

Trip quality in an ad-hoc shared-ride system

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INTRODUCTION AND MOTIVATION

In an ad-hoc shared-ride system, transportation clients and hosts negotiate for shared rides in a continuously changing environment, using wireless geosensor networks (Winter and Nittel 2006). Due to the peculiarity of this system—a local peer-to-peer communication strategy, and a complex and non-deterministic transportation network—clients will always have limited transportation knowledge, both from a spatial and a temporal perspective. Clients hear only from near hosts, and they do not know the future availability of current or new hosts. Hence, a client can plan an optimal trip prior to departure according to his current knowledge, but it is unlikely that this trip will be finally the optimal trip due to the continuously changing traffic condition. Therefore, it is necessary to evaluate the quality of trips generated in this dynamic environment in order to assess different communication and wayfinding strategies.

The aim of this paper is to develop a quality model comparing the realized sub-optimal trips with the optimal trip. Technically, the main objective of the paper is to calculate an optimal trip with entire knowledge of the network over time for a given cost function. The comparison between traveled and optimal trip is an objective measure of quality for the various methods of ad-hoc shared-ride trip planning. The hypothesis of this paper is that this quality can be determined in shared-ride system simulations.

In terms of trip quality in an ad-hoc shared-ride system, multiple criteria such as travel time, distance, costs and transfer numbers can be considered as cost functions. Shortest path algorithms find an optimal path according to any of these cost functions. In this paper, we choose travel time as a criterion for identifying the globally optimal trip. The globally optimal trip is compared to the trip realized by a client applying some communication and ad-hoc trip planning strategies in a simulation environment.

METHODOLOGY

We will set up an observer in the simulation process who is capable of monitoring the entire transportation network and storing this traffic information in a central database within the geosensor network. Note that such an observer is not feasible in a real peer-to-peer network. This observer stores not only the locations of transportation clients and hosts over time but also the shared-ride information including requests, offers, booking messages, and free seat capacities. While the client plans his trip to a destination from local knowledge, the observer will store full network information—both transportation and communication network—in the database. After the client finishes his trip, his travel history can be accessed by querying this central database. Thus a sub-optimal trip realized by the client during the trip is available to be measured for its quality.

All the knowledge of the transportation network is used as the input for a modified Dijkstra's algorithm (Dijkstra 1959) to calculate the optimal trip. By extending Dijkstra's algorithm to include time as a link weight, and making the relaxation function time-dependent, a time-dependent shortest path algorithm is available for identifying the globally optimal trip within this dynamic transportation and communication network (Orda and Rom 1990). Within the time-dependent algorithm, the weight function consists of a single criterion, in our case travel time. Based on knowledge of the entire transportation network monitored by the observer, reconstructing the transportation and communication network in hindsight is feasible after the clients complete their trips.

CONCLUSION

Preliminary computational results obtained from the trip quality model are shown in Figure. 1. The results support the hypothesis that within the simulation trip planning quality can be assessed as an average of the trip lengths for large numbers of simulation runs. As Figure 1 shows for one experiment, an optimal trip spends always (on average) less travel time than three suboptimal trips realized by three different communication strategies—short range, mid range and unconstrained (Winter and Nittel 2006)—and by a constant wayfinding strategy. Compared to Winter and Nittel's result (2006), only the curve for the optimal trip is new. The optimal trip, computed from global knowledge, is independent from any communication and wayfinding strategy (although it still makes assumptions such as the clients do not move on their own), and it is (on average) much shorter because both factors are limiting the trip progress.

All curves go down asymptotically to the theoretically quickest trip, which has the duration of travelling along the graph geodesic with no waiting time. This trip is available either by chance (which levels out with the large number of experiments made), or becomes available with large transport supply (high host density). For a host density of (on average) 1.56 hosts per street intersection, for example, and a theoretically quickest trip of 5 time units, the optimal trip length is 14 time units. The trip from spatially unconstrained network knowledge along the graph geodesic is 31, the one from mid range local knowledge is 33, and the one from short range local knowledge is 52 time units.

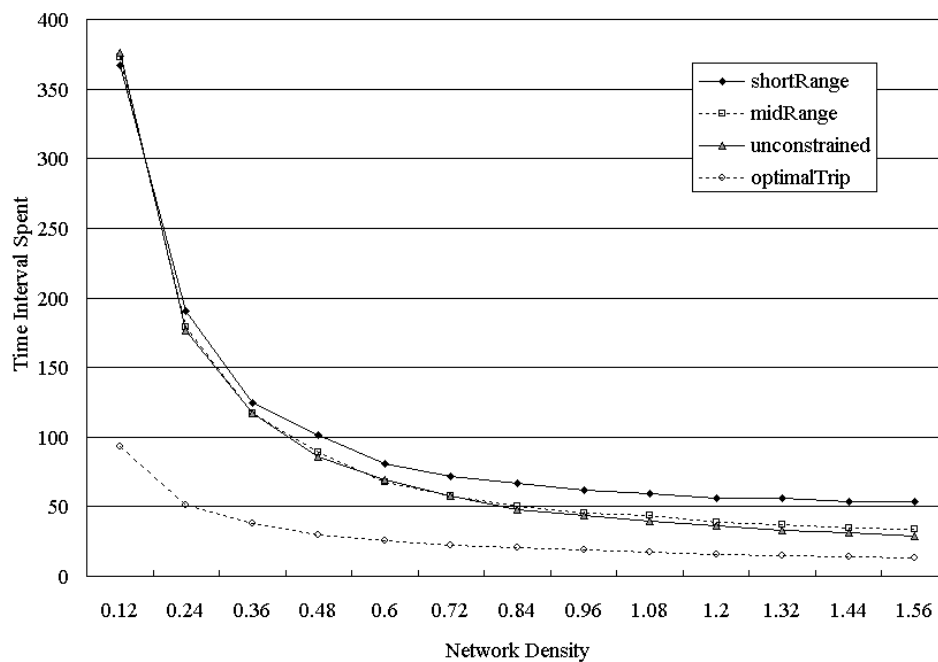


Fig 1: The average travel time for various host densities.

The future direction of this research is to utilize this quality assessment tool to determine the quality of trips for different other communication and wayfinding strategies, and also to control experiments for the reconstruction of routes from agents memories. Additional use of the tool can be made for visualization of simulations, since the observer has full knowledge of all space-time paths.

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