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ON DEVELOPMENT OF BACK-OFFICE SYSTEM FOR BUS TRANSPORT COMPANIES

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ABSTRACT: A back-office system in small to medium sized bus transport companies can simply be divided into two subsystems - office/business and sales subsystem. While the office subsystem takes care of the standard (legislative) rules allowing simple creation of all transport related documents, the sales subsystem can include support for different sales channels (office sales, agencies, bus/mobile sales, web shop). Our article describes a case study and implementation of model of such a back-office system in a mid-sized Croatian bus transport company. Most of the important features covered in our system are outlined and explained.

KEYWORDS: bus, road transport, back-office, ICT, sales

INTRODUCTION

Back in 2007, one Croatian mid-sized bus transport company (15-20 buses) gave us a request for implementation of certain changes in our software tool for road transport worksheets and travel orders. Since that moment, during four years of cooperation we managed to develop a few important subsystems, brought them all to production stage and finally covered all of the most important back-office system parts. In this article we present a model of back-office system and compare it to this case study.

Since the case study was something we worked on for a long time (and, more importantly, developed on-demand, sharing ideas and fulfilling customer requirements arising constantly), it is reasonable that it differs in small details to proposed model – one should look at this model as a result of our studies and consider it a starting point for future development. Even though implemented subsystems collaborate flawlessly and without any scalability problems, changes and reimplementations in certain parts are to be expected due to some technology changes that occurred lately. Also, lowered costs of telecommunication services make it more affordable to add new synchronization features to existing applications.

This paper will focus on proposing a model of back-office system for bus transport companies (PM – Proposed Model), analyzing and describing important subsystems, making notes about practical implementation and comparing it to our case study model (CSM – Case Study Model). First, overview of customer (company owner) requests will be given. Proposed near-optimal model shall be described with analysis of possible functional block. Next, current case study system will be discussed, with details about some implementation steps and problems that arose during development and production phase. Future work ideas will be stated, including both implementation of new features and modifications of existing functionalities due to some technology changes that could not have been foreseen during initial development steps. Finally, the article concludes with short remarks about the subject and implemented system.

CUSTOMER REQUESTS AND PROPOSED MODEL

Based on years of experience, we may be able to give some list of objective customer requests, where the customer is an owner or back-office staff of bus transport company or any other company which deals with transferring people. It is not necessarily limited and may be expanded from case to case. List of possible requests is given in table 1.

Of course, customers may prioritize requests listed in the table, exclude or add some requests etc. Most requests shall be related – e.g. passenger and luggage tickets must be archived in relation to certain worksheet, driver or personnel, tickets purchased using different sales channels must interact in order to get details about available number of seats, driver activities should be related to working hours and payment calculations.

Table 1 - Possible customer requests

Subject	Details
Drivers and personnel	worksheets, driving and travel orders, status, payments, routes, activities
Vehicles	worksheets, routes, insurance, registration and service register, fuel consumption, location tracking
Transportation/transfer	regular line, free/contract transport
Customers/passengers	international travel register, tickets, favorites and other CRM (customer relationship management) features
Ticketing	passenger and luggage, available tickets - directions, routes
Agents/partners	agencies register, sales contracts, tickets
Sales	register, multiple channels - office, agents, bus/mobile, web
Other	taxi support, AETR agreement forms, tachographs

The most important item of the back-office system (BOS) is driving worksheet (WS). Each and every bus transfer activity has to be documented and that is being done by creating new WS. All other data collected in the system (except transfer independent registers, such as insurance or service register) will be, at some point, related to WS. For example, drivers working on certain WS will get their driving orders, tickets sold for regular line transfer will be connected to their WS etc.

Based on requests, BOS can be divided into two main subsystems - office/business subsystem (OBS) and sales subsystem (SSS). It will, of course, include standard database server system (DBS) which will take care of archiving data used by both subsystems and network system (NS) which will allow interconnection of system elements using different telecommunication technologies with common IP network layer. SSS should include all sales and ticketing (+customer) related functionalities with function blocks directly related to different sales channels (office sales - offS, agency sales - agnS, mobile sales - mobS, online web sales - webS), while OBS includes all other functionalities - due to its complexity it will be divided into interconnected function blocks - worksheet and orders block (WO), transportation block (TB), sales support block (SB), tachograph related block (TAHO) and vehicle tracking block (GPS). Such a proposed model (PM) of BOS is depicted in figure 1. The most important features that should be implemented in function blocks that the BOS consists of are listed in table 2.

