

passenger rail transport; Near Field Communication technology

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APPLICATION OF NFC TECHNOLOGY IN PASSENGER RAIL TRANSPORT

Summary. The article discusses the possibility of the application of the NFC technology as a system of selling tickets in passenger rail transport. The NFC (Near Field Communication) technology is a wireless and contactless technology of transmission of radio data over short distances (max. 5 cm). This technology is very similar to the RFID (Radio Frequency Identification) technology. It is assumed that this technology will spread rapidly and that already in 2015 around 85% of the payments in the EU will be made via mobile phones. This paper presents a research of passenger interest in this method of payment for tickets in the passenger rail transport in Slovakia. Further, an analysis of the applications of the NFC technology as a system of selling tickets in passenger rail transport, including the protection of data in mobile phones, the processes in case of losing a mobile phone and ensuring the communication between both parties was presented in the article. The last part of this analysis shows the possibility of purchasing tickets regardless of the carrier and the transport type.

WYKORZYSTANIE TECHNOLOGII NFC W PASAŻERSKIM TRANSPORCIE KOLEJOWYM

Streszczenie. W artykule opisano możliwe zastosowania technologii NFC jako systemu sprzedaży biletów w pasażerskim transporcie kolejowym. Technologia NFC (Near Field Communication) jest bezprzewodową i bezdotykową metodą transmisji danych na krótkie odległości (max. 5 cm). Jest ona bardzo podobna do technologii RFID (Radio Frequency Identification). Zakłada się, że będzie się ona szybko rozwijała i już w 2015 roku 85% płatności dokonywanych na terenie Unii Europejskiej nastąpi za pośrednictwem telefonów mobilnych. W artykule przedstawiono badania oceniające zainteresowanie pasażerów tą metodą zakupu biletów kolejowych na Słowacji. Przedstawiono w nim także planowane zastosowania technologii NFC jako systemu sprzedaży biletów w pasażerskim transporcie kolejowym, z uwzględnieniem ochrony danych w telefonach komórkowych, czynności w przypadku utraty telefonu komórkowego i zapewnieniem komunikacji pomiędzy elementami systemu. Przeanalizowano w nim także możliwość zakupu biletów niezależnie od przewoźnika oraz rodzaju transportu.

1. INTRODUCTION

The source of the progress of any society is an idea and its subsequent implementation in practice. The first impulse is always a possible new demand. People's needs are constantly increasing, and so are quality requirements. Currently, payment cards have become a modern means of payment. It is a comfortable and safe tool for noncash bank transfers of financial resources. A payment card allows its holder to pay for goods in shops, restaurants, hotels, petrol stations or on the internet. Passenger rail transport is one possibility to widen the range of the use of payment cards [1-8]. In passenger rail transport cash payments and noncash payments are currently used only when purchasing tickets over the internet, and payment cards are used when purchasing tickets at the ticket office.

Table No. 1 shows the development of a number of payment cards. The source of the presented data is the Slovak Banking Association. These statistics provide relevant data about the number of payment cards issued in the Slovak Republic as well as the volume of transactions made with payment cards [16].

Table 1

Development of the number and volume of card transactions in Slovakia

Together	Number of prepaid cards	Value of transactions by prepaid cards (in EUR)	Number of debit cards	Value of transactions - by debit cards (in EUR)	Number of credit cards	Value of transactions by credit cards (in EUR)	Number of contactless cards	Value of transactions by contactless cards (in EUR)
31.12.2008	-	-	3 913 009	3 208 859 621	1 321 382	197 467 398	-	-
31.12.2009	-	-	3 998 137	3 273 197 274	1 062 065	177 557 824	-	-
31.12.2010	-	-	4 176 196	3 648 132 517	795 777	176 247 505	-	-
31.12.2011	9 648	593 645	4 520 612	3 977 112 088	818 132	191 444 893	392 387	-
31.12.2012	51 587	601 000	3 929 979	4 232 266 519	604 992	199 587 443	1 207 052	15 646 327
31.12.2013	50 309	659 915	4 115 198	4 450 199 795	620 776	223 522 290	2 150 984	100 932 358
31.12.2014	70 175	13 704 482	4 313 089	4 892 084 535	654 281	247 927 042	3 216 030	229 471 014

Source: <http://www.sbaonline.sk/sk/bankovy-sektor/statistika>

The given table demonstrates an increase in the number of payment cards as well as the volume of transactions made by payment cards. For comparison, the volume of transactions made in 2013 compared to 2008 increased by 145%. The number of payment cards issued increased by 158%.

