PRONTO – Support for Real-time Decision Making

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ABSTRACT

For public transport authorities, the most important aspects for operations are passenger satisfaction and safety. Based on surveys, passengers regard punctuality as the most important aspect, which makes it an important factor of passenger satisfaction for the operators [10].

In the City of Helsinki, the public transport vehicles' movements and status are monitored through a real-time information system, which provides authorities information about punctuality of vehicles. Furthermore, the gathered information is used for route planning and scheduling.

Due to the existing information systems in Helsinki, the focus in operation planning has gradually moved from real-time timetables to other factors affecting passenger satisfaction and safety, aiming to find ways to further improve public transport operations.

The PRONTO research project focuses on two demonstration cases. One is emergency rescue operations in Dortmund, Germany. The other one is public transport in Helsinki, where the research focuses on developing methods for improving passengers' travel experience through monitoring and analyzing vehicle events in real-time. Through these methods, it is possible to further improve public transport punctuality and especially the driving style that would lead to improved passenger safety and satisfaction, as well as better vehicle endurance.

A variety of sensors and connections to existing systems have been implemented in order to provide the PRONTO system with valuable data about the both demonstration cases. This paper presents the activities and achievements so far of the public transport demonstration case.

Categories and Subject Descriptors

J.1 [**Computer Applications**]: Administrative Data Processing - *Business, Government*

General Terms

Management, Performance, Reliability, Human Factors.

Keywords

Complex Event Processing, City Transport Management.

1. INTRODUCTION

Due to the continuous traffic growth in many of the world's capital cities, there is a need to further improve public transport services and make them more attractive to passengers – while optimizing the use of available resources. This is also the case in the City of Helsinki in Finland, where the public transport authorities have been actively involved in improving especially real-time information services.

PRONTO[1] is an international research project, partially funded by European Commission. It was launched in March 2009. The project is due to last for three years and during this time, the main emphasis of the project is to investigate the impacts of event recognition on intelligent resource management (IRM). This is done by gathering data from various sources, analyzing it to extract useful information in the form of events and then delivering the resulting knowledge for decision making in emergency rescue operations and public transport.

In order to achieve this objective, PRONTO uses techniques and expertise from the areas of data fusion, information extraction, temporal representation and reasoning, machine learning and knowledge-based management systems.

PRONTO sets specific goals to its two main targets: real-time decision support for IRM in public transport and emergency rescue operations, both cases typically involving large volumes of various types of data.

2. PROJECT SCOPE

The PRONTO project has two demonstration cases and two test areas; city transport management in Helsinki, Finland, and emergency rescue operations in Dortmund, Germany [8]. The demonstration cases have their own specialties, but the common core is the same in both of them. This paper focuses on the city transport management demonstration case.

During the project a city transport management pilot is done in the City of Helsinki, Finland, where vehicles are equipped with computational units that send sensor information to a central server. The central server offers information about the current status of the transport system such as, for example, the location of the vehicles on a map, and the noise level, temperature, 3D acceleration of a vehicle.

The vehicles already have a mobile broadband connection, which makes it possible to send sensor data to the server in real time. That way the management can detect exceptions regarding the operations and even possible threats in the vehicle. Moreover, it is possible to effectively use this information in analyzing the need

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[1] http://www.ict-pronto.org/.

for interaction with the driver or authorities in terms of stabilizing exceptional situations. In the pilot phase of the PRONTO project, scheduled to take place in late 2011, the aim is to detect various complex events that create a need for decision making.

In terms of city traffic management, the study emphasizes in detecting events that cause decreasing passenger safety, passenger satisfaction and vehicle endurance. These events will be analyzed in real-time. Moreover, the gathered information will also be used in post analysis.

3. SYSTEM ARCHITECTURE

Vehicles connected to the system transmit sensor data to a centralized server, as frequently as once per second. In the server, data is processed for detecting simple events when sensor data values change. Various types of simple events are used to derive and detect complex events that would be interesting from the user point of view. The data processing is done continuously and in

real-time. An interesting complex event concerns, for example, passenger comfort which is derived from cabin temperature and sound pressure level. Another interesting complex event concerns driving style, which is derived from vehicle acceleration changes.

The system receives information from vehicle sensors collecting following types of data: location, noise level, 3D-acceleration, technical vehicle data (for example, fuel consumption, engine temperature and engine revolutions) and departure information. The system also handles timetable and stop location data for monitoring the punctuality of the public transport operations.

