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Research paper

Implementation of Automated Electronic Payment Control System with the Use Of Wireless Technologies for Fare Tariffing in Public Transport

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Abstract

Purpose of the study. Implementation of automated electronic payment control system with the use of wireless technologies while urban transportation.
Methods: The article describes the main characteristic of automated electronic payment control system (AEPCS) and proposes the stages of its implementation at the transport enterprise in order to ensure full control over the transportation process and cost estimates.
Results: The use of the proposed automated payment control system will provide transport companies with control over the rolling stock operation, the number of passengers using this system, and load capacity of routes which enable the most efficient operation of vehicles on the line. The proposed kind of control can be carried out directly through the transport company's database. For passengers, this system is easy to use, because having only a mobile phone or a smart card it is easy to pay for travel and control the amount of travel expenses for a certain period of time. At present, the software is in the final stage of testing and has positive results of the tests conducted.

Keywords: *AEPCS, validation, validator, smart cards, wireless technologies.*

1. Introduction

Urban passenger transport is one of the most important factors that ensure city livelihood and its functioning effectiveness while connecting different parts of the settlement into a single complex organism [4, 5].
The most important criterion for passenger transport efficient operation should be the safety and comfort of passengers, as well as shorter time to commute from one place to another. Thus, the development and modernization of passenger transport are factors that stimulate socio-economic development of the country and strengthen its territorial integrity. Despite the advanced position of national science, the practical issues of organizing passenger transportation, as a rule, lag behind modern requirements. The reasons for this are objective and subjective circumstances. These include the lack of attention in the past to the problems of rolling stock technical re-equipment [1, 3].
The basis of passenger traffic organization in the city is a transport network, which is a collection of routes for various types of transport, charted on the city plan. It satisfies the coordinated connection of all types of urban passenger transportation. According to the polls, in most cases more than 65% of respondents expressed dissatisfaction with the work of public transport, regardless of the questions wording [2, 16].
The rules for passenger transportation organizing by road transport foresee the following basic tasks to be solved [6, 7]:
- complete and forehanded satisfaction in the public transportation;
- providing high culture of service;
- providing safety of transportation;
-efficient use of vehicles, productivity increase and transport costs reduction.

The main problems concerning improving of the system are [8, 15]:
1. The imperfection of the existing route network and rolling stock structure.
2. Reducing the number of routes served by transport in the "ordinary" mode.
3. Inappropriate relationship between different types and kinds of rolling stock serving city bus routes.
4. Lack of dynamics in increasing the number of road transport rolling stock of large and medium capacity for urban passenger transportation in the town of Kremenchug.
5. Insufficient updating of electric vehicle rolling stock.
6. The need to improve tariff policy in the area of passenger transportation.

It is assumed that rational use of the stopping points makes it possible to service efficiently passengers on urban road transport. One of the main problems of present time is their inadequate state, most of which do not meet the main requirements of their arrangement. Not all points have signs with routes of public transport, and those that have, have not been outdated for a long time.
The best solution to this problem will be the use of electronic technologies.
Therefore, passenger road transport in many cases can not effectively fulfill its most important function of providing high-quality service to the population.
The study of the problems of organizing the functioning of passenger transport through the use of new technologies is timely and relevant.

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2. Related Work

In this paper, it is proposed to consider automated electronic payment control system (AEPCS) or "Electronic Travel Ticket" which is a software and hardware complex for fare payment control in public transport. The Electronic Travel Ticket System is based on contactless smart cards used for automated tracking of passenger transport. This information is centrally processed and serves as the basis for actual reciprocal payment with passenger transporting enterprises [9].

The Electronic Travel Ticket System is a modern tool for increasing the profitability of passenger transportation and an effective way to improve the organization of transport services for people.

The advantages of the electronic payment control system are in collecting traffic data, which enable the analysis and optimization of transport operations, taking into account the needs of the city, passengers and passenger traffic flows. This, in turn, will help the company achieve the following:

- make changes to the schedule of vehicle movement;
- make changes in the vehicle routes;
- make changes in types of rolling stock;
- collect incomes, eliminating the influence of "human factor";
- receive full payment for each passenger trip by electronic bus passes;
- provide better services for the transportation of passengers of all categories;
- carry out an operational analysis of their activities.
- receive valid information about the company's work;
- review reliable results of the company's performance;
- control the cost of funds allocated to the company;
- provide better services to people.

Passengers using the "Electronic Travel Ticket" system will receive the opportunity:

- to control their travel costs;
- to save on trips, using more economical "Electronic Travel Ticket" for payment;
- to use the "Electronic Travel Ticket" to pay for travel of several passengers;
- to use more flexible fare system using different traffic rates;
- to choose the carrier, that provides better quality services for transportation at a lower cost.