2. INTEREST OF PASSENGERS IN NONCASH PAYMENTS

At present, only 5% of customers of the Slovak railway company Železničná spoločnosť Slovensko, a. s. (hereinafter ZSSK), purchase tickets via internet banking. In contrast, in the case of the private carrier RegioJet, it is 75% of customers. It is possible to assume that this is due to the fact that the private carrier does not have such a large number of ticket offices as the national carrier. Table No. 2 shows the number of ticket offices of the passenger rail carriers [14].

Table 2

Number of ticket offices of the passenger rail carriers

Carrier	Number of ticket offices	
	Number of ticket offices at railway stations	Number of franchising ticket offices
ZSSK	280	0
RegioJet	10	14
LeoExpress	0	30

The data in Table No. 2 show that the number of ticket offices of the given carriers in the rail passenger transport is diametrically opposed. ZSSK offers its customers the purchase of tickets in 280 occupied railway stations across Slovakia, of which 32 stations are equipped with electronic devices for noncash payments (called KVC—complex service for passengers). That means that the customers of the national carrier are used to paying for the purchase of tickets in cash. Customers of private carriers are forced, given the low number of ticket offices, to buy tickets via internet banking [11] [12].

In 2014 a research into the interest of passengers in noncash purchase of tickets directly on the train by a payment card was carried out. In the research, 1260 respondents were polled, out of which 1020 respondents who were using rail transport were considered as relevant. The assumption was that customers would welcome such a service, which was also confirmed. The research showed that 82% of respondents would welcome such a service. The rest of the respondents were not interested in the introduction of such a service or would not welcome such a service. It means that the introduction of such a service has the potential to improve the quality of travelling. As a demonstration, an analysis of the costs associated with the introduction of such a service was carried out within the research. After evaluating several options, the authors of the research agreed to use a company that has been on the market for more than 40 years and has a subsidiary in Slovakia to calculate the costs. Due to the necessary flexibility of conductor costs of mobile terminals, they had to be included when calculating the costs. Table No. 3 shows the costs involved in the introduction of this service in the ZSSK company. Given that it is impossible to determine what proportion of the receipts the purchase by payment cards on the train represent, the possibilities of turnover were calculated in percentage [9-10].

Table 3

Calculation of costs after the introduction of services "Noncash purchase of a ticket on the train"

Percentage of made transactions	Amount for calculating commission in €	1,30% provision in €	Fixed charges rental of POS + General Packet Radio Service fee in €	Overall costs of using POS in €
50	1122122000	14587586	360000	14947586
60	134654400	1750507,2	360000	2110507,2
70	157096800	2042258,4	360000	2402258,4
80	179539200	2334009,6	360000	2694009,6
90	201981600	2625760,8	360000	2985760,8
100	224424000	2917512	360000	3277512

These costs are around 2 694 000 € for the company ZSSK at the option of 82% (as many respondents said they would be interested in buying the ticket by a payment card on the train).

3. NFC—NEAR FIELD COMMUNICATION

Another option for improving the transport for customers was the possibility of using the NFC (Near Field Communication) technology [11].

The NFC technology is a wireless and contactless technology of transmission of radio data over short distances (max. 5 cm), enabling an easy and secure either-way communication. This technology is very similar to the RFID (Radio Frequency Identification) technology.

The use of this technology in practice would mean a significant change in the quality of passenger transport. It is possible to integrate payment or loyalty cards, IDs and driving licenses, electronic keys or travel documents into the NFC technology. The use of the NFC technology has many advantages, which result from noncash payments, and the new advantages include:

- in case of the card expiry date, it is not necessary to visit a bank institute to get a new card,
- the NFC technology can also replace physical or virtual keys (car, home, log into the PC),
- the NFC technology facilitates communication between all devices, which are currently widely used [11, 15].

