Usability of Dial-a-Ride Systems

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ABSTRACT

A case study of usability of dial-a-ride bus systems is reported. We conduct a social simulation to compare efficiencies of the dial-a-ride bus systems, one of possible multi-agent applications, and traditional fixed-route bus systems. Simulation results indicated that dial-a-ride systems are reasonable for large cities but their advantage depends on structures of the town.

1. INTRODUCTION

Transportation systems in urban area are one of possible application area of ubiquitous and multi-agent technologies, because these technologies enable flexible control of mass-transportation according to various demands and situations. However, it is difficult to figure out benefits of these technologies, because utilities of these technologies are not tangible until they are deeply incorporated in social systems. Our purpose of this work is to compare efficiencies of a traditional fixed-route systems and dial-a-ride systems to show such benefits.

As an application of MAS, many researchers have already attacked an issue, how to handle a huge number of passengers with many buses [2, 1]. On the other hand, few works have examine the problem from the viewpoint of another issue whether traditional fixed-route systems can be replaced by the dial-a-ride system no not. Especially, it is not clear how usability of the dial-a-ride system changes when the number of passengers increases compared with fixed-route systems. This article shows results of a comparison of the usability of both of fixed-route and dial-a-ride systems with the same profitability through simulation of transportation in a virtual town.

2. PROBLEM DOMAIN

2.1 Dial-a-Ride System

In this article, we suppose that a dial-a-ride system is operated as follows: A passenger can raise a demand to bus centers when she wants to ride. Then the centers assign the best bus for it on the occasion. The assigned bus can run on any road in a certain area according to passenger's requested pick-up and drop point.

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2.2 Usability and Profitability

As written in section 1, the purpose of the simulation is to compare *usabilities* and *profitabilities* of dial-a-ride and fixed-route systems. In order to avoid difficulties to estimate social effects on such criteria, we define these words as follows.

For *usability*, we specifically address the primary purpose of a bus system: to provide a way for a passenger to reach her destination as quickly as possible. From this point of view, *usability* is defined as average elapsed time from when a demand is told to the bus center until the demand is satisfied.

On the other hand, *Profitability* is formalized as the number of demands occurring in a unit period per bus. In the experiments shown below, we set conditions of simulations to keep the same profitability on both bus systems.

3. EXPERIMENTS

3.1 Simulation Setup

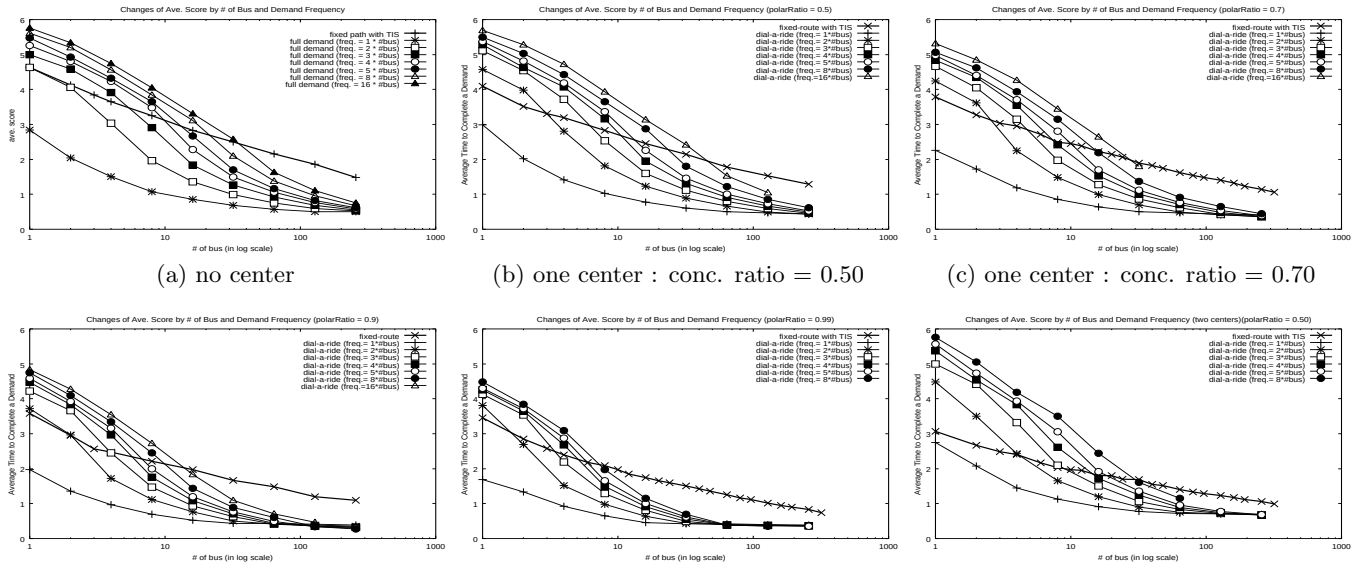
In the simulation, both bus-systems are operated in a town whose roads form an 11×11 grid. Both of passengers' orientations and destinations are at crossings of the roads. We suppose that there are no traffic jam.

