FRI-ONLINE-1-CCT2-09

BUILDING A CENTRALIZED SMART CITY SYSTEM FOR URBAN MOBILITY MAANAGEMENT AND SOLVING PROBLEMS RELATED TO PARKING AREAS, PUBLIC TRANSPORT AND ECO-TRANSPORT

PART 1 - STRUCTURAL ELEMENTS AND PROTOCOLS FOR COMMUNICATION THROUGH REST API IN SMART CITY SYSTEM - PUBLIC URBAN TRANSPORT[25]

Eng. Ivan Kolev, PhD
Department of Telecommunications,
University of Ruse "Angel Kanchev", Bulgaria
Tel.: +359 899 075 092
E-mail: ikolev@uni-ruse.bg

Assoc. Prof. Georgi Hristov, PhD
Department of Telecommunications,
University of Ruse "Angel Kanchev", Bulgaria
Tel.: +359 82 888 353
E-mail: ghristov@uni-ruse.bg

Assoc. Prof. Plamen Zahariev, PhD
Department of Telecommunications,
University of Ruse "Angel Kanchev", Bulgaria
Tel.: +359 82 888 353
E-mail: pzahariev@uni-ruse.bg

Abstract: *The focus of this article is to consider the basic protocols of communication and all the building blocks of the entire hardware and software structure in the construction of a Smart City System in public transport. The basic concepts of the names and the function of the individual building elements and their division (hardware + software) of the whole structure of two main subdivisions will be introduced, conditionally called Exterior and Interior. The need to create such a centralized system, which consists of many different software applications communicating via API (Application Programming Interface), data collection in the central database, performing the necessary computational actions on central servers will be considered. The structure of the communication protocols for data exchange via REST API, which are specifically developed for Smart City System - Public Urban Transport, will also be considered and the overall concept of data exchange between the individual hardware and software modules will be explained through these protocols.*

Keywords: *Smart City, smart solutions, public transport, eco transport, LoraWan network, API and central database, smartphone app, Android, iOS, Validators, Centralized system, Web applications, Servers, efficiency, GPS*

INTRODUCTION

The Smart City systems are gaining more and more application and popularity in today's fast-paced society (Cairns, S., Behrendt, F., Raffo, D., Beaumont, C., & Kiefer, C., 2017). This, in turn, requires their constant development and improvement, increasing their functional efficiency and generally increasing their usefulness to the society. There are several areas, in which the systems in focus undergo development and improvement (TRID, 2017). These areas are:

[25] Докладът е представен на заседание на секция 3.2 на 29 октомври 2021 с оригинално заглавие BUILDING A CENTRALIZED SMART CITY SYSTEM FOR URBAN MOBILITY MAANAGEMENT AND SOLVING PROBLEMS RELATED TO PARKING AREAS, PUBLIC TRANSPORT AND ECO-TRANSPORT PART 1 - STRUCTURAL ELEMENTS AND PROTOCOLS FOR COMMUNICATION THROUGH REST API IN SMART CITY SYSTEM - PUBLIC URBAN TRANSPORT

- Easy to use when used by the end user, by completely improving the ergonomics of the user interface.
- Add more fast and reliable payment methods for end services by users of these systems.
- Speed of communication protocols for data exchange and processing in the centralized system.
- Universalization of the Smart applications for the end user, thus enabling with one application to make use and respectively payment of separate services from the separate integrated Smart City systems, be it the use of public transport or Paid parking in the Blue / Green zone or bicycle / el. bicycle from Ecological public transport.

The widespread use of intelligent transport systems in the public sector will inevitably lead to the collection and processing of large flows of personal data (Cherry, C., Weinert, J., & Xinmiao, Y., 2009). Due to their deliberately "invisible" design and their purpose to perform continuous real-time monitoring, technological solutions - part of intelligent transport systems, must comply with the legal and ethical features and requirements for protection at the earliest stage of their design of personal data and the privacy of citizens. A small part of the mandatory measures to be taken into account under the General Data Protection Regulation and Directive 2010/40/EU on the deployment of intelligent transport systems in the field of road transport are the principle of minimizing the collection and processing of personal data, anonymization, the use of cryptographic mechanisms, etc. (ERTICO, 1998a and ERTICO, 1998b).

