Usage of GPS Data for Real-time Public Transport Location Visualisation

Aleksejs Zacepins, Egons Kalnins, Armands Kviesis and Vitalijs Komasilovs
Department of Computer Systems, Faculty of Information Technologies, Latvia
University of Life Sciences and Technologies, Jelgava, Latvia

Keywords: Public Transport, Smart City, Smart Transportation.

Abstract: The concept of the smart city has been fashionable in the political arena in recent years. Cities are trying to be modern and provide various ICT based services for their citizens. An efficient public transportation service is critical for the citizens, but traffic congestions are still a problem in cities and are one of the main reasons for public transport delays. Therefore, it is important for citizens to know where the needed public transport vehicle is located at the moment, to know if the transport has already passed the stop or not. Authors of this research propose a real-time public transport tracking system using a global positioning system (GPS) technology module to receive the location of the vehicle in a real-time. System is based on the Raspberry Pi 3, which is used to transfer positioning data received from GPS module to the remote database. Based on received data, the location of the bus is visualised in the developed Web system.

1 INTRODUCTION

The concept of Smart city is not novel, but in the recent years it rose up to a new level by using ICT (Information and Communication Technologies) and IoT (Internet of Things) to build and integrate critical infrastructures and services of a city (Nam and Pardo, 2011). Smart city can be defined in many ways (Partridge, 2004; Harrison et al., 2010; Hall et al., 2000; Giffinger, 2007; Washburn et al., 2010; Caragliu et al., 2011; Albino et al., 2015), but the main idea of the Smart city is to provide efficient services for the citizens. Smart city consists of several multidimensional components (like Smart energy, Smart government, Smart economy etc.), and Smart mobility is one of them (Nam and Pardo, 2011). In its turn, Smart public transportation is a significant part of the Smart mobility dimension in Smart cities, as one of the main problems of urban centres today is mobility of citizens (Lima et al., 2017). Efficient urban transportation systems are widely accepted as essential infrastructure for smart cities, and they can highly increase a city's vitality and convenience for residents (Liu et al., 2017).

Governments on the national and municipalities on the local level are trying to motivate citizens to use public transport service instead of private vehicles by promoting the development of journey planning technologies in order to optimise commuter interactions with transportation systems (Cohen et al., 2017). Still huge amount of people are using private vehicles for transportation in the cities and bus passengers journeys are decreasing. For example in 2016/2017, 2.20 billion passenger journeys were made by local bus in England outside London, down 0.8% compared with 2015/16. In London decrease of 2.3% is observed and passenger journey number is decreasing for several years in a row (information by Department for Transport, Annual bus statistics: England 2016/17[1]). Situation in author's home country Latvia is similar, in year 2016 passenger flow is decreased by 2.8% compared to 2015 and tendency is to have passenger number decrease by 2% each year (statistics by Latvian road transport directorate[2]).

Many citizens using public transportation have experienced time losses because of waiting at the stops (Jadhav et al., 2017), which is not corresponding to the efficient service. Citizen does not get any idea of current location of a bus or exact timing of arriving bus. So citizen have to wait for a bus at the bus stop for several tens of minutes or even hours, when considering regional buses (Khot and Yadav, 2016). Public transport is suffering from a number of uncertain conditions for the possible delays, like traffic conges-

[1]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666759/annual-bus-statistics-year-ending-march-2017.pdf

[2]www.atd.lv/sites/default/files/Info_2016_9_menesi_05122016.pdf

Zacepins, A., Kalnins, E., Kviesis, A. and Komasilovs, V.
Usage of GPS Data for Real-time Public Transport Location Visualisation.
DOI: 10.5220/0007350902770282
In *Proceedings of the 5th International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS 2019)*, pages 277-282
ISBN: 978-989-758-374-2

tions, traffic accidents and others (Suganya and Valarmathi, 2017). But still improvement and expansion of the public transportation service is a key factor to minimise traffic congestions in urban cities (Garg et al., 2017).

