A Geographic Information System for the Integration of Heterogeneous Traffic Information

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Abstract: In Germany, a lot of services providing online traffic data based on different sources. The recorded data (traffic flow sensors) combined with other traffic messages have improved the quality of travel planning services. However, in huge urban areas (capital Berlin) the number of traffic sensors is insufficient. A qualitatively better approach can be used by exploitation of the Global Positioning System (GPS), which nowadays is available in an increasing number of commercial vehicles. Interesting synergetic effects could result from GPS and modern wireless communication. From the recorded road position data, the dynamic behaviour of the vehicles can be easily extracted. Furthermore, the detection of traffic jams is quite simple, when the velocity drops below a given threshold within a timeframe. The integration of heterogeneous data sources projecting realistic traffic situation is only partially offered by traffic information services. The aim of the paper is to introduce a web-based traffic information system, providing online traffic information (Floating Car Data, sensor data). The system is implemented in a client server environment based on Java technology. The client site consists of geographic maps with online information and given a chosen travel route, the user is able to receive individual travel information. A Geographic Information System (GIS) is defined as interface to transform and process the online traffic data. In order to avoid communication bottlenecks, requests for online data and application are handled by different server and communication protocols. For broadcasting of the online traffic data different approaches like sockets, http connections or multicast sockets were tested. For the integration and a uniform transport layer of the heterogeneous online data, the client and server communicate via an XML protocol.

Keywords: *Online Traffic Information System; GIS; GPS Technology; Network Communication; Telematics*

1. TRAFFIC INFORMATION AND FLOATING CAR DATA (FCD)

In Germany, a lot of services providing online traffic data based on different sources. The main types of travel information services are Radio and TV-information channels, Internet sites, Newspapers (e.g. for reconstruction areas) and Information from local Police departments.

In most cases the data sources of these types of traffic information are information from Point sensors (e.g. Inductive loops, video observation, infrared and laser vehicle detection etc.). On the other hand traffic information are messages from private individuals, from commercial flight services or information from traffic police departments.
The output information detected by point sensors could be summarised in: 1. Velocity, 2. Traffic volume and 3. a classification of vehicles (partly). There are still some disadvantages, for e.g. time lags and less continuities of the data [Klein, 1997].

More satisfactory results arise from telematics applications which use the GPS (Global Positioning System) technology. The quality of the GPS-data has been highly improved after the correction of the GPS-signals by the U.S. Government in 2000 (for Details: http://igscb.jpl.nasa.gov).

Over the last years the commercial market of telematics applications (e.g. Integrated Transport Information Systems) [Etches, 2000] – some of them based on GPS technologies – has been rapidly grown. Meanwhile, many transport companies use location technologies and wireless communication for fleet tracing and optimisation of their fleet management. In taxi transport companies