STRUCTURAL ELEMENTS OF THE SMART CITY SYSTEM

As already mentioned, the focus of this article is on the structural elements (hardware and software modules) that make up a complete Smart City system in Public Urban Transport. According to their location and application in the overall system, these structural elements can be divided into two main groups, which can be conditionally called **EXTERIOR** and **INTERIOR**, respectively (Fig. 1).

The reason for them being conditionally called by these names is that **INTERIOR** will mean everything that is in the central building and is part of the Smart City system in Public Urban Transport, namely the central servers, routers, additional network equipment, Ticket Center, Monitoring Center.

The ticket center, which is part of the **INTERIOR** (Fig.1), is directly related to the work with the end users / clients of the services and accordingly has N number of jobs, each equipped as follows:

- **Computer system** and access to the centralized web-based system with the respective limited rights only to the software modules necessary for sales on Paper - Tickets and Subscriptions, respectively, in the form of Plastic Cards of Mifare type, in which they can be repeatedly read and rewritten subscription data and the user himself.

- **Scanner for reading personal data directly from an Identity Document** (ID Card) via OCR recognition. This peripheral is used for quick and easy reading of names and photos of a customer who for the first time wants to use services, such as Subscription of Smart City system in Public Urban Transport. After these data are read and extracted, through the appropriate software modules they are stored in the database of the centralized system and so the client is already in the system.

- **A card printer** is another part of the periphery with which each workstation is equipped and serves for printing on the plastic card for Subscription, the personal information about the Client read by the scanner of the previous step.

- **NFC reader** for reading and writing in MIfare cards is the next peripheral, a mandatory part of the equipment at each workplace, through which the necessary data for the Customer's Subscription are recorded in the plastic card itself.

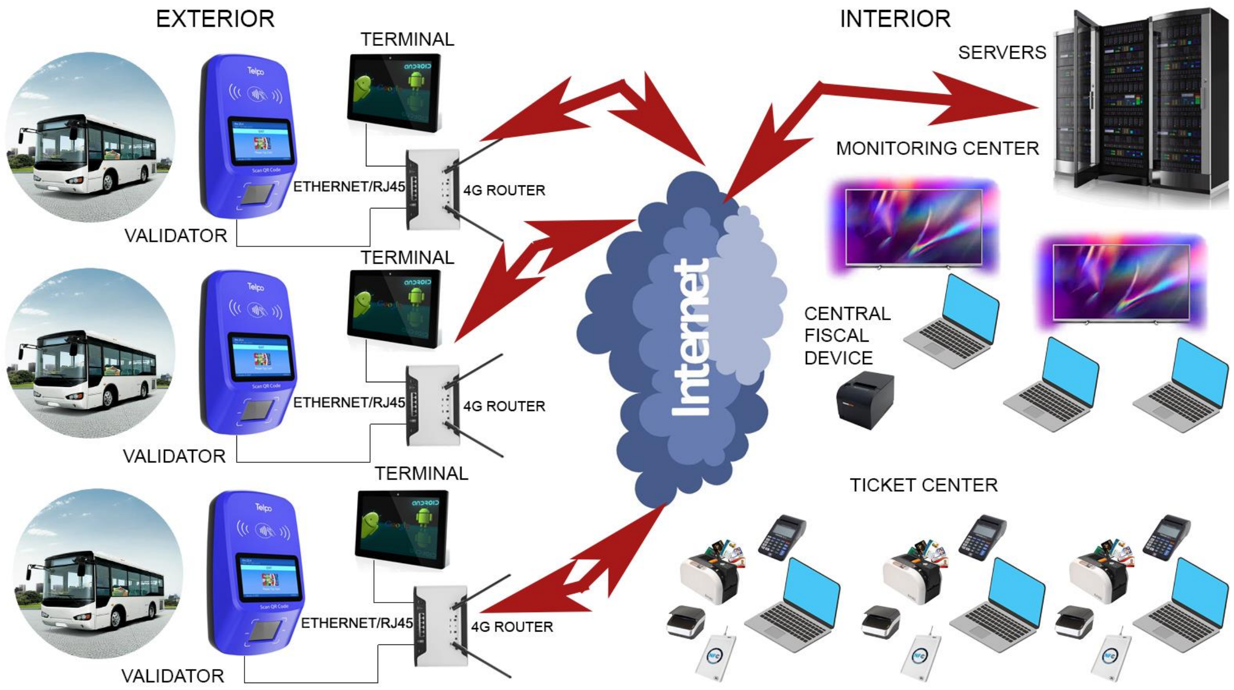

Fig. 1. Block diagram of Interior/Exterior parts of Smart City System

- **Fiscal device** is, last but not least, also a mandatory part of the necessary peripherals for reporting the relevant sales of PD (Subscription Cards and Tickets) made at each workplace.