We apply a genetic algorithm (GA) to determine bus-routes for fixed-route systems [3]. Usability of a fixed-route system varies according to bus-routes. It is difficult to find the optimal set of routes to cover a town theoretically, because it is affected by many factors like the number of buses, average bus speed, and so on. GA will seek a semi-optimal set of routes for a given condition.

For simulation of a dial-a-ride system, we must solve problem how to assign a new demand to buses and to re-plan a path for each bus. To do this, we use a kind of a simple auction system called *successive best insertion* [3] in which the system seeks the best pair of insertion positions for two new via-points (departure point and destination point) in queues of buses when a new demand occurs.

3.2 Results and Discussion

As described in section 2, we measure usabilities of both bus systems under fixed profitabilities. Fig. 1 shows the changes of usabilities (average times to complete a demand)



(a) no center (b) one center : conc. ratio = 0.50 (c) one center : conc. ratio = 0.70

(d) one center : conc. ratio = 0.90 (e) one center : conc. ratio = 0.99 (f) two centers : conc. ratio = 0.50

Figure 1: Changes of Usability (Average Elapsed Time) under Fixed Profitabilities.

in both systems. In each graph, thin lines indicate changes of the usabilities of dial-a-ride systems where the ratio between the frequency of demands and the number of busses is fixed (the number of demands per bus is 1, 2, 3, 4, 5, 8, or 16). Generally, the high ratio is better for the profit of bus companies. A thick line in each graph indicates changes of the average elapsed time by the fixed-route system. There are only one line for one condition because its usability depends only on the number of buses but not on frequency of demands. Graphs (a)∼(f) show results of experiments under the following conditions: (a) Demands occur equally in any points in the town. (b) ∼ (e) There is a center (like a train station) where 50–99% of demands are concentrated. (f) There are two centers where 50% of demands are concentrated.

General Feature of Both Systems. Graph (a) tells that the usability of the dial-a-ride system is improved faster than one of the fixed-route system when the frequency of demands increases. In both systems, the usabilities are improved because a passenger can have many choices to reach a destination. In addition, because the dial-a-ride system provides more flexibility to fit passenger's demands, the improvement is greater than the fixed-route system.

Effects of Concentrated Demands. A town generally has several centers like a train-station or a shopping center, where demands are concentrated. Graphs (b)-(e) and (f) show results of such cases. Compared (b)-(e), we can see that the advantage of dial-a-ride systems in the usability becomes more obvious when the concentration ratio is high. For example, when a dial-a-ride system suppose the number of demands in time-unit per bus is 8, its usability becomes better than the fixed-route one when the number of busses is about 20 in (a), 16 in (c), 10 in (d) and 8 in (e).

On the other hand, (f) tells the fixed route system gets more benefit than dial-a-ride system in the case of two centers. The usability of the fixed-route system is improved drastically in (f), while the dial-a-ride systems show similar results as the case of one center. Therefore, the balancing point of usability moves right so that dial-a-ride systems have advantages under situations that the number of demands are very large.

4. CONCLUSION

From results of simulations showed in the previous section, we can summarize features of a dial-a-ride system compared with a fixed-route system as follows:

- Generally, dial-a-ride systems have more scale-merit than fixed-route systems.
- The benefit of dial-a-ride systems is enhanced when the town has a single center, while fixed-route systems get large advantage when many people move between two centers.

These results indicate that the benefit of MAS and ubiquitous computing application is not guaranteed for all condition. This kind of analysis will be provide more objective measure to justify costs of these technologies.

5. REFERENCES

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