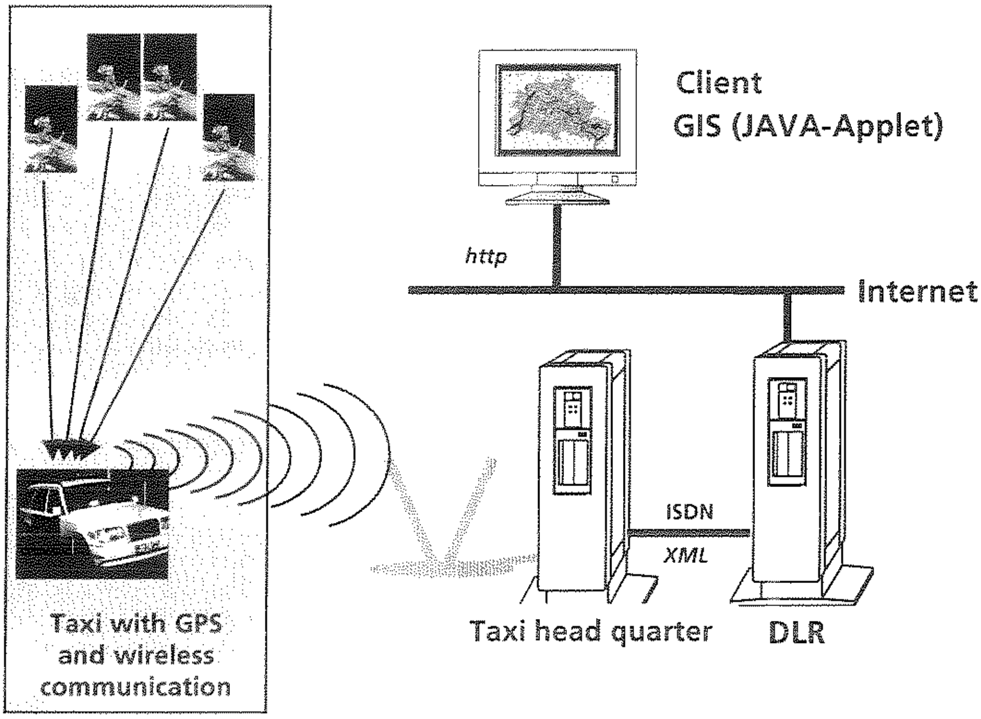

Figure 1. Architecture of the Traffic Information System (here with active Floating Car Data).

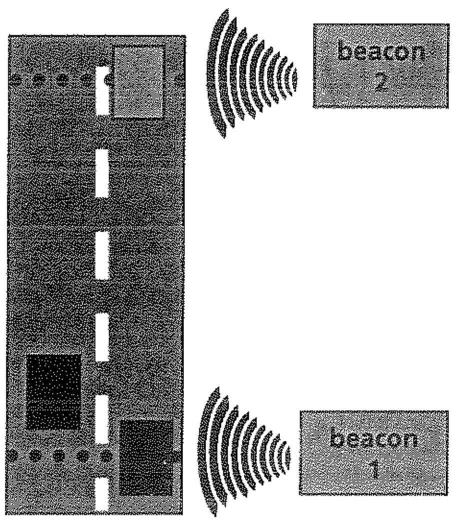

Figure 2. Scheme for the collection of passive Floating Car Data.

the use of the GPS has greatly improved the disposition of client travel orders. Out of the taxi disposition by GPS interesting synergy effect result for Floating-Car Data (FCD) collection. Along with the on-board location-sensing technology and the cellular connection to the central data server, the taxis can easily used as cheap data suppliers.

In our approach we use the Floating Car Data for traffic data management in real time, providing online information for road users. In general, Floating Car Data are classified in two types, 1. active FCD and 2. passive FCD. The main scheme for active FCD is shown in the left part of Figure 1 while the scheme for passive FCD is shown in Figure 2.

In the term of active Floating Car Data the vehicles equipped with GPS sends the data over a wireless communication network to a server, where the data can be processed. The main advantages of this system are investigations about continuous routing information and detailed specifications of travel times. One disadvantage is the still relatively expensive hardware.

Passive Floating Car Data are characterised by getting information through road beacons (Figure 2). The advantages of this system are very low costs for the on-board installation of the hardware. By contrast to active FCD, the vehicle position is only detected at the location of the beacons. In case of higher distances between the beacons, there could be a lack of necessary information about the actual traffic situation.

2. A TRAFFIC INFORMATION SYSTEM FOR THE GERMAN CAPITAL BERLIN

2.1 Aims of the Project "Taxi-FCD"

In order to exploit Floating Car Data for online traffic information systems in the German capital Berlin at the Institute of Transport Research of the German Aerospace Center (DLR) a cooperation project with a local Taxi transport company was established in 2000.

The main idea and goal of this project is the recording of travel time data and traffic information from the taxi fleet, equipped with GPS technology, the real-time data preparation and the transfer to the World Wide Web.

In the first step of the project the positioning data of approximately 300 taxis are continuously recorded. Via a wireless network the positioning data of the taxis are transmitted to the central data server of the taxi transport company. The server at the German Aerospace Center (DLR) is connected with the server of the taxi company via an ISDN line. The data exchange between the two server is handled by an XML protocol (Figure 1).

2.2 The System Architecture

The traffic information system is implemented in a client-server environment [Etches, 2000; Guptill and Morrison, 1995] based on Java technology. Figure 1 outlines the concept distributing the traffic data.

On the *server* site a database management system deals with the data storage of the positioning data as well as different kinds of static data describing the traffic network, waiting zones for taxis or identification data of involved taxis.

The *client* site of the web-based information system consists of different geographic maps (e.g. topographic maps etc.) with *online* information concerning the actual velocity and travel time in the network as well as warnings for congested roads.