The monitoring center is the next unit of the **INTERIOR** and it represents the control center of the whole system, in which stops, schedules, routes, devices, vehicles, staff and access privileges are managed through the centralized web-based software.

- **The monitoring center** has N number of workplaces and is equipped with computer systems and additional large screens to facilitate the monitoring of the locations of certain vehicles or video surveillance inside or outside them. Also, a very important part of the monitoring center is the **Central Fiscal Device**, which is a network fiscal printer managed by the centralized software and serves to register sales of e-tickets, purchased through the customer's mobile application.

- The next unit of the **INTERIOR** is the **server equipment**, which includes all servers, server cabinets, routers, UPSs, etc. This equipment contains the entire core of the software and the Database, which is replicated on several separate physical machines.

The **EXTERIOR** (Fig.1), as already mentioned, includes all hardware elements and their control software, which are located outside the Centralized system. This includes all of the devices and systems in each vehicle of the public transport system:

- **Validator -** this is the hardware device with the corresponding software developed for it, which certifies the validity of the PD for each trip. The validators themselves are a combination of an NFC Mifare card reader, a QR code reader, for the validation of paper and / or electronic tickets, an information display, respectively a controlled processor and an Android or Linux operating system.

- **Driver terminal -** this is an Android device / industrial tablet, with a network interface, several USB interfaces and the corresponding software for selecting line numbers, routes, schedules, courses, etc. as well as for registering sales of PD.

The validator and the driver terminal communicate separately via the REST API with the central servers, as well as with each other in the local network in the vehicle itself.

- **Network Router 4G** – this is the connecting unit in the vehicle, which simultaneously builds the internal local network and via this router the Validator and the Driver's Terminal are communicating with each other. Through the 4G mobile network, these devices are also communicating with the Central servers.

Although they are not part of the equipment of the vehicle, the EXTERIOR system components also include the following two hardware elements with the accompanying software:

- **Control terminal** - Android device with the appropriate application for checking the validity of PD of passengers, by scanning the relevant QR codes or reading Mifare plastic cards.
- **Client application** - Android / iOS, this is the relevant software that the users of the service install on their own phones and thus have the opportunity to purchase e-tickets or electronic subscription, respectively. They can validate their PDs to the validators in the vehicle, they can track the history of trips and payments, as well as other add-ons functions related to the use of public transport.

The Control terminal and the Client application, which are not part of the on-board vehicle equipment, but are part of the **EXTERIOR** system components, also communicate through the **REST API** with the central servers.

All protocols for communication between the individual hardware elements and the accompanying software in the **EXTERIOR** part are of the structured data type in JSON format, as the respective objects containing the individual parameters are encoded to plain text and transmitted by standard HTTPS transport protocol. The other side, are decoded again to a JSON object and can be easily extracted the relevant parameters for further processing, calculations, recording, etc.

In the same way, the hardware / software from the **EXTERIOR**, in addition to each other, communicates in the same way with the central servers. Although they are of the same type and are similar in that all data packets are of the JSON format, they are transmitted via the standard HTTPS transport protocol, they can be conditionally divided into 2 main parts according to their purpose, namely:

- **Internal Protocols** for communication between the hardware in the vehicle - this is the communication between the Validator and the Driver terminal, which takes place in the internal network of the vehicle, as the connecting unit is the 4G router in the vehicle.
- **External Protocols** for communication between the hardware in the vehicle and the Central Server - this is the communication that takes place between the Driver Terminal and the Central Server, as well as between the Validator and the Central Server.

Separately, or together with the external communication protocols, the protocols used by the hardware or the software, which the controlling bodies use to carry out periodic inspections of passengers in vehicles from the public transport systems, can be considered. Such are the communication protocols of the client application, which the users of the service have installed on their personal smartphones and through it make trips with the purchase of electronic tickets and / or subscriptions.

Here will be considered first the Internal Protocols for communication, namely the exchange of data between the Validator and the Driver's Terminal in the local network of the vehicle.