In today's smart world in line with all fast emerging technologies public transport system must be improved. One of the technological solutions, which can improve transportation system quality, is GPS (Global Positioning System). GPS allows the precise positioning of an object using satellite signals. There are a many applications of this technology in various scientific fields including transportation sector (Mintsis et al., 2004). GPS has nearly global coverage, that allows to detect location almost everywhere, and nowadays technology demonstrates high robustness (Dani Reagan Vivek et al., 2017). Using GPS data, transport system can also keep track on driver's performance while s/he is driving a bus. Tracking of all buses helps to reduce chances of vehicle theft operations and if any accident happens with bus system, it can be easily identified (Garg et al., 2017). GPS data are not just useful for travel time prediction and location identification, but can also provide information about traffic, e.g., the existence of congestions (Bacon et al., 2011), therefore it can extend the ITS (Intelligent Transport System) concept, which is basically used to improve the safety and efficiency of the traffic management system (Nasim and Kassler, 2012).

There are many approaches and algorithms of bus arrival time prediction based on GPS data (Kviesis et al., 2018; Amita et al., 2015; Yin et al., 2017; Fan and Gurmu, 2015)), but author's idea is to give citizens an easy tool to see the public transport location in real-time and make decisions by themselves. In overall, collection of public transport GPS data can be as a one source for the data mining in Smart cities, as data mining is one of the three core pillars (Nasim and Kassler, 2012) for the smart city together with IoT and mobile wireless networks.

So the main aim of this paper is to describe approach for real-time GPS data collection with its further application in public transport vehicles for service quality improvement by visualisation of real-time vehicle location. Such system will help to improve interest of citizens towards usage of public transportation system.

2 MATERIAL AND METHODS

Within this research authors developed GPS data collection system for demonstration of real-time public bus location. For GPS data visualisation additional

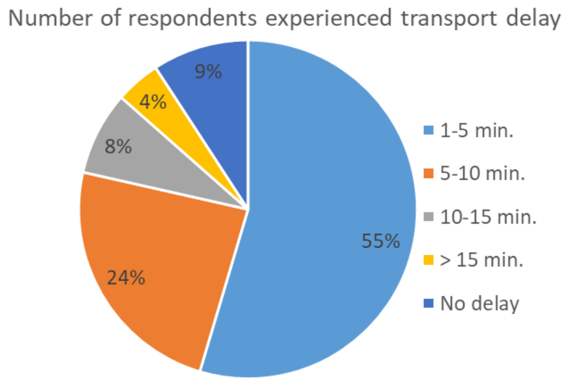

Figure 1: Delay of the transport, experienced by the respondents.

WEB system is developed for use in any device with Internet connection. Before the development process, authors conducted a survey to know the Latvian society opinions and their needs to know the public transport real-time location and approximate bus arrival time at the specific bus stop. As well existing intelligent transportation systems in Latvia are described and compared with some international systems.

2.1 Survey about Research Topicality

To get to know the Latvian society opinion on the importance of knowing the public transport real location and approximate bus stop arrival time authors conducted a survey using the Google Forms. For the survey citizens of Riga (capital of Latvia) were asked to answer 13 questions about Riga main public transportation service provider "Rigas Satiksme" (RS[3]). Survey included questions about how often they use public transport, how often transport has delays and how those delays affects citizens plans. There were also some questions about GPS technology and possible benefits of its usage. 163 respondents replied to the survey. Respondent group consisted of 78.5% women and 21.5% men, average age was 25.4 years.

Analysis of the answers concluded, that bus has the most delays. As well more than 30% of respondents marked that their used public transport has delays almost every day. Regarding the delays, 54.6% said that delay was less than 5 minutes, but other 36.4% marked that delay was more than 5 minutes (4.3% said that delay was more than 15 minutes) (see Fig 1).