The performance of the network communication between the client and server is heavily dependent on the number of users requesting data from the server site. Therefore, the system was implemented with different communication interfaces. For the traffic data exchange between client and server different approaches like http connections (Apache Web Server), sockets or multicasting were tested. By contrast to point-to-point communication multicasting sends data from one host to many different hosts. In a sense, it is like a public meeting, where people could together listen to one data source. It is usually used for broadcasting video conferences or radio programmes via the Internet, in order to avoid communication bottlenecks at the server site.

For the visualisation of the calculated velocity data a Geographic Information System (GIS) is used and advanced for this application. The spatial and temporal quality of the data has been proved in different ways [Buziek et al., 2000; Cartwright et al., 1999; Gordillo et al., 1999; Streit, 1995]. Then, the velocity data are divided in five velocity classes. These velocity classes are plotted in different colours (red for congestion areas with velocities < 10 $km\ h^{-1}$ and green for free roads with velocities > 40 $km\ h^{-1}$). This differentiation allows an easy detection of the current travel time as well as heavy congested road in case of the red coloured regions (Figures 3, 4 and 5).

3. DETECTION AND VISUALISATION OF DIFFERENT ROAD CONDITIONS IN BERLIN, GERMANY

Over the last six months the information system has been intensely tested. First results have shown, that the given approach detecting congested roads works quite stable and can provide an additional data source for online traffic information. In contrast to existing services, where the driver is only informed concerning the location of congested roads, this service is able to give more precise information, like the congestion detection time or the **exact** travel time through a congested road. Furthermore, the continuously recording of the car positions also returns the route choice of each vehicle.

Beside the taxi order disposition the collected data can be widely used for other purposes, even when the velocity and travel time of the vehicles are calculated from the position data.

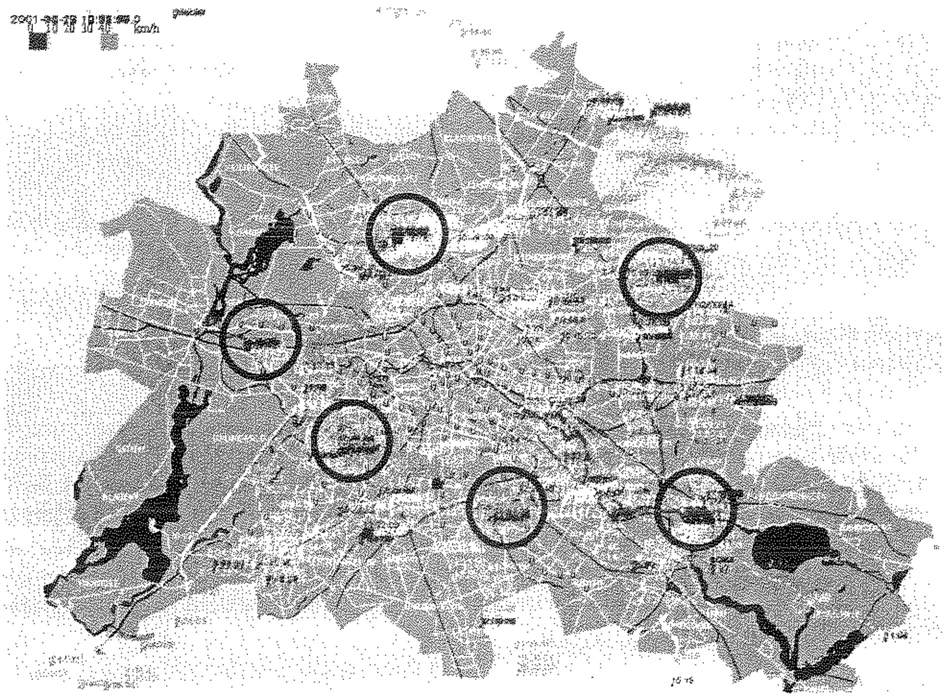

Figure 3. Visualisation of traffic conditions in Berlin, Germany, on April 27th, 2001 including detected congestion with velocities below 10 $km\ h^{-1}$ (marked areas) (Scale: 1:400,000).