Figure 1 presents a simplified view of the system architecture. The vehicles are equipped with sensors transmitting the data to the centralized server that takes care of the event detection. The system has real-time view for monitoring the detected complex events and a post analysis interface for a more detailed analysis of the events.
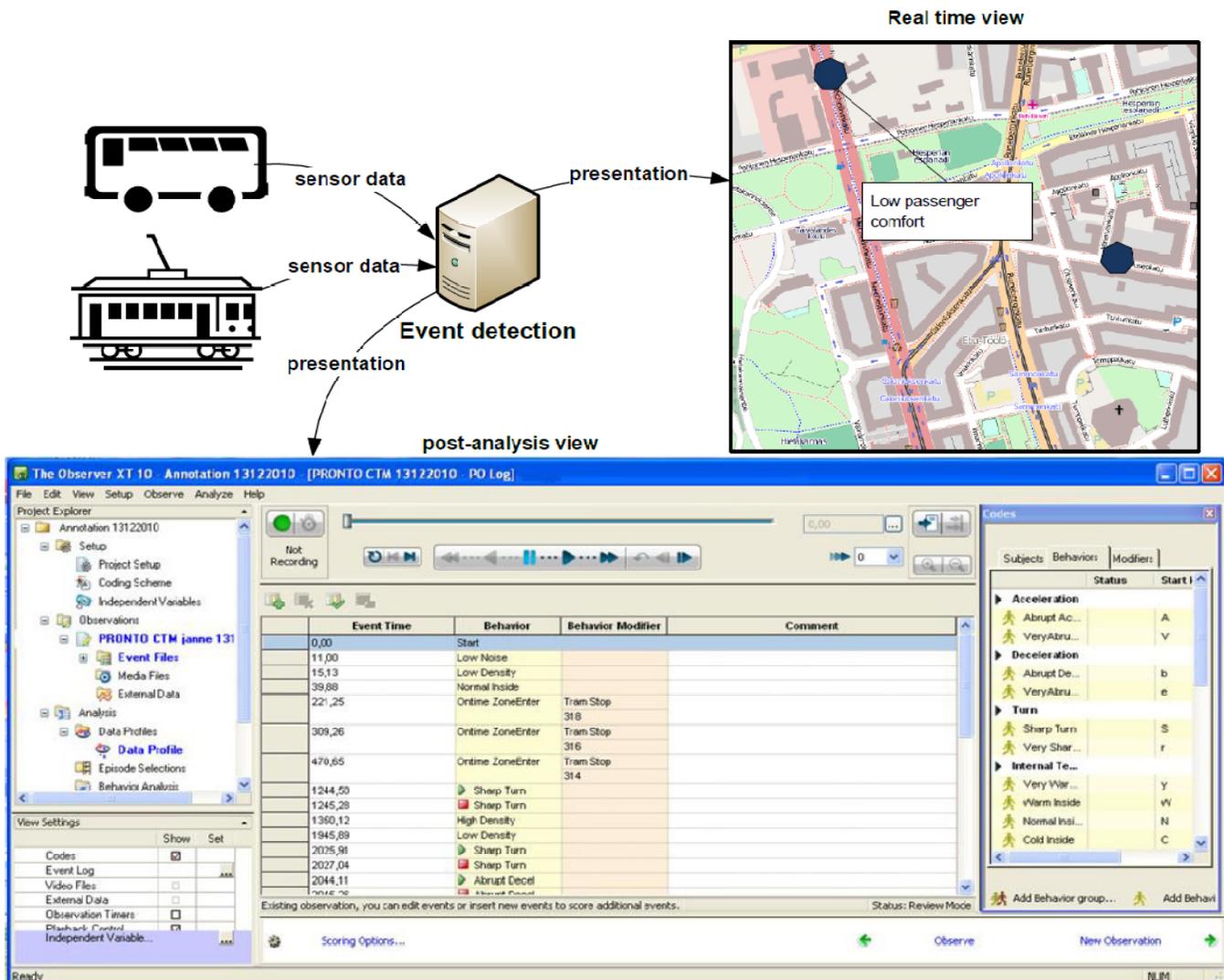

Figure 1. PRONTO system architecture[2]

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[2] The system developed includes the use of The Observer XT, provided by Noldus Information Technology BV [6] and Mattersoft Live! system provided by Mattersoft Ltd [5], Map by OpenStreetMap [7].