It is worth to emphasize that plenty of respondents (65%) said that they missed their work, school or meeting due to transport delays. 43.6% noted, that this really spoiled their mood. The next question was

[3] https://www.rigassatiksme.lv/en/about-us/

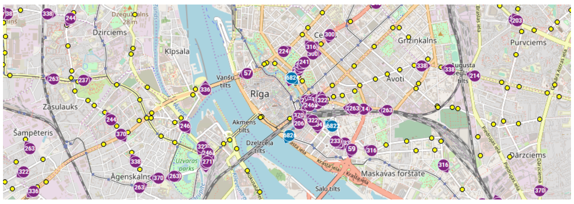

Figure 2: RS web system for minibus location visualisation.

about the citizens' wish to know not only the transport scheduled times, but also real location showed that this is very actual, because 92.7% respondents replied positively. This allows to re-plan their schedules, inform others about possible delays, and consider other transportation options.

2.2 Existing Intelligent Transportation Systems in Latvia

Today GPS data is used in many logistic enterprises to monitor the transport, calculate fuel consumption, driver work load etc. As well, taxi companies use transport positioning data for optimising operational efficiency of the driver, but mainly this data is not for a public use, but for private enterprise needs. It is found that in Latvia only two public transport service providers started to analyse GPS data and provide it for the public usage. In Riga, Rigas Satiksme developed mobile and web applications for real-time GPS data visualisation. Each vehicle, which is equipped with GPS device is demonstrated on the map, based on OpenStreetMaps. To get GPS data from vehicle, GET query is sent to the specific web address: *https://marsruti.lv/rigasmikroautobusi/gps.txt*. Using this text file, it is possible to get vehicle number and it's exact location. GPS data is updated with 5 sec intervals. Web system for public use (see Fig 2) is accessible online[4]. At this moment, only location of minibuses is shown.

In authors' home town Jelgava (Jelgava is the fourth largest city in Latvia, a historical centre of Zemgales region, distance from Riga is 42 km, residents number is approx. 62 000), local public transport operator "Jelgavas Autobusu Parks" (JAP[5]) also implemented feature of demonstrating real GPS position of the buses. In Jelgava there are twenty local bus routes. JAP also uses the same approach as RS, using the Mapon service. But the visualisation approach is different, JAP shows approaching buses in 30 minutes time interval to the selected bus stop and not showing all bus real-time location on map. As well provided

[4]https://marsruti.lv/rigasmikroautobusi/#minibus/map/en
[5]https://www.jap.lv/?lang=en

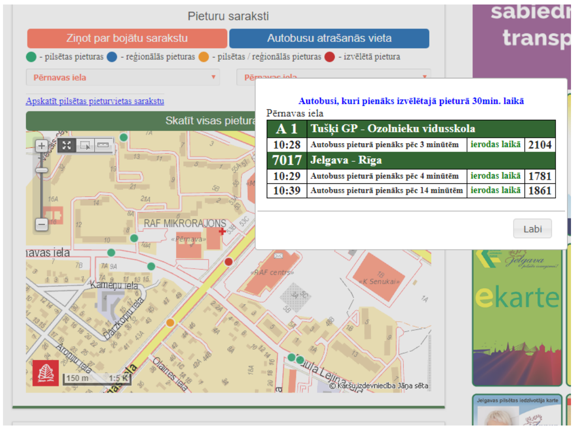

Figure 3: JAP web system for bus location visualisation.

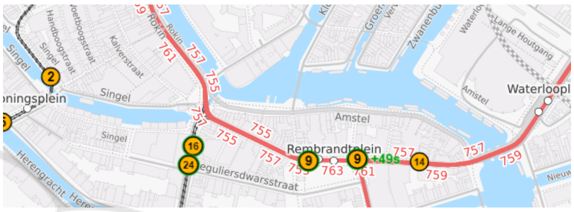

Figure 4: TRAVIC web system.

information about bus location is only textual, not visual (see Fig 3).

Comparing to local systems in the world, there are TRAVIC (Traffic Visualisation Client), which is developed by geOps company collaborating with the University of Freiburg (see Fig 4). This product is a web-based solution for real-time transport location visualisation and route demonstration by the static transport schedule. The application combines static and real-time schedule data and calculates the current position of the transport vehicles. TRAVIC solution uses publicly available open data, which is stored in General Transit Feed Specification format. To this moment, system collects data from more than 700 sources mainly from North America and from Central Europe (Germany, Switzerland, Netherlands). 66 sources are for real-time data (in the system marked with green line of the circle) other are static, based on transport schedule. Real time data is collected using the GTFS RT format, which is extension of GTFS. Data transfer is made using Google developed platform independent protocol.