AEPCS transmits the work of all participants through electronic media and provides, in combination with other electronic systems (global positioning, scheduling systems, security systems), a greater effect, a modern look and a completely different approach to work organization.

It provides the following opportunities:

- formation of interactive database within AEPCS;
- interaction of open protocols with other adjacent systems in order to get more AEPCS efficiency ;
- use of WEB technologies for realization of AEPCS working places. This creates conditions for centralized maintenance of workplaces and does not require the specialized software installation. It's enough to have a standard Internet browser;
- use of the Internet as open networks of data transmission ;
- technological provision of confidentiality of information stored in the database and transmitted on open networks.

The AEPCS functional model is shown in (Fig. 1).

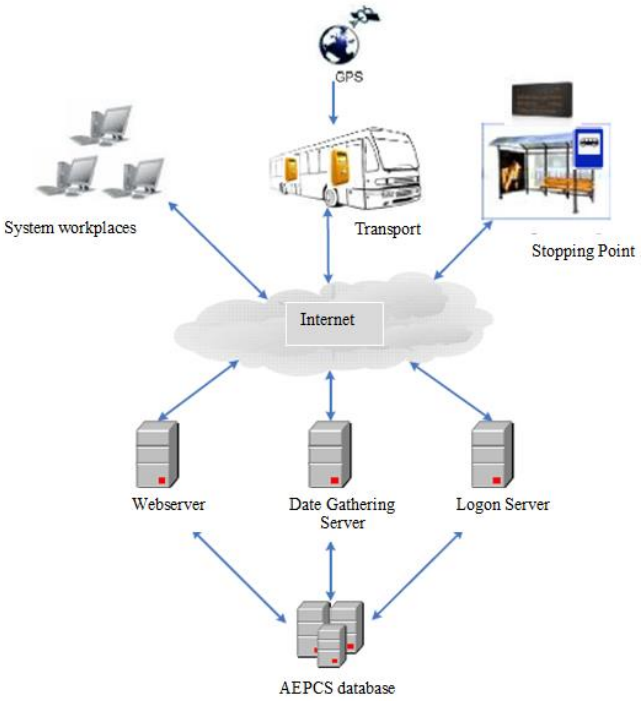


Fig. 1. AEPCS Functional opportunities

Traffic rates and tickets formation is carried out using the following criteria [11, 12]:

- full fare payment;
- social categories fare payment;
- different fare payment on different routes and modes of transport;
- fare payment depending on the day of the week (weekends and working days);
- zonal fare payment;
- different fares for different categories of passengers depending on the privilege;
- preferential registration card without restrictions. Service cards, 100% beneficiary;
- preferential registration card with restrictions on the amount or the number of trips;
- a text-based travel ticket which allows paying for free transfers within N minutes;
- daily and monthly ticket pass (30 days).

Characteristics of traffic rates and tickets are presented in Table 1.

Table 1 - Existing transport traffic rates and tickets within AEPCS

№	Traffic rate	Card	Rate characteristic
1.	Municipal chargeable reduced-fare	Permanent use card (plastic)	The rate that sets the amount of payment which is lower than in an entire municipal. On the basis of the travel document, information is provided to the administration in order to compensate for the real transport expenses.
2.	Entire municipal	Permanent use card (plastic)	The rate where the fare is the same for the same type of transport within the city.
3.	Areal chargeable reduced-fare	Permanent use card (plastic)	This rate determines the fare depending on the area and calculates the fare (at a discount) on the basis of the reduction. Based on the trip fact information is provided to the administration in order to compensate for the real transport expenses.
4.	Areal	Permanent	The rate determines the fare

		use card (plastic)	depending on the area. The tariff may vary for different kinds of transport.
5.	Municipal free ticket	Permanent use card (plastic)	The rate determines free passenger passage according to the benefits list. Based on the fact of the journey, information is provided to the administration in order to compensate for the real transport expenses.
6.	Unlimited monthly student or student buss pass	Permanent use card (plastic) or single use card (cardboard)	The rate is formed on the basis of travel documents and facts of tickets sale and information is provided to the administration in order to compensate for real transport expenses.
7.	General pass with limited trips. (time limit, usually a month or two)	Permanent use card (plastic) or single use card (cardboard)	The rate is formed for making passes by type of transport, if the fare differs. You can make a universal pass for all types of transport, if the fare is the same. Information is provided on the distribution of money between operators.
8.	Unlimited travel ticket with time restriction (week, month, quarter)	Permanent card use (plastic) or single use card (cardboard)	For making tickets, both for certain types of transport, and for all types of transport. Information is provided on the distribution of money between operators.
9.	Hourly rate (Types of tickets: morning / evening, daytime, a number of certain tickets is bought)	Single use card (cardboard)	Special rate, convenient for use in different types of transport, when passenger should get with transfers. One ticket allows you to go on any transport for a certain time. Information is provided on the distribution of money between operators.

