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Intention-Aware Routing of Electric Vehicles

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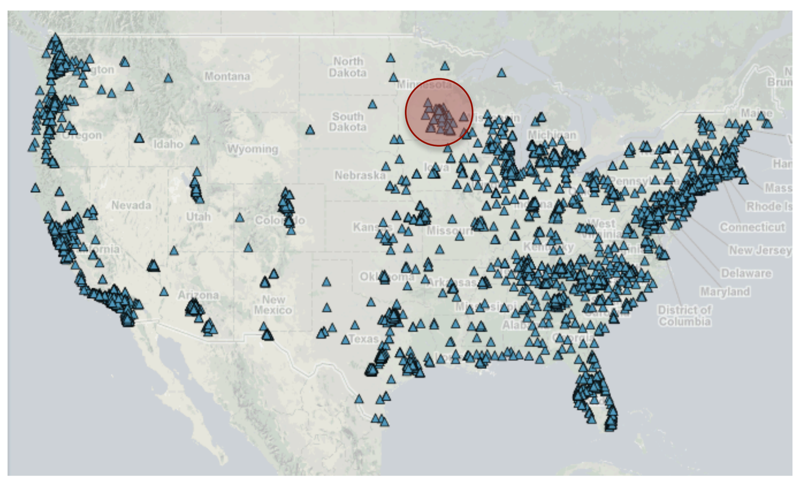
Electric Vehicles

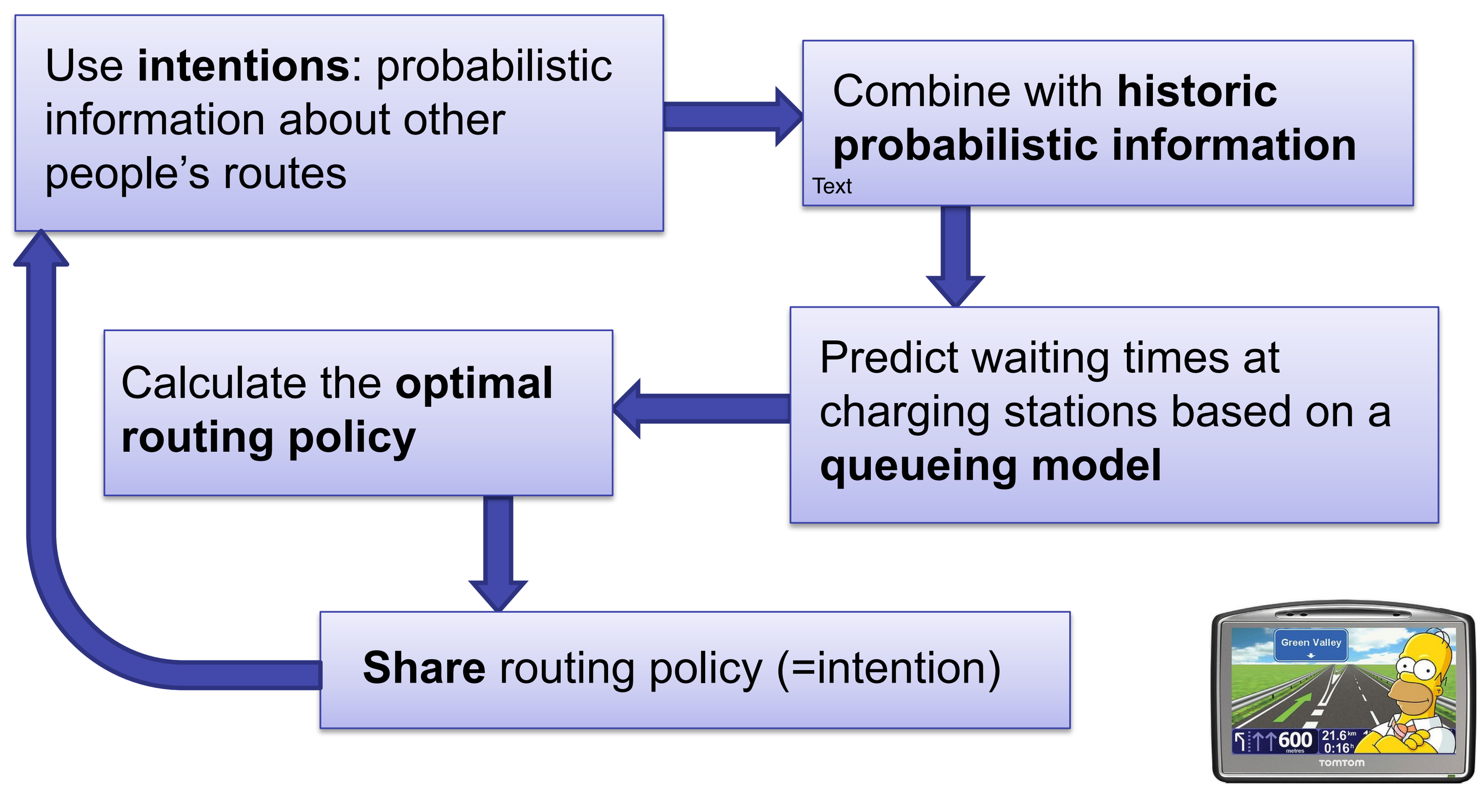
Electric vehicles (EVs) reduce:
- CO_2 emissions and
- dependence on fossil fuels.



