SmartCityBus -A platform for smart transportation systems

Georgios Bouloukakis, Chrysostomos Zeginis, Nikolaos Papadakis, Kostas Magoutis, George Christodoulou, Chrysanthi Kosyfaki, Konstantinos Lampropoulos, Nikos Mamoulis

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Georgios Bouloukakis
Télécom SudParis, Institut Polytechnique de Paris
France
georgios.bouloukakis@telecom-sudparis.eu

Chrysostomos Zeginis[1]
Nikolaos Papadakis[1]
Kostas Magoutis[1,2]
[1]Institute of Computer Science (ICS), Foundation for Research and Technology - Hellas (FORTH)
[2]Computer Science Department, University of Crete
Greece
{zegchris,papadakni,magoutis}@ics.forth.gr

George Christodoulou
Chrysanthi Kosyfaki
Konstantinos Lampropoulos
Nikos Mamoulis
Department of Computer Science and Engineering, University of Ioannina
Greece
{gchristodoulou,xkosifaki}@cs.uoi.gr
{klampropoulos,nikos}@cs.uoi.gr

ABSTRACT

With the growth of the Internet of Things (IoT), Smart(er) Cities have been a research goal of researchers, businesses and local authorities willing to adopt IoT technologies to improve their services. Among them, Smart Transportation [7, 8], the integrated application of modern technologies and management strategies in transportation systems, refers to the adoption of new IoT solutions to improve urban mobility. These technologies aim to provide innovative solutions related to different modes of transport and traffic management and enable users to be better informed and make safer and 'smarter' use of transport networks. This talk presents SmartCityBus, a data-driven intelligent transportation system (ITS) whose main objective is to use online and offline data in order to provide accurate statistics and predictions and improve public transportation services in the short and medium/long term.

KEYWORDS

Smart Cities, Smart Transportation, Context Brokers

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1 GOALS AND RESEARCH CHALLENGES

As a data-driven intelligent transportation system (ITS), the main challenge in SmartCityBus is to collect and combine a variety of data inputs (passenger crowd-sourcing data, sensor data, schedules, historical data) to achieve multiple objectives at the best possible degree, without requiring all data inputs to be complete and available at all times. SmartCityBus proposes a platform that collects and manages public-transport data, in order to improve (i) the service provided to passengers and (ii) the effectiveness of allocation of resources (e.g., fleet) to routes. For this, SmartCityBus dynamically define bus service schedules and resource allocation, taking advantage of online data provided by the passengers and by IoT devices installed at buses.

SmartCityBus will enable passengers to express their intent to move in time and the anticipated demand at each stop will be continually and accurately estimated. In addition, the current loads of vehicles are estimated with the help of sensors placed at the entrances and exits of the buses. Specially designed algorithms will combine these two sources of information and accurately assess the occupancy risk of vehicles over time in order to make timely and effective use of the spare fleet or to launch larger capacity vehicles where necessary. Thus, the bus company is able to efficiently plan the routes and intervene dynamically with changes wherever the need arises. An equally important objective is to achieve high accuracy in informing passengers about the ETA of buses at specific stops, helping citizens to avoid long waiting times, in case of abnormal circumstances (e.g., traffic, bad weather, construction works). Although some passengers may submit their travel intent (explicitly or implicitly via queries), the system does not require all passengers to do so and employs statistical techniques (e.g., extrapolation, historical data) to estimate the transportation needs at each bus stop. In addition, although electronic ticketing can facilitate counting the number of passengers that enter a bus, some passengers may prefer to use cash; besides, it is not possible to measure how many exit the bus via e-ticketing. SmartCityBus employs sensor technology for estimating how many people are on board at all times.

Research on the IoT platform aims to explore the benefits of modeling internal spaces and information sources of buses and bus stops using the NGSI-LD protocol [1, 2] and the benefits from integrating with other NGSI-LD data models and services in federations within a broader smart-city environment [5]. We will further explore IoT platform architecture that allows for scalable event dissemination and analytics that leverage modeled information for purposes of finer-grain seat planning, occupancy prediction, social distancing, etc. and relationships to emergency response scenarios.

