries are processed one at a time

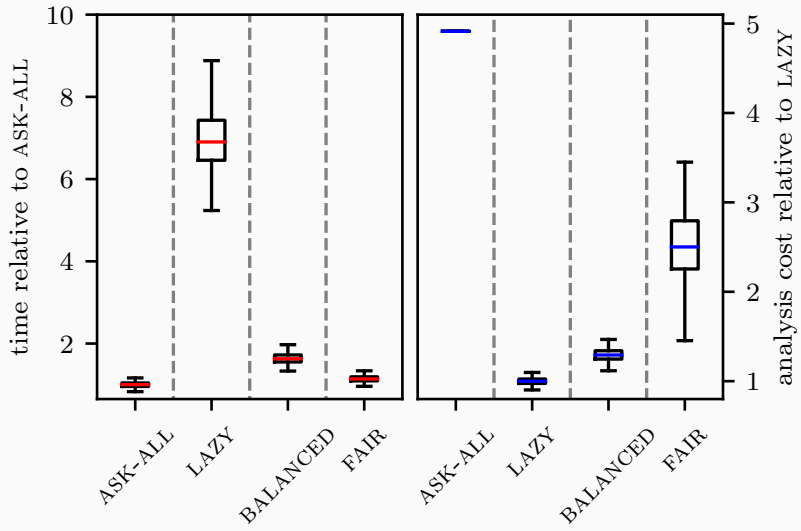
Some Extract from our Results

Quantitative Analysis: Response Times



- Our balanced algorithms solve all queries within 1-2s independently of query answer rate.

Comparison of the diff. algo.



- A much more balanced trade-off is obtained for our solutions
- Each introduced algorithm better on a different dataset

Conclusion

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Sum-up

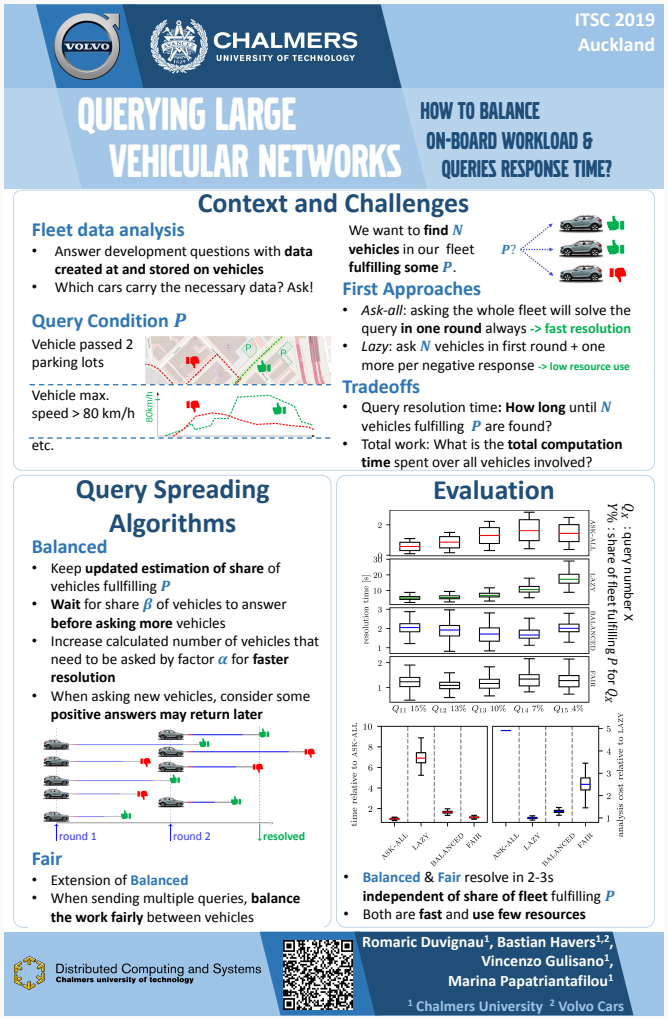
- We introduce balanced query-spreading algorithms
- Simulation environment for on-board task simulation using real traces and realistic query processing times

Future work (ongoing)

- Consider a **dynamic** fleet and *longer* queries (requiring in the order of minutes to process)
- Introduce some methods for selecting the *appropriate* amount of answers needed for a *good* estimation of the fraction of positive answers

Thank you

Thank you for your attention, do you have any questions?



Poster presented in the lobby.