However, EVs have a limited range (typically <100 miles).

Public charging stations are scarce and charging is slow (at least 15-30 minutes), leading to potentially long queues and delays.

Our Solution: Intention-Aware Routing System (IARS)

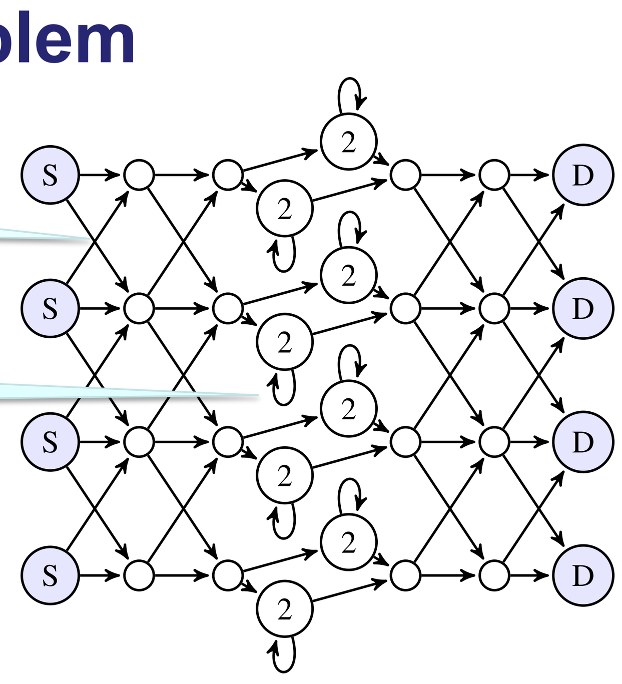


Routing Problem

Traffic network is modelled as a graph:

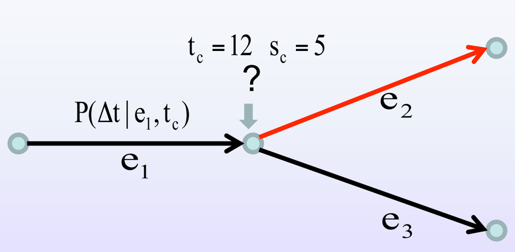
Edges represent roads…

… or charging stations.



Travel and waiting times are probabilistic and depend on time of day: $P(\Delta t | e, t_c)$

Solution is a **routing policy** (state-dependent plan): $\pi(e_1, t_c, s_c) = e_2$



Optimal policy maximises user's expected utility **E(U(t,s))**.