Unlike previous work that relies on data from smart cards [4] or ticket purchases, SmartCityBus should predict the transportation needs of passengers without the use of ticketing information, since many passengers do not use smart cards and zone tickets and passes

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do not necessarily capture the entry and exit points of passengers. We analyze historical data to extract motifs of high traffic on specific lines at specific dates and times, which, in turn, are used to predict the current travel needs. Online data from sensors and apps are also used to boost the prediction accuracy. One of the key services of SmartCityBus is the accurate estimation of bus arrival times. Previous work [6] builds models (clustering and Kalman filters) that combine the current positions of buses with historical data. We also have additional real-time information to be considered (passenger travel intents, current loads of buses), which calls for more complex prediction models.

One last challenge of the project is the exploitation of historical data about route accuracy, vehicle load, passenger satisfaction, fleet utilization, for optimal route network design. In its simplest form, this problem keeps the routes (lines) fixed and optimizes the timetable and use of fleet [9]. We will focus on this problem first, as applying its solution is easier in practice. Applying long-term changes to lines and positions of bus stops [3] is harder to apply (and also harder to solve as a problem) and it will be studied later.

2 SYSTEM AND CURRENT STATUS

The platform consists of an information system that is managed by bus operators and is able to monitor in real time vehicle movements (via GPS) coupled with accurate measurements through special IoT devices installed at buses and stops and passenger feedback, for the load of the routes and any unexpected situations as well as the load requirements in the near future at every stop and route. By analyzing the collected information, the system can calculate timely and propose changes to timetables, choice of vehicles (large or small) according to requirements, extra services, etc. The system's data and predictions can also be fed to passengers and drivers through a specially designed mobile apps. Through the passenger app, the passengers are able to search for current routes, share their current locations (using GPS), and submit their intention to use a particular line and stop at a specific time. Finally, the app can give an estimate about the predicted number of passengers in a bus that a passenger expects at a bus stop. The system also records historical, anonymized data in a database, which are analyzed by offline, optimization algorithms, aiming at redesigning bus routes/lines, reconsidering the locations of bus stops, estimating future fleet requirements, and serving any other long-term needs by the bus company. In addition to the expected benefits to stakeholders (enhancing their know-how in high-volume IoT data management and the development and management of public transportation systems), this project brings significant benefits to the society (improving public transportation services, reducing travel time), the economy (resource management, tourism development) and the environment (reduction of the population percentage that uses cars, reducing carbon emissions by maximizing fleet utilization).

A prototype of the IoT platform [2] depicted in Figure 1 is already available and provides the necessary functionalities to store and query live and historical transportation data. In particular, this architecture consists of the following components: (i) the context broker that is implemented using Orion-LD and Mintaka; (ii) the backend storage using MongoDB and TimescaleDB; (iii) Applications that rely on the NSGI-LD extended data model to create requests/subscriptions; and (iv) an MQTT Mosquitto broker that collects sensors data from vehicles and converts them to NGSI-LD based data using NGSI IoT agents. For our experiments we used Time-of-Flight sensors[1] to measure the number of passengers who pass through the entrances of exits of buses. Some preliminary results of the projects are already available and will be demonstrated in the presentation of this work.

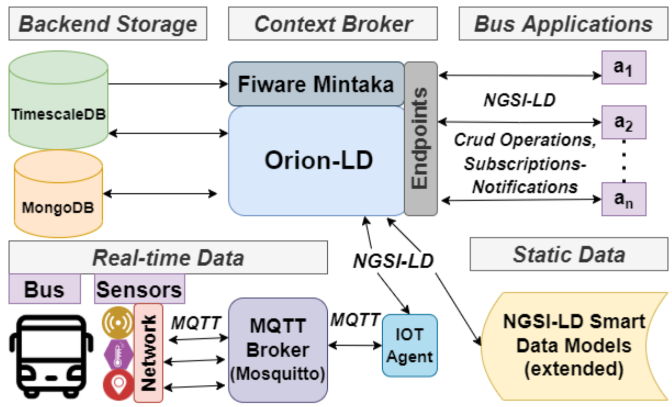

Figure 1: Transportation System Prototype Implementation.

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