1. Automatic driver identification (Login to the system) after scanning your ID card to a validator. Address to the local address of the Driver's Terminal

https://192.168.xxx.xxx:8080

Request:

{"cmd": "driver-identify", "card":"345634563456"}

Response:
Success: {"code":"ok"} / Failure: {"code":"error"}

2. Command to retrieve the current parameters for Line / Route / Schedule / Course on which the respective vehicle is moving. Address to the local address of the Driver's Terminal

https://192.168.xxx.xxx:8080

Request:
{"cmd": "get-current-department"}
Response:{"code":"ok","aid":1,"vid":1,"department_id":"24","department":"T27","route_id":118," schedule_id":2853,"course_id":"2","start_time":"17:30","line_name":null}

3. Notifications to the Driver's Terminal for errors / invalid tickets / cards of the Validator's PD. Address to the local address of the Driver's Terminal https://192.168.xxx.xxx:8080

Request:
{"cmd": "external-notification", "code":"3"}
Response:
Success: {"code":"ok"} / Failure: {"code":"error"}

4. Command for reproduction of voice notification for current stop and visualization of the Driver's terminal at the previous / current / next stop. Access to the local address of the Driver's terminal https://192.168.xxx.xxx:8080

Request:
{"cmd":"play-audio","audio":"085-serviz-svirchev","nextbusstop":"Serviz Svirchev"}
Response:
Success: {"code":"ok"} / Failure: {"code":"error"}

CONCLUSION

The application of smart technologies is increasingly finding its place in the transport and logistics sector, and here in particular we have briefly considered a part of this sector of high public interest, such as Public Urban Transport.

Smart City systems in public transport can be implemented in many different ways depending on the purpose and requirements, as well as depending on the technical preferences of hardware and software engineers in the design itself to meet the relevant requirements. Due to its great functionality and complexity, one such system is composed of many separate elements. Respectively, these components can be hardware and software modules, some of which will be in a static environment, such as the control center, while the others will be located in the vehicles and will be in constant motion. This requires from them to have increased level of security and to be suitable for all sorts of interactions during their operation. Therefore, many different technologies are used in such systems, both software and hardware solutions, which must be carefully selected by design engineers, at the design stage, to ensure high reliability, as well as long life at a later stage and a long period of operation at minimal costs for maintenance. Only under these conditions, the system will be efficient and reliable and will have a high return of the initial investment and therefore a profit.

The benefits of using an automated system for sales/reporting and validation of travel in urban transport are huge. Nowadays, it is no longer a question of whether such system is needed in the public urban transport of both small and large municipalities, but when and how it will be realized.

ACKNOWLEDGMENT

This publication is developed with the support of Project BG05M2OP001-1.001-0004 UNITe, funded under Operational Programme “Science and Education for Smart Growth”, co-funded by the European Union trough the European Structural and Investment Funds.

This publication is developed with the support of the National Scientific Program "Information and Communication Technologies for a Single Digital Market in Science, Education and Security (ICTinSES)", financed by the Ministry of Education and Science of Bulgaria.

REFERENCES

Buehler, R., & Pucher, J. (2017). Trends in walking and cycling safety: Recent evidence from high-income countries, with a focus on the United States and Germany. American Journal of Public Health, 107(2), 281–287

Cairns, S., Behrendt, F., Raffo, D., Beaumont, C., & Kiefer, C. (2017). Electrically assisted bikes: Potential impacts on travel behaviour. Transportation Research Part A: Policy and Practice, 103, 327-342.

Cherry, C., Weinert, J., & Xinmiao, Y. (2009). Comparative environmental impacts of electric bikes in China. Transportation Research Part D: Transport and Environment, 14(5), 281-290.

TRID. (2017). Transport research international documentation. Washington, DC: National Academy of Sciences, Transportation Research Board. and Organisation for Economic Cooperation and Development, International Transport Forum, Paris.

ERTICO (1998a) Intelligent city transport: A guidebook to intelligent transport systems. Brussels. ITS City Pioneers

ERTICO (1998b) Intelligent city transport: ITS toolbox. Brussels. ITS City Pioneers

IHT (Institution of Highway and Transportation) (1997) Transport in the urban environment. Chapter 18 Technology for network management.

Perrett, K.E. & Stevens, A. (1996). Review of the potential benefits of road transport telematics, TRL Report 220. Crowthorne. TRL.