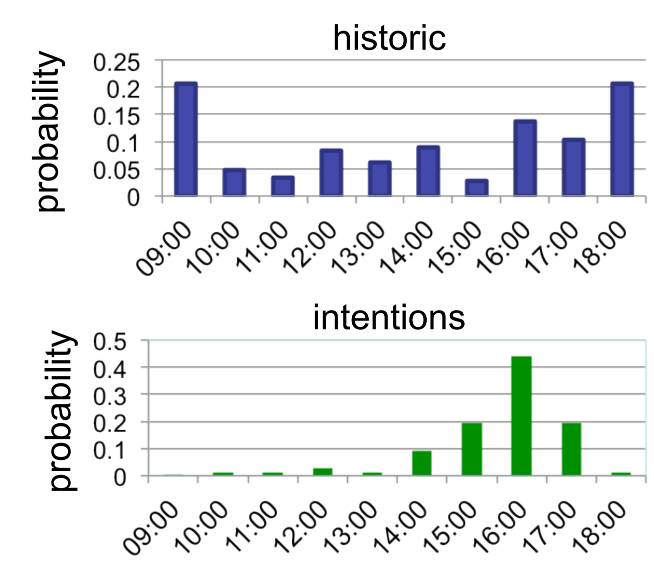
t: time of arrival at destination
s: state of charge at destination

Developed two algorithms to solve this, based on dynamic programming and AO*.

Waiting Time Distributions at Charging Stations

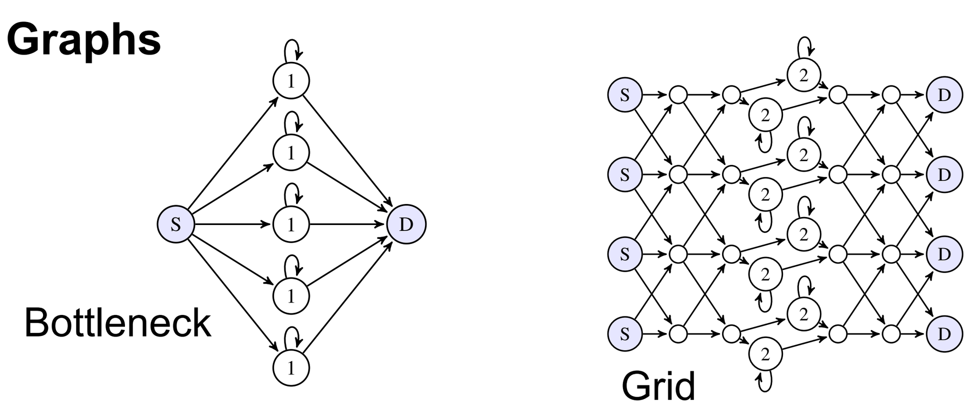
Step 1: Compute probability $P_i^{arr}(e,t)$ of vehicle *i* arriving at station *e* at time *t*, using historic information or intentions, when available.

Step 2: Approximate waiting time distribution by sampling from $P_i^{arr}(e,t)$ and simulating waiting times using a queueing model.

