19th ITS World Congress
Vienna, Austria
22 to 26 October 2012
smarter on the way

# Agent based assignment of cybercars for a shuttle service

**Michael Behrisch**[1*]
1. Institute of Transportation Systems, German Aerospace Center, Rutherfordstr. 2, 12489 Berlin, Germany, +49/30/67055210, Michael.Behrisch@dlr.de

## Abstract
The CityMobil projects general goal „To bring the implementation of automated transport systems in urban areas a major step forward“ included the implementation of automatic management systems for different types of transport systems at least in a traffic simulation environment. Complete automization gives way to a number of new management techniques including agent based marketplaces which give higher flexibility together with shorter travel times as will be shown here.

**Keywords:**
Cybercars, Traffic simulation, Multi Agent Systems, Scheduling, Assignment

## Introduction
Fully automated transport while already being quite common in inhouse factory transportation is still a novelty in passenger transportation. The management strategies developed for individual drivers need to be revisited in order to manage new transportation systems as for instance cybercars which travel at a given shuttle route but may interact with ordinary traffic and passengers. A centralized yet flexible approach to the management of such systems are agent technologies where every stakeholder is represented by a (software) agent giving bids and orders for the services. This paper evaluates such a system with respect to waiting time and travel time compared to an ordinary bus system. The focus of this paper is on management strategies rather than on safety or cost effects of the automated system. See the final conclusions for some remarks on those topics.

The layout for this system was inspired by the Rome demonstrator of the CityMobil project which included a shuttle from a central parking lot to the new Rome fair ground.

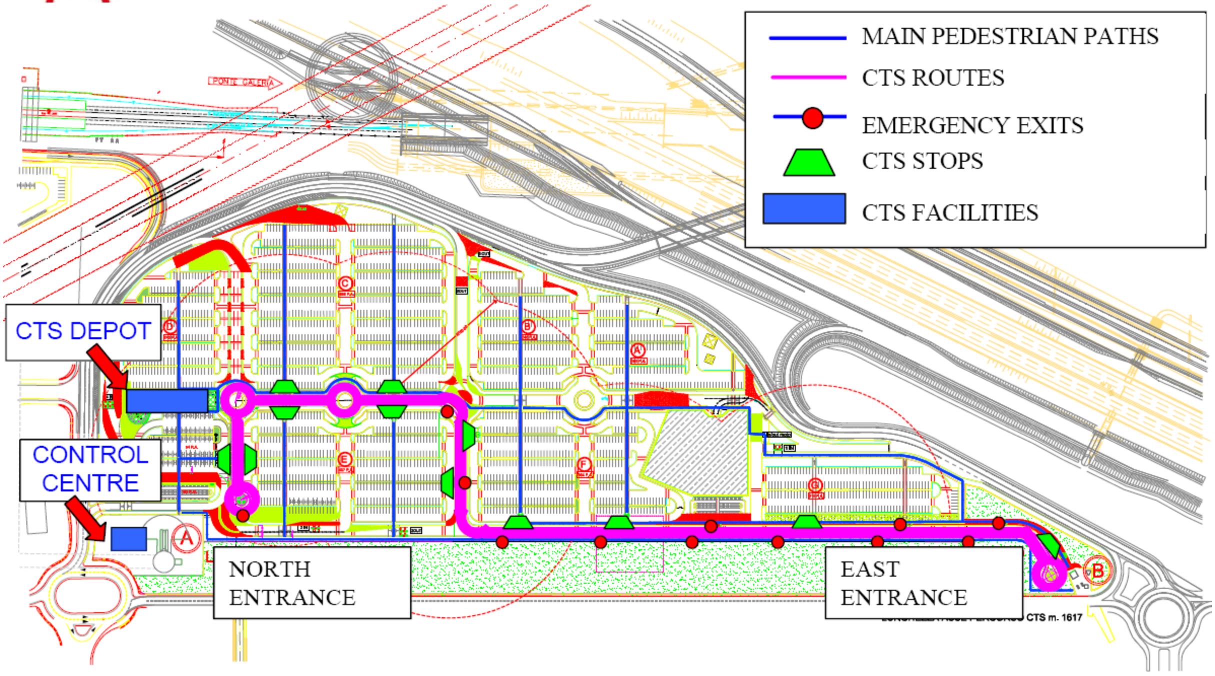



**Figure 1 The car park layout in Rome**

## The network

The setup consisted of 160 parking spaces organized in eight (double) rows each served by a single bus stop.

People had to walk from the parking space of their vehicle to the bus stop where they are picked up and travel to the main entrance. Streets and footpaths as well as the CyberCar lanes are modelled without intersecting each other.