In order to use the passive NFC technology, it is not necessary to own a mobile phone supporting this technology; it is enough to have the passive NFC chip (a so-called sticker) powered by the electromagnetic field of a payment terminal. Stickers take the form of a sticker. In order to actively use the NFC technology, it is necessary to own a mobile phone, especially a smart phone that is equipped with an NFC chip. The most important brands of mobile phones supporting the NFC as of 13th April 2015 include these phone brands:

- Samsung 28 mobile devices
- Sony 16 mobile devices
- Apple 14 mobile devices
- Nokia 13 mobile devices
- further brands include LG, Xiaomi, Huawei, etc.

Technical data and parameters of the NFC:

- the NFC technology has a reserved bandwidth and operates at a frequency of 13.56 MHz
- the data transfer rate is 106 212 or 424 kbps
- the intended speed is 1 Mbps
- the NFC technology uses radio waves for transfer
- the transmission is Half-Duplex
- the NFC connects two modes—active and passive
- it uses its own Open Source protocol NFC [15]

The NFC technology has a wide range of applications, especially in mobile phones. In this case via this technology the user can buy tickets or exchange contacts with other devices supporting this technology. The figure below shows the use of the NFC technology, which is currently used in developed countries in Europe and the world. However, these options are not final because the NFC can be applied to all areas of daily life.

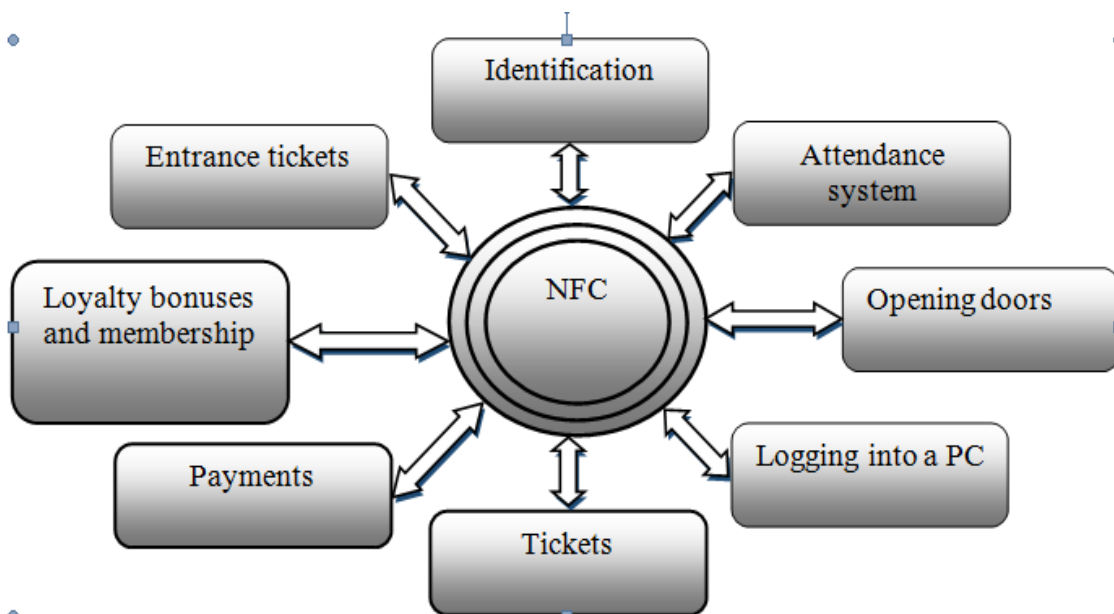


Fig. 1. Areas of use of the NFC technology
Rys. 1. Obszary zastosowań technologii NFC

The research has further observed the possibilities of using the NFC technology for:

- loyalty bonuses and membership;
- payments;
- tickets.