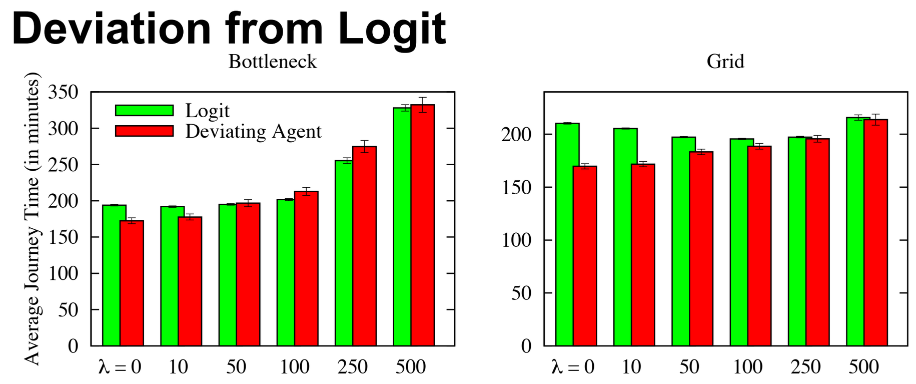


Results

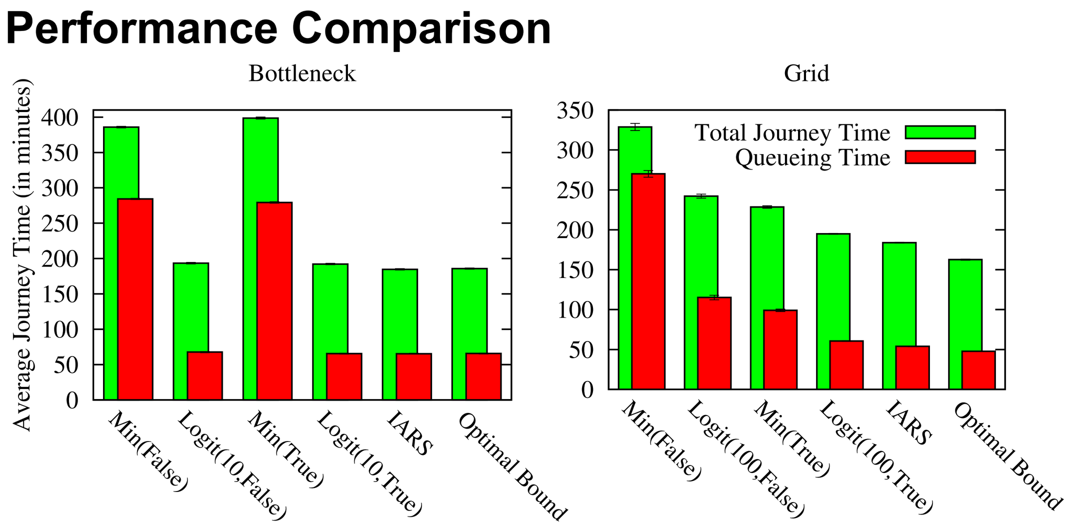
Graphs



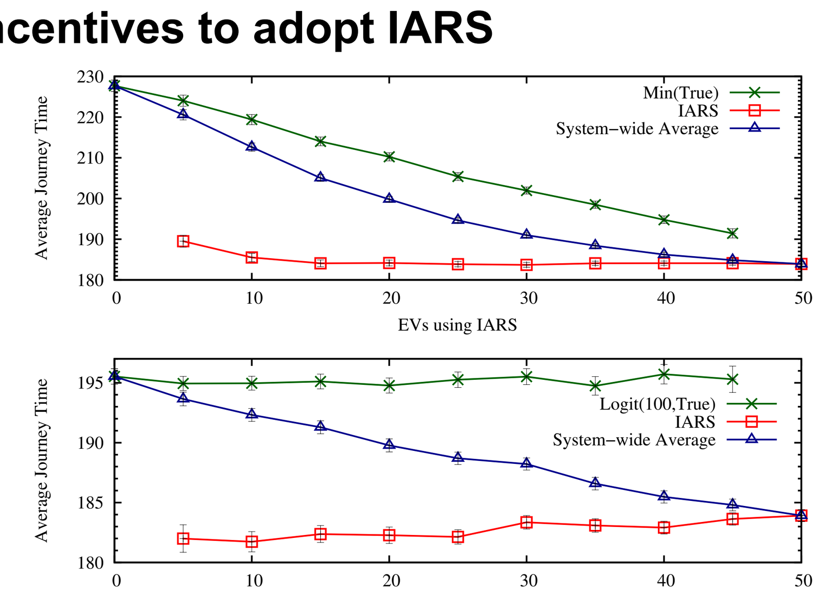
Deviation from Logit



Performance Comparison



Incentives to adopt IARS



Benchmarks

Min(False): Shortest path *without* considering historical waiting times.

Min(True): Shortest path considering historical waiting times.

Logit(λ,True/False): As Min(True/False), but with random deviations (using logit function with parameter λ).

IARS: Intention-Aware Routing System

Conclusions

- Proposed new routing model for the EV charging setting.
- This incorporates intentions by:
  - Combining known EV policies with historic information.
  - Using a principled approach for approximating waiting time distributions based on a queueing model
- Evaluation shows significant reduction in overall journey time, compared to approaches using only historic information.
- IARS benefits all agents, even those not using the system.

Future Work

- Evaluation on real road networks and traffic data.
- Comparison to reservation-based systems.
- More advanced queueing models, including variable charging times.

BAE SYSTEMS   ACFR Australian Centre for Field Robotics   SECURE   University of Southampton