3 RESULTS AND DISCUSSION

As a result of authors developed approach efficient tool for extracting valuable traffic data from vehicles is presented. Within this research authors demonstrate

Figure 5: GPS module GP-20U7.

simplified approach for GPS data collection, which can be used in public transport sector without additional need to buy expensive GPS commercial hardware. The GPS accuracy was accepted to be within 10 meters as the primary use would be for public bus tracking. This is easily obtained with the most GPS sensors on the market. As a result, authors demonstrate developed system and user interface for GPS data visualisation.

3.1 Developed System for GPS Data Collection

In authors' case Raspberry Pi 3 with additional GPS module GP-20U7 was used (see Fig 5). Based on technical specification module precision is 2.5m, but during experiments authors observed location precision about 9m. An update of GPS coordinates was immediate, when data from GPS module was received, module sent coordinate updates each second. The GP-20U7 GPS module is energy efficient and has only 40mA power consumption. GPS module and Raspberry Pi is connected using UART interface, and only 3 wires were necessary – Vcc, GND and RX. Authors chose to use Raspbian as Raspberry Pi operating system. Software, to communicate with GPS module, was developed using Python programming language. Software aim was to get raw GPS data from GPS module and send values to dedicated cloud server for further data analysis and visualisation. For system tests Internet access was shared from mobile phone, but for the final solution additional 3G/4G module should be connected to the Raspberry Pi for persistent Internet access.

Example of data that is sent to the remote database is shown below. For data transfer to the cloud server PUT request is used.

{"id":"5ad39422c57f652a8827e225","vehicleId":"11001","serialNumber":1337,"routeId":"riga_trol_27","vehicleTypeId":800,"geoData":{"latitude":56.92166,"longtitude":24.091107,"speed":0.0,"provider":null,"date":"2018-04-16T19:55:05.832Z"}}

For public transport GPS data visualisation standalone web system was developed. It is possible to see real-time transport location based on selected route. For system development several technologies were used: NoSQL database MongoDB for data storage, .NET Core SignalR library, for data transfer from server to client, web API for GPS data collection. SignalR library was chosen to implement data exchange using websockets protocol which allows to faster update data in real time using one websocket connections. Web API was implemented in REST architecture style and its main purpose is to allow using HTTP protocol for getting, updating and adding new data in database. GPS receivers use web API to update location data and each time corresponding API method is called, it also calls SignalR hub method that distributes data to clients who has joined group, which has been identified by selected route. All vehicle data on given route identifier is distributed to all clients that has subscribed for vehicle data method. C# and JavaScript languages were used for server and client application development. For server-side .NET Core 2.0 framework version was used. Client side was made using JavaScript Angular 2 framework. Client application is integrated in the same solution and deployed on one Azure web application service. Architecture of the developed system is demonstrated in Fig 6.

3.2 Web System for GPS Data Visualisation

User interface of the developed system is shown in Fig 7. Basic idea is, that user choose the needed public transport route and stop, afterwards system shows on the map where is the nearest transport. All RS public transport routes and stops were integrated from their publicly available GTFS feed[6]. Feed information was converted from .txt to JSON format, using Javascript library for further data upload to local database. Google Maps services were used to display map and location. In case when there is no GTFS feed for public transport agency, it is possible to retrieve route data from Google Directions service and with custom algorithm extract waypoint information and draw approximate route polylines in map and mark stops. Based on provided information system user can see if the public transport has already passed the stop or is still approaching it.