3.1. The NFC technology in the rail passenger transport

In 2015 a survey of the interest and knowledge of rail passengers about the NFC technology was conducted. A repeated survey of the interest of passengers in the noncash payment when buying a ticket and what form of payment suits the passenger was also a part of the research. The research involved 504 respondents who were contacted either directly or through the website on which a questionnaire was published.

The respondents rated the options of ticket purchasing with grades 1 to 4 where 1 means "suits the best" and 4 means "suits the least". Of course, it was assumed that mainly pensioners and respondents with lower education will prioritize cash payment for the ticket. Table No. 4 presents the evaluation of questionnaires about the use of payment systems.

Table 4

Preferred payment system of passengers divided by age

Age of respondents	0-26	27-52	53-78	79 -
Cash payment	1598	1896	1235	1
Noncash payment with authorization	2171	2085	2824	3
Noncash payment without authorization	2016	1915	2529	35
Internet banking	2168	2451	3176	4

The surprising finding was that all age categories of respondents preferred mostly cash payments when purchasing a ticket. The assumption that people aged over 79 years are not interested in internet banking was confirmed, which is logical since they have no knowledge or experience with this form of payment.

In the research the division of respondents according to education was also examined. The assumption was that passengers with a university degree would prefer cashless payments prior to cash payments, while on the contrary passengers with lower education would prefer cash payments. Table No. 5 shows the results of the research.

Table 5

Preferred payments of passengers divided by education

Education of respondents	Higher education	Secondary education	Vocational training	Primary education
Cash payments	1729	1658	1645	1455
Noncash payments with authorization	2	2288	2419	2364
Noncash payments without authorization	1978	1986	2097	2364
Internet banking	2044	2495	2613	2591

The research has proven that regardless of the education level the respondents prefer cash payments. In the case of higher and secondary education, respondents prefer contactless payment cards out of noncash transactions.

Table 6

Preferred payments of passengers divided by economic activity

Economic activity	Student	Employed	Unemployed	Self-employed	Retired
Cash payment	1594	1865	1043	225	1
Noncash payments with authorization	2177	2085	2435	1833	3
Noncash payments without authorization	1996	189	2348	2167	38
Internet banking	2138	2445	2478	1917	34

Cash payments are again, in all groups of respondents, except for self-employed people, the most accepted. The assumption that pensioners and the unemployed will prefer cash payments was confirmed. It was assumed, however, that students and employed respondents are more likely to prefer cashless payments. Out of noncash payments, cashless payments without authorization, that is, payment with contactless cards, are the most accepted by respondents.

That means that the citizens of Slovakia still prefer cash over noncash payments. It also depends on the area where the respondents are located as the noncash payment system is rather common in larger towns.

3.2. Knowledge of passengers about the NFC technology

The research has surveyed the knowledge of passengers about the NFC technology. The assumption was that the passengers will not have knowledge about this technology. It is a new platform through which payments can be made. The research results confirmed the low awareness of the respondents about the NFC technology. Almost 60% of respondents said they do not know about this technology. Interestingly, respondents with a primary education knew the most about the NFC technology (63.64%). Subsequently, the respondent was informed about the NFC technology. After explaining what the NFC technology means, the respondents were asked whether they would use this technology when buying a ticket. Most respondents answered positively (37.09%), 25% of respondents said "do not know", and 35.91% said "certainly not". Respondents who answered "no" explained that their reasons was concern over their mobile phone being stolen and worries over not being able to use the phone because of a discharged battery.

4. THE NFC APPLICATION IN THE RAIL PASSENGER TRANSPORT

In passenger rail transport, there are many possibilities of serving passengers. The goal of the research was to project a payment system that is simple and uncomplicated and uses a known technology that would speed up and simplify the service of passengers. In order to carry out and implement the draft of the payment system, it is necessary to establish cooperation with existing payments and thus incorporate current iKVC (innovative KVC—complex service for passengers) in the case of the national carrier with the payment systems of private carriers and bank institutions and with each other.

For the use of the NFC technology, an NFC chip is required. Any contactless card sticker or other object with a built-in chip can be used as a chip carrier in the case of passive connection to a terminal or a mobile phone in case of an active connection. In order for this complex worked as a payment system, it is necessary to determine how the payment will be made. There are two options—it is either only the overhead of the carrier itself or it is an integration of the whole process with bank institutions.