4. USE CASES

The system has two use cases, real-time event detection and post analysis of driving.

4.1 Real-time event detection

In event detection, the most important aspect is to automatically detect and forecast events that require instant reaction. These types of events concern passenger and driver safety, as well as issues that significantly affect vehicle condition. Real-time information not only enables analyzing transportation in a wider perspective, but also demonstrates the system performance.

The system is capable of detecting exceptional changes in acceleration that can be a result of an accident, for example. Also changes in driving style that threaten passenger safety can easily be detected, and the driver can then be contacted in order to prevent accidents from occurring.

The system is also capable of detecting vehicles gathering up on a limited area. With this information it is possible to detect traffic jams or impassable obstacles in certain routes and thus detect the need for re-routing.

4.2 Post analysis

Typically passengers do not communicate with drivers about their driving. For operators, the feedback is given only when something exceptional has happened. However, feedback is an important way of driver guidance and training, and the system is capable of offering feedback and helping the drivers to develop a better driving style.

By following and giving feedback on driving style, the aim is to be capable of having an impact on passenger comfort, safety, vehicle endurance and fuel consumption.

Before, the driving style has been impossible to monitor on a wider scale with any other ways than observing it on the vehicle and collecting feedback. Thus, by automatically analyzing the driving style, driver training and guidance can be renewed completely.

Driving style follow-up and analysis enables realistic and equitable driver feedback. Also, several drivers' driving style can be compared to each other and the feedback given equivalently. With collected location data, the system is capable of pointing out where problems in driving style or operations have been and what have, or could have been the outcomes. On the other hand, the system points out skillful drivers according to their merits.

When renewing vehicles in Helsinki, it was noticed that intersections of tramlines are problematic for the vehicles, infrastructure and people living in the area. Because of this, the trams should drive in intersections with a limited speed. With an event-based approach, vehicles and drivers driving too fast in intersections can also be easily detected by the PRONTO system.

5. COMPLEX EVENT DETECTION MODULE

To perform complex event detection we developed a dialect of the Event Calculus (EC) [3]. EC is a logic programming language for representing and reasoning about events and their effects. (A recent overview of logic-based languages for complex event detection may be found in [2].)

The formal semantics of EC allows for validation and traceability of the effects of events. The declarative semantics of EC facilitates considerably the interaction between the complex event 'definition' developers and the users (city transport officials, in this case).

EC allows for the succinct and structured representation of all complex events of interest in city transport management. The availability of the full power of logic programming is one of the main attractions of employing EC as the temporal formalism. It allows event definitions to include not only complex temporal constraints - EC is at least as expressive as purely temporal reasoning systems proposed in the literature - but also complex atemporal constraints.

To perform real-time event detection we implemented a caching algorithm for our EC dialect. The performance of our EC dialect is summarized below. Details about our current empirical evaluation of the complex event detection process, as well as the implemented caching algorithm, may be found in [1].

During rush hour, at most 1050 vehicles operate at the same time in Helsinki, that is, 80% of the total number of available vehicles. It is estimated that no more than 21000 simple events are detected per minute on the 1050 operating vehicles. The user requirements can be met by running, in parallel, EC on four desktop processors. Using each processor, EC detects the complex events concerning one quarter of the operating vehicles - at most 263 vehicles. The complex event detection on each processor is performed in less than 100 milliseconds, taking into consideration the simple events detected in the last 10 seconds.

6. CONCLUSIONS AND FURTHER WORK

The PRONTO system brings unforeseen added value for public transportation management and especially to driver training. The driver can be given specific feedback more detailed than they have ever received. The system also points out event locations and ensures the feedback is not only equal, but also righteous.

The event-based architecture has enabled surprisingly fast the development of such features that were not originally on the requirement list. These features include, for example, vehicle chaining detection and fuel consumption monitoring.

The next phase in the project is to test event detection in order to ensure the credibility of information provided by the system, which is a major requirement for being able to utilize the system comprehensively.

Our logic programming approach to complex event detection has the advantage that machine learning techniques, such as abductive and inductive logic programming, can be directly employed in order to construct or refine complex event definitions in an automated way. We are currently developing such a machine learning technique that takes advantage of very large datasets, where available.

Finally, we are extending our Event Calculus dialect for reasoning under uncertainty in order to deal with noisy sensor information. To achieve this we are using two different technologies: a probabilistic logic programming framework [4], and Markov Logic Networks [9].

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