The bus stops were served by a fleet of eight cybercars with a capacity of five passengers each and for comparisons in a simpler scenario with two busses carrying 20 passengers. This gives a total capacity of 40 in each scenario. Furthermore also the maximum speed of the vehicles was chosen to be equal in both scenarios (about 10m/s).

**Figure 2: Excerpt from the CyberCar Network (persons: red, cybercars: green, cars: grey)**

**The demand**

As a demand we assumed a constant demand ranging from 80 to 720 vehicles per hour (in different scenarios, each vehicle carrying two passengers) accompanied by a return traffic of 40 to 360 persons per hour.

The simulation was carried out using the SUMO simulation framework modelling each vehicle and passenger individually as shown in Figure 2. Two strategies were implemented to compare the results of the cybercars with the traditional approach. For the traditional approach (busses with a capacity of 20 each), the busses approached and slowed down at each station (if they were not completely full), checked whether there are waiting passengers and picked them up. Since the car park layout provided only one linear route for the busses, all busses served all stops.

**The agent system management approach**

In order to get a very flexible but yet performant solution to the routing and demand management problems a multi agent system was implemented which assigns an agent to each passenger and each vehicle and lets the agents negotiate which cybercar will serve which request.

The advantages of this approach are

1. flexibility

more cybercars can easily be added, different layouts are also possible

2. robustness

agents can have their own protocol how to react on failures

3. the possibility for distributed implementation

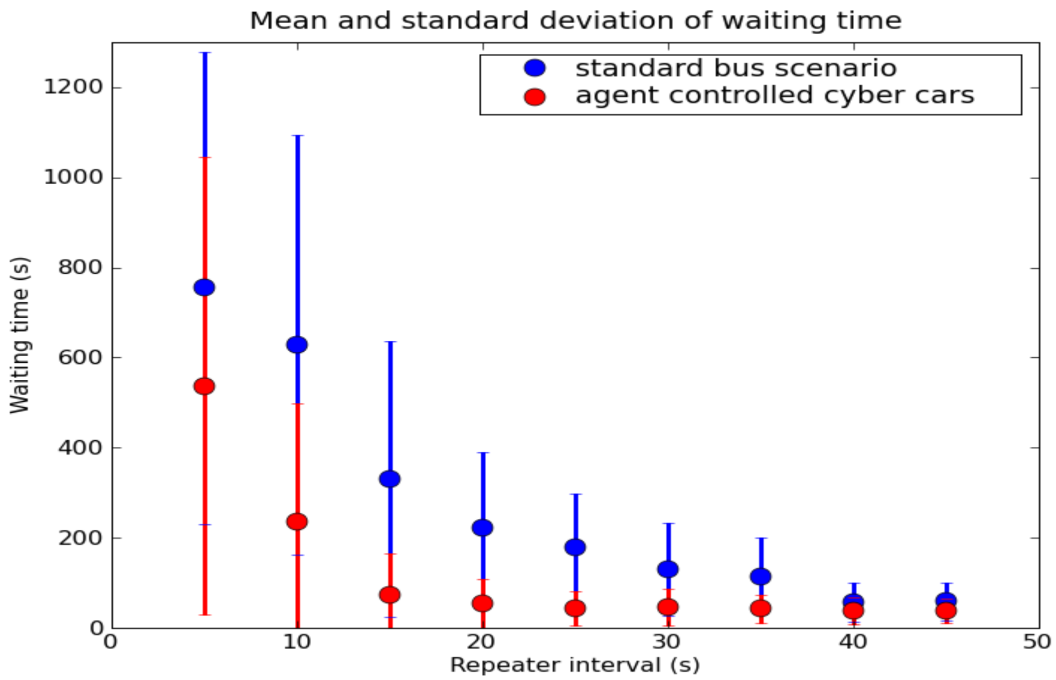
the communication between the agents is limited to small, well defined, interfaces which makes an implementation on the car / bus stop feasible

4. direct connection to the objects in question

the behavior of this system is often easier to understand if one can imagine the cars and persons as agents (actors) in a system.

In our simulation study the cybercars give a “bid” on a request of a passenger by presenting an estimated time of arrival resulting from the “experience” of the car on the route in question. The passenger simply chooses the car with the smallest of the times given.