4.1. NFC as a payment and loyalty card

One option is to implement the payment module into a mobile application with a device that actively supports the NFC technology and at the same time integrating with bank institutions of the customer so the payment for the ticket would be made directly from the customer's personal account. The customer in this case would use his mobile phone as a payment and loyalty card. The process of buying a ticket is shown in Fig. No. 2.

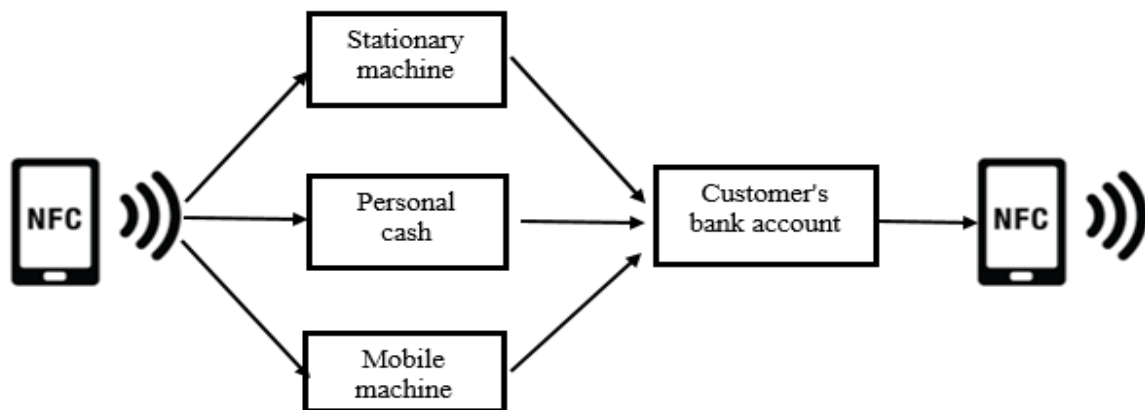


Fig. 2. Scheme of the payment via the NFC technology

Rys. 2. Schemat płatności przy użyciu technologii NFC

This system increases the quality of passenger service since the only essential activity of the customer when purchasing the ticket is to verbally order a ticket and put the mobile phone to the terminal. The rest would be done by a sophisticated payment and identification system. The technology starts with the verbal ordering of a ticket at the ticket office where the customer informs the staff that he will pay with a mobile phone and the staff will only enter the initial and destination station into the cash register. After putting the NFC device within the range of the terminal, the process shown in Fig. No. 3 would be performed. Within a few seconds the system would:

- 1) identify the customer;
- 2) calculate the price of the ticket;
- 3) call upon the customer's bank to pay for the ticket;
- 4) generate and send the ticket to the passenger's mobile phone.

In this system the entire technology of the system of the service of the customer is to put the mobile phone to the NFC terminal. In order for the ticket to have the smallest possible size, it is necessary that the invoice information is sent separately by e-mail to the passenger. The ticket would contain only the information necessary for identifying the passenger and the services he paid for.

In this option the majority of incurred costs are the overhead of the passenger himself who will purchase a mobile phone that supports the NFC technology. Another device necessary for communication is the NFC terminal, for example:

- DUALI DE-620;
- DUALI DRAGON;
- ACR122U.

This option of noncash payment, however, is costly in terms of the work of an IT employee who will program the application required for the operation. It is important that the system is stable and not overly demanding on the hard drive and RAM resources of the mobile device. Conciseness and a graphically suitable user environment are also necessary. Synergetic effects that need to be considered are shown in Fig. No. 3.