[6]http://saraksti.rigassatiksme.lv/riga/gtfs.zip

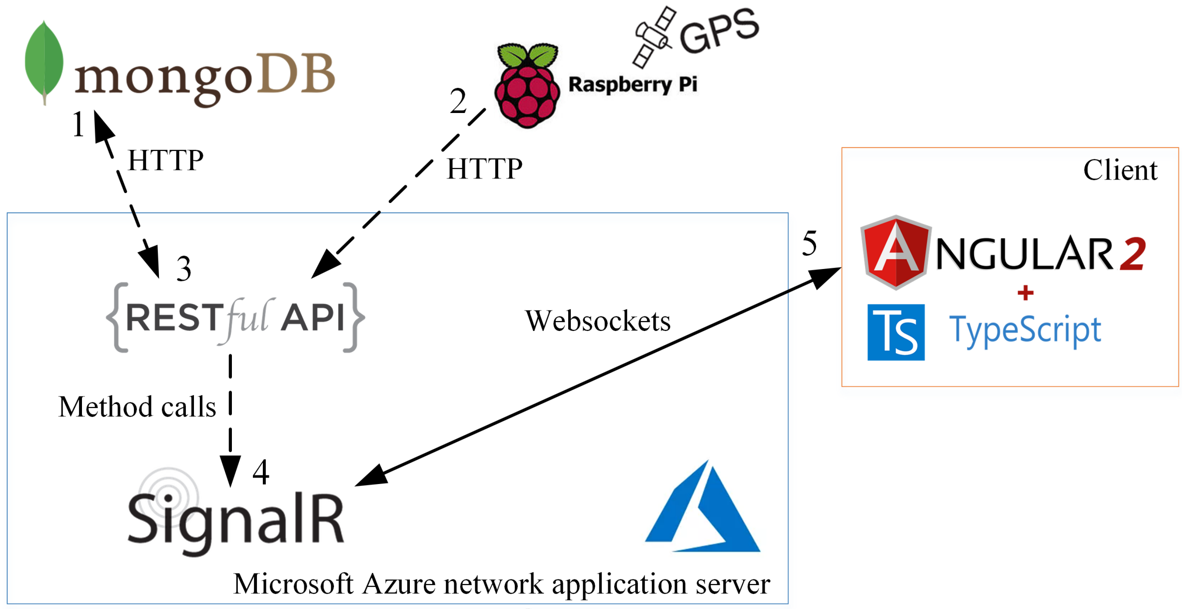

Figure 6: Architecture of the developed system for GPS data visualisation.

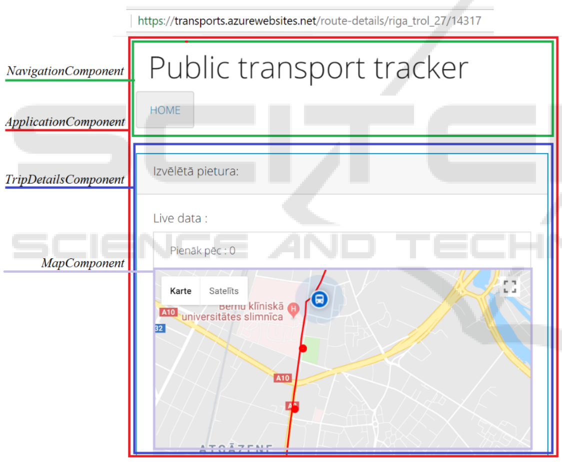

Figure 7: User interface of the developed system.

4 CONCLUSIONS

Implementation of GPS data monitoring for public transport needs can significantly increase service quality for its customers and give additional value for service provider internal needs.

The data provided by the GPS records can be translated into reliable indicators that will show the exact position of the bus on the route.

Developed system prototype demonstrates easy and relatively cheap solution for public transport location visualisation for service users based on GPS data. Developed system eliminates the need for a third party to maintain the infrastructure and management of the system.

The GPS location reported by the unit was almost always accurate to within 10 meters and no loss of signal was experienced during the testing phase. Knowing real-time transport location helps citizens to avoid unpredictable transport delays and helps to re-plan their scheduled route.

ACKNOWLEDGMENTS

Scientific research, publication and presentation are supported by the ERANet-LAC Project „Enabling resilient urban transportation systems in smart cities (RETRACT, ELAC2015/T10-0761)".