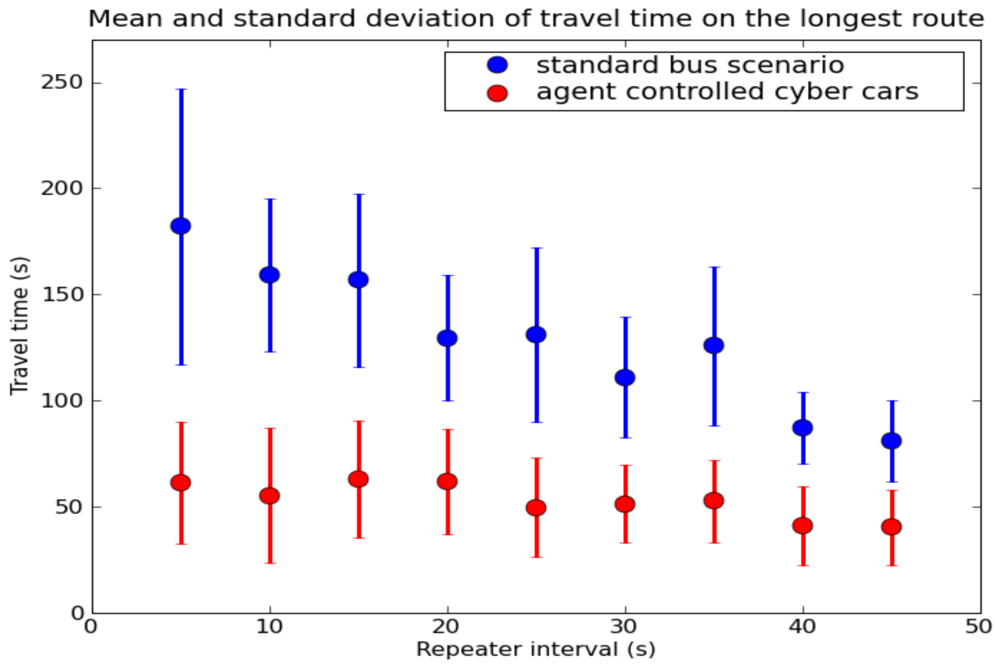
In case of a breakdown the car gives back all trips which were assigned to it (except for the ones already onboard) and the marketplace process restarts.




**Results**

The first results of our simulation show that the overall waiting is smaller with the cybercar agent system approach especially at higher demands (the x axis ranges from a vehicle repeater interval of five seconds to 45 seconds meaning the highest demand is on the left). One reason for this is of course the larger number of vehicles which increases the probability of a car being "at the right place". Nevertheless even at lower demands where most cybercars are at an idle position in the system, the waiting passengers can benefit from the higher flexibility provided by the on demand scheduling.

The comparison of the routing times in the next figure shows, the cybercars can also travel faster because they know in advance which trips they will cover. This enables them to employ




their intelligent route choice mechanisms which decreases both routing and waiting times. An important factor as well is the fact that the cybercars do not have to decelerate at each possible stop because again they "know" beforehand whether they will need to stop.

Especially the last point is also an advantage concerning the fuel / energy efficiency of the vehicles. Since there are less accelerations and decelerations the vehicles can drive very efficiently.

We also performed first studies including a failure of a vehicle. Since a failure in the traditional example (20 seat busses) results in half the capacity while a cybercar breakdown reduces the capacity only by 12.5% the results are not quite comparable. The overwhelming advantage of the cybercar approach is a bit misleading then.

**Conclusions and discussions**

The simulations carried out clearly show the superiority of the cybercar approach over the traditional one concerning the important factors of waiting time, travel time and fuel consumption / emission.

Nevertheless due to the small complexity of the network and the relative simplicity of the marketplace approach there is still much room for improvement on the implementation of the agent system approach before it can show its full potential.

The CityMobil project did further analysis on different aspects of automated systems. For the estimation of cost benefits it provided a business case model [1], which build on earlier results such as of the EDICT project where comparative analyses were carried out between PRT systems and more conventional systems like Light Rail Transit (LRT) and bus systems. This study found that investment costs for a PRT (based on the ULTRa system to be built and demonstrated at Heathrow in CityMobil) are only 35% of the costs for the more conventional systems and that, for example, a 10km track implementation of a PRT system could achieve savings of up to 111 M€.

These savings in investments costs were mainly due to the use of lighter vehicles and correspondingly lighter guideway constructions. But the study also found that In terms of system operating costs large savings can be achieved due to the automated operation of PRT, and the consequent saving in manpower costs.

Regarding safety and security issues as well as public acceptance of automated transport several workgroups in CityMobil delivered important advice such as the City Application Manual [2] and the Guidelines for safety, security and privacy [3]. Both give detailed accounts on which measures to take to bring transportation systems such as the one described above in the broader public. All documents are available at http://www.citymobil-project.eu/site/en/documenten_deliverables.php

**References**

1. Jeffery, D., T. Vöge, A. Tripodi (2011). *CityMobil D2.4.1 Generic Analysis Tool for Business Cases*, European Commission, Brussels.
2. CityMobil (2011). *CityMobil D2.2.4 City Application manual*, European Commission, Brussels.
3. CityMobil (2011). *CityMobil D2.5.3 Guidelines for safety, security and privacy*, European Commission, Brussels.