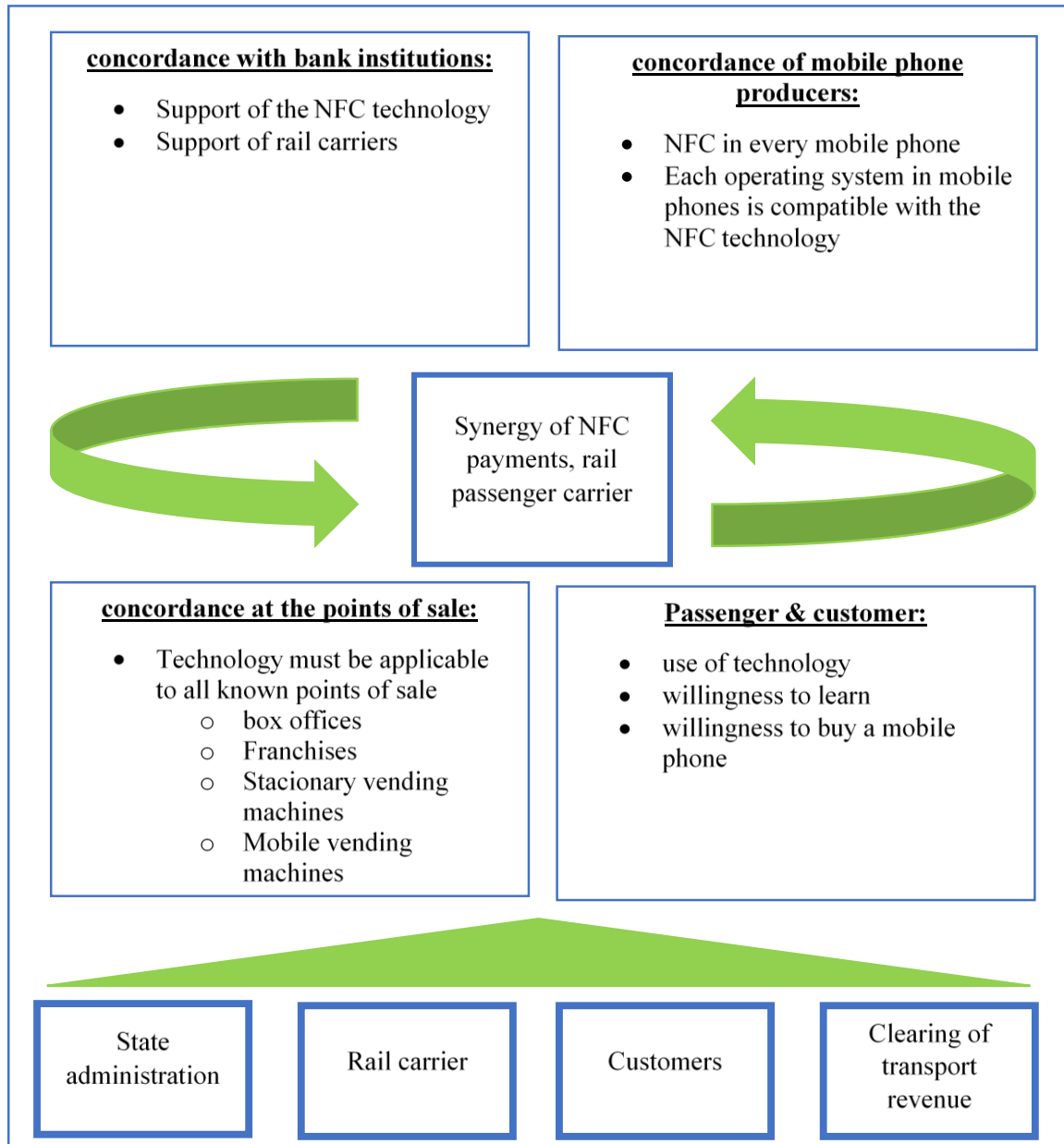


Fig. 3. Synergy of NFC in the rail passenger transport
Rys. 3. Synergia NFC w pasażerskim transporcie kolejowym

The whole chain of successive transactions between individual fractions will work only if conditions for the functioning of the service are clearly determined. Especially, there must be a synergetic effect between bank institutions and the carrier in order to ensure a smooth transfer of financial resources in favour of the carrier.