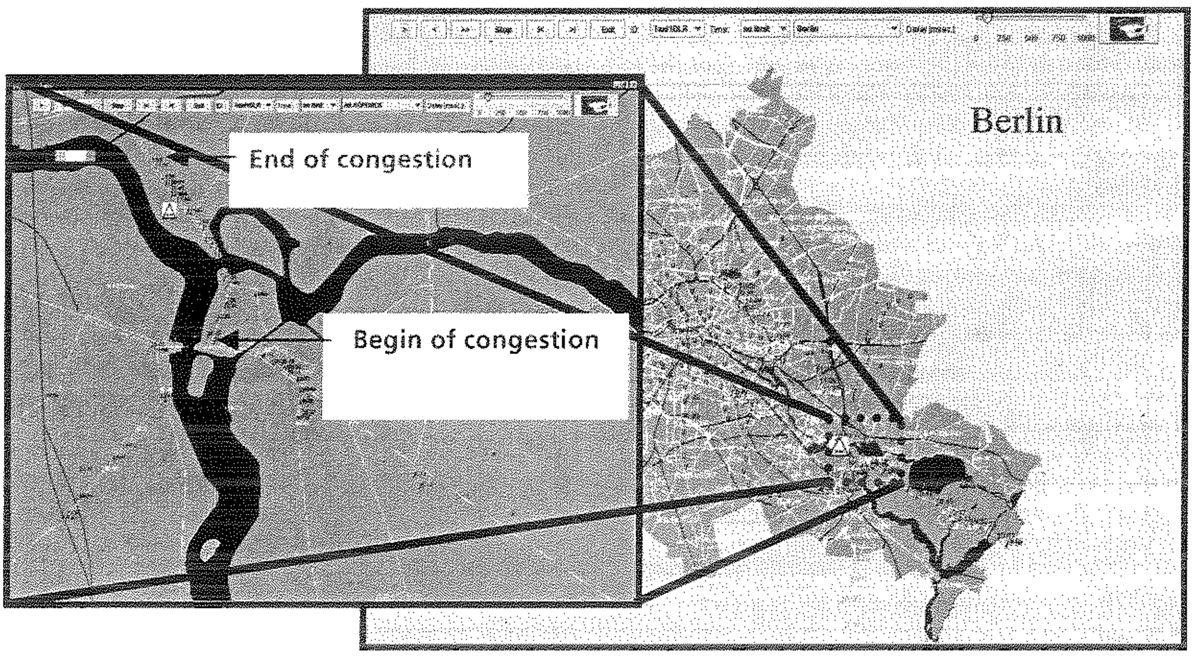

Figure 4. Stop & Go scenario in Berlin-Köpenick, Germany, detected on November, 4th, 2000.

In case, that the velocity significantly decrease from normal conditions, there is a high probability for a congested road. In order to avoid misinterpretations, the observation time slots should be well conditioned. Beware in such situations, when vehicles come to a complete stop, because taxis frequently wait for new clients.

As everybody knows taxis frequently wait for new clients. In that case, a taxi has *not* to be considered for the road congestion algorithm. Therefore, the taxi status message ("occupied" or "not occupied"), which the taxi driver has to sent to the headquarter can be used, avoiding misinterpretations.

After the correction of the data and the implementation into the GIS a directly spatial survey of the actual road conditions is possible. For the area of Berlin, this is shown in Figure 3. This tolerably survey based on the data of only one third of max. 300 taxis. In Figure 3 – which represents the view on the online screen – congested areas could be pointed out immediately.

A detailed scenario for Berlin is shown in Figure 4. In the data a Stop & Go area was detected in the eastern district 'Köpenick'. In combination with the traffic information system (GIS) it is possible to zoom out the congested areas for a detail analysis. The individual dots represents the velocities and the calculated travel times of the respective vehicles.

An example for a situation with blocked streets and a multiplicity of traffic jams in the inner city district of Berlin shows Figure 5. The plot represents the situation during the event "Love Parade" (with nearly 800,000 participants) in July, 2001. The main East-West axis ("Street of the 17^{th} June") was closed on a length of approximately 4 km for the whole traffic. For this reason a huge number of traffic jams in the surrounding areas (southern parts of the inner city district of Berlin) were detected. Furthermore, velocities and exact travel times through the congested roads has been evaluated during this time period. In addition, it was possible to detect rapid changes of the traffic situation *online*.