One of the priorities is the use of an automated electronic payment control system based on the NFC non-contact mobile module which is wireless communication that allows to exchange data between devices located at a short distance (no more than four centimeters) at high frequency of 13.56 MHz. This technology was developed by Philips and Sony, which began developing a new radio standard called Near Field Communication (NFC) [13]. The NFC module outward is show in Fig. 2.

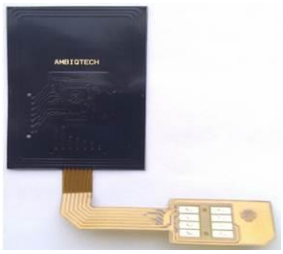


Figure 2 The NFC module sticker

The NFC module is embedded in the phone and requires no SIM-card replacement [13]. Structurally, the module is executed in an elastic body in thickness of several millimeters and size from 2 to 3 centimeters. The antenna is located on the module perimeter, and a flexible loop with a contact pad in SIM card form goes out of the case. The thickness of the body and the contact elements allow you to place the module easily inside the phone directly under the body cover. The SIM card is connected with the module contact pad, which has a multiple glue base, and is placed on the SIM contact pads in the phone. All this is covered with the phone cover.

The module has a microprocessor that provides reliable storage of service applications, cryptographic protection and supports the following main communication channels:

1. NFC for contactless transactions.
2. Information stream from TSM (Trusted Service Manager) through the mobile operator network.
3. Data exchange with the user through the user's interface which is a mobile phone application.
4. Service applications which are program modules (payment, transport, loyalty cards, etc.) are stored in a security element protected by keys from unauthorized access.

The user selects the required number of trips through the mobile phone menu and press "pay". Immediately thereafter, the module sends a request to TSM for a ticket purchase, a cash withdrawal takes place, and an electronic ticket is sent back to the module for updating the information in the transport application.

TSM is hardware and software complex, which implements functions of service application management, users of services, software module management and encryption keys, etc. The module data and TSM exchange is implemented through a mobile phone and traditional SMS communication channels. From the standpoint of the phone, the module operation is the SIM card service activity.

Today, NFC technology is increasingly being implemented combined with mobile phones equipped with NFC modules. These include the phones of well-known manufacturers like Samsung, Benq, Nokia, LG, HTC. They allow access to a list of new digital services, such as:

- ticket registration which means interactive means of payment in public transport systems;
- electronic payments as an alternative to cash and plastic credit cards for purchasing goods and paying for services.

These technologies are currently widely used in such countries as the USA, Japan, some European countries like Germany, Great Britain, Italy, France, Spain and Russia.

Numerous tests of services based on NFC mobile technology are being carried out and, in general, they have already shown that this technology in the field of public transport operates successfully.

Mobile NFC services have already been implemented commercially in a number of countries, such as Japan, South Korea, France, Turkey and South Korea, where more than 10 million NFC-enabled phones based on SIM-cards have been sold.

The use of SIM cards with NFC technology in the future will enable the client to access the cellular network, travel documents and, in fact, all "profiles" of bank cards, service documents can be downloaded to a SIM card. It is also planned in the future to provide the opportunity for subscribers to conduct transactions using the new technology. Mobile operators and their partners should strive to ensure that any legitimate transport operator can use NFC applications and UICC cards to provide the consumer with mobile NFC services.

UICC is a universal card with an integrated circuit, known as a SIM-card, acting as a protected element for confidential data storage.

A passenger will have access to mobile NFC services by opening a special transport application on his phone, which will then interact with the corresponding UICC mini-application [10].

The widespread use of NFC mobile modules with the use of UICC cards will provide authentication, security and portability for a multitude of different phones (Fig. 3).