4.2. Draft of the stationary vending machine

For maximum efficiency of the new payment method, it is effective to service the passengers through a stationary vending machine where the passenger would manage to purchase a ticket in several procedures. Such vending machines would be reasonable in bigger railway stations located on the main lines. Stationary vending machines would fulfil the function of a universal vending machine, which means that customers of any carrier could use them. In the initial phase of the introduction of the technology in the vending machines, it would be possible to buy a ticket in domestic passenger transport. The home screen would welcome the passenger and offer one of the following options:

- find transport line;
- attach the NFC device.

In the first option the vending machine would have the function of an information panel where passengers could find information about the price and transport lines departing from the station. In the second option the passengers would actively attach the NFC device to the stationary vending machine, which would automatically identify the passenger and offer him the list of transport lines that are available in the near future. Such a menu should have the form of a table with the list of transport lines and their identification, especially information about the carrier's time of departure, the price for the ticket and possibly information about the service such as train delay and closure of traffic. Setting the language would be possible by a pictogram of the national flag.

The whole service process would include four steps. The passenger would mark each step by touching a touch screen. Resistive touch screens are more suitable for these systems because of a better touch transfer. The final step would be a repeated active attachment of the NFC device to the terminal. Firstly, a payment would be made and then the ticket would be sent to the mobile device—all within 15 seconds. The ticket would have the form of a QR code and would be in one of the supported data formats (e.g. jpeg, pdf, png).

In the case of this option, it is necessary to determine the number of stationary vending machines and their locations. It would be suitable to place the vending machines at stations that are equipped with iKVC, i.e. the 32 major railway stations in Slovakia. The terminal must be equipped with the following components:

- device for the acceptance of payment cards;
- device for the acceptance of banknotes and coins;
- touch screen;
- RFID reader.

On the market there are many producers who offer payment kiosks for their customers, for example, PAYMEN4U.eu. This company has a long tradition and offers its customers a complete service before, during and after the implementation of the payment system. The company for PAYMENT4U.eu offers a self-service payment solution with acceptance of cards and cash. The system can issue coins and banknotes and is marked P4U/CH3D and costs 15 298317 €. However, this vending machine does not have an RFID reading device worth almost € 300.

Table 7

Price for the purchase of stationary vending machines

Price of 1 vending machine P4U/CH3D [EUR]	Price of the RFID reader [EUR]	Total price of 1 vending machine [EUR]	Price of 32 vending machines [EUR]
15 298317	298681	15596998	499103936

If 32 stations were equipped with stationary vending machines, the total price of the stationary machines would be € 499103.94. It is necessary to mention that the price is not final because it is only for the hardware. For a proper operation it is necessary to supplement the system by a software and its price would be known only after programming it. Sample locations and a detailed view are shown in Fig. No. 4.



Fig. 4. Stationary vending machines (source: <http://www.payment4u.eu/>)

Rys. 4. Stacjonarny automat sprzedazowy (source: <http://www.payment4u.eu/>)

5. CONCLUSION

Most experts agree that NFC is the smart technology of the future and that phone-based applications will become increasingly important. NFC applications can integrate several independent services and hold the promise of freeing single operators from the need to set up a cost-intensive infrastructure of check-in/check-out devices. Instead, the users—with their mobile phones or with their contactless bank cards—provide a large portion of the necessary infrastructure. Modern contactless (be-in/be-out) technologies in public transport, for example, do not even require the passenger to actively register at the ticket gate. Instead, a tag at each station or in each vehicle automatically detects and registers new passengers when they enter during the trip and at the end to automatically calculate the most favourable fare. Therefore, different payment options should remain available.

At present and in the medium term, smart cards offer an attractive medium to connect payment options in public transport with additional services; however, they require operators for larger investments in access control infrastructures. In either case, a change in the ticketing environment must be accompanied by a communication strategy explaining the change in detail and emphasizing its benefits for all actors that are involved in the process.

The article discusses the possibilities of applying the NFC technology in rail passenger transport. It is necessary to say that unless there is a third person in the role of a coordinator, it is possible to use the drafts only for individual carriers. This fact, however, would decrease the advantages of the NFC system and its applications in the passenger rail transport. The integration of all rail carriers is necessary in favour of the passenger.

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