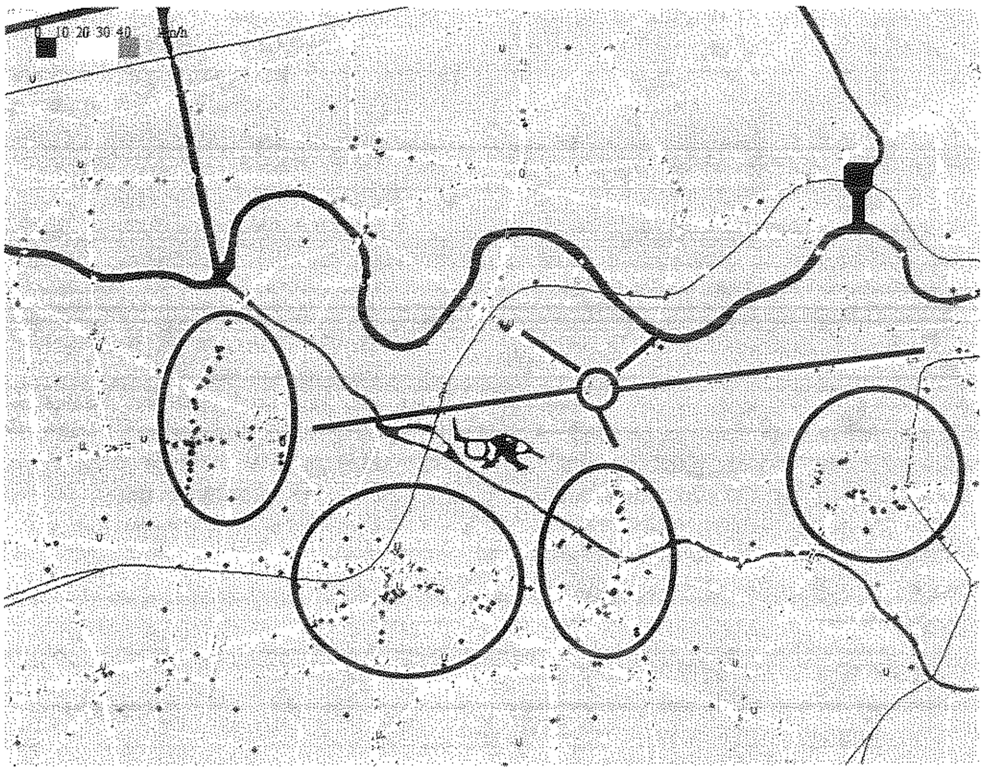

Figure 5. Visualisation of road conditions in the inner city district of Berlin during the event "Love Parade 2001", July, 21^{st}, 2001. In the middle the blocked roads ("Street of the 17^{th} June") are marked with thick lines, and the congested areas with circles. In these areas the mean velocity is less 10 $km\ h^{-1}$ (Scale: approx. 1:50,000).

4. CONCLUSIONS

It could be shown that Taxi-Floating Car Data is a low-cost traffic sensor for inner city applications. There are a lot of synergy effects from the Taxi disposition by the use of the GPS technology. It is easy to evaluate velocity profiles and exact travel times. These data are a very important source for further processing in an GIS-based and integrated traffic information system with a real-time connection to the World Wide Web.

The next priority objectives are to improve continuously existing traffic information services.

But, such point measurements are not suitable, because the dynamics and the route of a single vehicle could not evaluated. Obviously, the quality of the information depends on the actual number of taxis moving in the network. Only approximately one third of the fleet are permanently moving in the network. However, the growing number of taxis and other commercial fleets in the transport branch equipped with GPS technology will significantly improve this situation in the near future.

Furthermore, a huge number of various additional commercial applications by this approach could be implemented.

Beside the preparation of online traffic information the Floating Car Data could be widely used. Such applications are the online fleet management in commercial transport companies or a dynamic routing of the fleet in case of congestion. The recording of the Floating Car Data (active and passive FCD) helps to build up historical travel time data bases as a base to forecast the traffic conditions.

In the traffic simulation such data can be used for the evaluation of traffic models [Helbing 1997]. Actually, the validation of traffic simulation results is usually done by traffic volume measurements. FCD in combination with volume measurements could greatly improve the validation procedure of traffic simulation results.

Another important task is to integrate more and detailed information layers within the GIS for an enhanced traffic information system. Especially the integration of environmental data (actual weather conditions, high demanded meteorological time series from commercial organisation) as well as the modelling and simulation of emission data – especially in congested urban areas [Eissfeldt et al., 2001] – are the main future tasks within this research project.

5. ACKNOWLEDGEMENTS

The authors wish to thank the companies Taxiruf "*CITYFUNK*", Berlin, Germany, and *Austrosoft*, Vienna, Austria, for the kind collaboration.

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