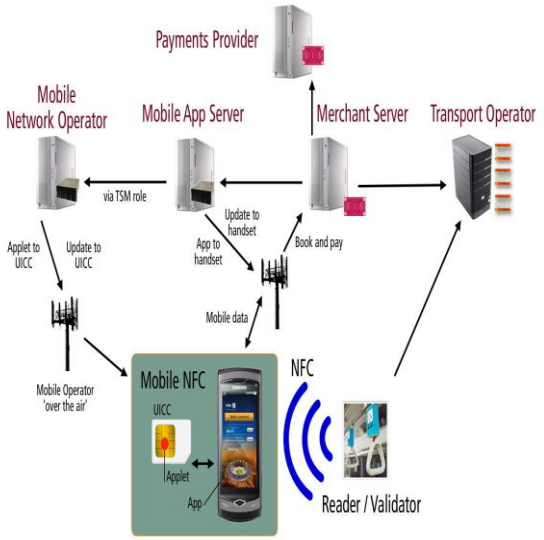
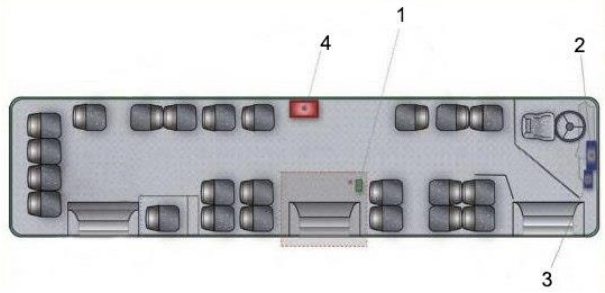


Fig. 3 Using NFC mobile module with UICC card

This technology implementation consists of several stages:
The first stage is purchase and installation of on-board equipment on the rolling stock for testing operation on the route.
Placement of on-board equipment on a bus (fig. 4).
On-board computer runs all the devices and reveals interaction interface with a driver[13].



1- equipment for counting entering/leaving passengers; 2- information module; 3- global positioning equipment (GPS); 4- validators;

Fig.4 Placement of on-board equipment on a bus

Onboard computer manages all devices and provides interface for interaction with a driver.
Validator is an electronic or mechanical-electronic device intended for displaying and checking information of documents concerning travel tickets on public transport, passes recorded on contactless or contact electronic media for operational control of the lawfulness of passage transfer into the bus. It is often combined with a turnstile.
GPS equipment is designed to determine the vehicle coordinates and transmit data with on-board devices (validator, autoinformer).
Information module is a device that with the help of GPS data informs the passenger due to sound and light indicator panel about the situation on the route. GPS equipment and autoinformer can be part of on-board computer or be a separate standalone device.
The equipment for counting entering/leaving passengers is installed at the entrance doors of vehicles and it records the number of passengers who entered and left the rolling stock and it notifies on-board computer.
The payment for traveling by bus will be able to be confirmed by passengers' tickets (or payment cards) just by attaching the phone to a contactless reader, providing faster transfer and more reliable validation than paper and magnetic tickets (Figure 4).



Fig.4 Direct payment process

The main advantages of such payment are quickness and convenience, because there is no need to pay cash, which slows down passengers entering the bus and delay of vehicles at stops. As a result of implementation of the electronic payment, transportation company can reduce conductors' wages costs, since the driver can control the entire process of transportation.
In case a passenger does not pay fare, the motion sensor operates and sends a signal from the validator to the driver's onboard computer who in his turn takes appropriate measures. In case of mobile phone absence, you can use a contactless smart card, which can be purchased in special sales points.
For social categories, pensioners there are special smart cards that do not need to be replenished, and the state must compensate the fare for these categories of passengers.
If there are not enough funds on the account to pay for travel, it can be replenished in three ways:
- fund withdrawal from a mobile account;
- fund withdrawal of from the subscriber's bank account (using the installed phone program);
- replenishment through the terminal.
The second stage is to organize tickets' sale and validation through the existing distribution channels, so that passengers can purchase contactless smart cards and special SIM-cards for mobile devices, for contactless payment through non-contact terminals.

3. Conclusion

Using NFC an electronic trip record is created both for a passenger and a transport service provider. This record allows a passenger to review the amount of time spent on travel, to check the number and time of trips and, if it is necessary, to confirm to the employer or other people when they were using public transport. To ensure the convenience of transportation in case of tracking route overload, it is possible to warn passengers when the route is overloaded, for example, sending text messages to passengers who regularly use this route. In these warnings a discount can be offered to passengers. The discount can be realized automatically when they bring their phone to the NFC terminal when leaving the bus. Passengers who use the NFC mobile can easily review, change, and reimburse the cost of tickets or bonus points stored on their phones.
Having analyzed the work of non-contact payment system in public transport of the town of Kremenchug, it should be said that with implementation of this system, transport enterprises will be able to control rolling stock operation, the number of passengers using this system, the load capacity of routes, which will allow provide the most efficient work of vehicles on the line. This control can be carried out directly through transport company database directly. For passengers, this system is easy to use, because having only a mobile phone or a smart card it is easy to pay for travel and control the amount of travel expenses for a certain period of time. At present, the software is in the final stage of testing and has positive results of the tests conducted.

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