REFERENCES

Albino, V., Berardi, U., and Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, 22(1):1–19.

Amita, J., Singh, J., and Kumar, G. (2015). Prediction of Bus Travel Time Using Artificial Neural Network. *International Journal for Traffic and Transport Engineering*,, 5(4):410–424.

Bacon, J., Bejan, A., Beresford, A., Evans, D., Gibbens, R., and Moody, K. (2011). *Using real-time road traffic data to evaluate congestion*, volume 6875 LNCS.

Caragliu, A., del Bo, C., and Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, 18(2):65–82.

Cohen, Y., Makri, S., Reymann, S., and Kaparias, I. (2017). User-Centred Design in Public Transport: Discovering Mobile User Needs. In *12th ITS European Congress*, pages 1–17.

Dani Reagan Vivek, J., Gokul Prashanth, R., and Ganesh Prabhu, B. (2017). Smart transportation system. *Imperial Journal of Interdisciplinary Research (IJIR)*, 3(4):1855–1858.

Fan, W. and Gurmu, Z. (2015). Dynamic travel Time Prediction Models for Buses Using Only GPS Data. *International Journal of Transportation Science and Technology*, 4(4):353–366.

Garg, N., Gawande, P. V., Kurekar, P. P., and Kharat, D. B. (2017). Bus Tracking using GPS and Real Time Prediction. *International Research Journal of Engineering and Technology(IRJET)*, 4(4):3477–3479.

Giffinger, R. (2007). Smart cities Ranking of European medium-sized cities. *October*, 16(October):13–18.

Hall, R. E., Bowerman, B., Braverman, J., Taylor, J., and Todosow, H. (2000). The vision of a smart city. *2nd International Life . . .* , 28:7.

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., and Williams, P. (2010). Foundations for Smarter Cities. *IBM Journal of Research and Development*, 54(4):1–16.

Jadhav, A., Kodre, A., Shejul, P., Awaghad, S., and Shirke, S. (2017). Smart Bus System Implementation of Smart Ticketing and Bus Tracking System. *International Education and Research Journal*, 3(1):2016–2017.

Khot, S. and Yadav, R. (2016). GPS Tracking System for Public Transport. *International Journal of Advanced Research in Computer Engineering & Technology*, 5(6):2278–1323.

Kviesis, A., Zacepins, A., Komasilovs, V., and Munizaga, M. (2018). Bus arrival time prediction with limited data set using regression model. In *Proceedings of the 4th International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS 2018)*, pages 643–647.

Lima, S., Barbosa, S., Palmeira, P., Matos, L., Secundo, I., and Nascimento, R. (2017). Systematic Review: Techniques and Methods of Urban Monitoring in Intelligent Transport Systems. In *ICWMC 2017 : The Thirteenth International Conference on Wireless and Mobile Communications*, pages 1–5.

Liu, Y., Weng, X., Wan, J., Yue, X., Song, H., and Vasilakos, A. V. (2017). Exploring Data Validity in Transportation Systems for Smart Cities.

Mintsis, G., Basbas, S., Papaioannou, P., Taxiltaris, C., and Tziavos, I. N. (2004). Applications of GPS technology in the land transportation system.

Nam, T. and Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times - dg.o '11*, pages 282–291.

Nasim, R. and Kassler, A. (2012). Distributed Architectures for Intelligent Transport Systems: A Survey. In *2012 Second Symposium on Network Cloud Computing and Applications (NCCA)*, pages 130–136.

Partridge, H. (2004). Developing a Human Perspective to the Digital Divide in the Smart City. *ALIA 2004 Biennial Conference Challenging Ideas*, page 7.

Suganya, S. and Valarmathi, A. (2017). Gps Enabled Android Application for Bus Schedule System. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 2(3):2456–3307.

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., and Nelson, L. E. (2010). Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO. *Cambridge, MA: Forrester Research, Inc.*

Yin, T., Zhong, G., Zhang, J., He, S., and Ran, B. (2017). A prediction model of bus arrival time at stops with multi-routes. In *Transportation Research Procedia*, volume 25, pages 4627–4640.