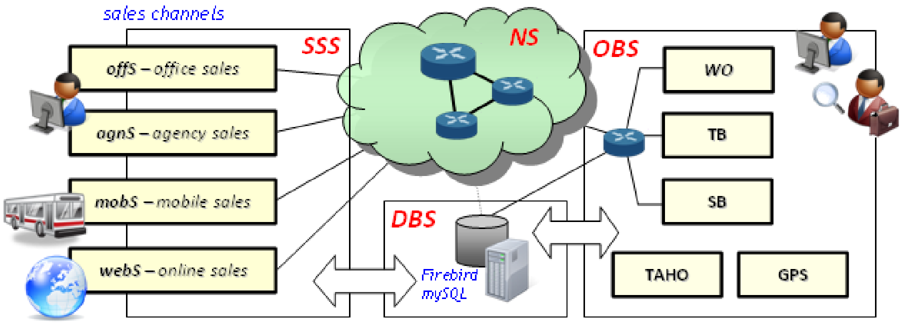


Figure 1 - Schematic overview of proposed model

Table 2 - Function block features

Block	Description - Features
DBS	reliable relational database server collecting and archiving all data used in BOS - should be partially replicated to host online sales or other public sales channels not connected to company intranet
NS	network system allowing interconnection using different telecommunication technologies - usually IP based with different access technologies (ADSL, fiber, GPRS or UMTS/HSDPA for mobile access) + Bluetooth for mobile devices interconnection
SSS	sales subsystem responsible for providing sales capabilities through different sales channels
SSS - offS	office sales block - allows ticket sales and printout in office
SSS - agnS	agency sales block - allows ticket sales and printout in contracted agencies
SSS - mobS	mobile sales block - allow ticket sales in the busses - driver or conductors can sale and print tickets for their passengers using mobile devices different implementation (concurrent) possible depending on devices used
SSS - webS	web sales block - allows ticket sales online, supporting regular credit or debit card payment methods
SSS - CRM	customer relation management block - directly related to ticket sales, should be used to analyze passenger satisfaction, inform customers about new offers...
OBS - WO	main functional block of BOS - WS register, drivers and vehicles, legislative, reporting
OBS - TB	transportation block handling data about transport modes and other partial independent registers - vehicle insurance, registration and service, fuel consumption etc.
OBS - SB	sales support block used to define tickets, agency and agent permissions
OBS - TAHO	driver activity and tachograph data collecting and analysis
OBS - GPS	GPS block handling of vehicle location data

The proposed model is, of course, open for any improvement, modification and expansion - its structure allows interaction between functional blocks and subsystems. Functional blocks can be implemented as standalone desktop, mobile or web applications or can be developed as part or module of existing, more complex applications.

CASE STUDY

As stated previously, development and implementation of BOS started back in 2007. During this time, the system diverged from a simple desktop application for WS registration to a complex system of interconnected modules including a few desktop intranet solutions, mobile applications with synchronization mechanisms, and online ticketing and web sales applications. The mixture of development technologies and platforms doesn't decrease system functionalities or its scalability and stability. The schematic model of implemented BOS is given in figure 2 - captions of main parts of CSM are named after their real-world correspondent applications.

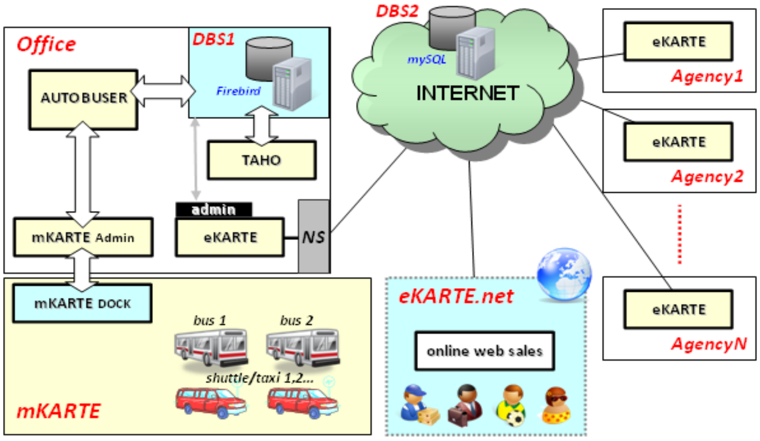


Figure 2 - Schematic overview of implemented case study model

All depicted modules have been implemented and operative for at least two or more years. Module eKARTE.net, used for online ticket sales, is grayed and dotted since it is the newest module which is still being tested, but its production phase should begin prior to summer of 2012.

Since one of the goals was, in addition to the main goal of achieving complete functional implementation of all given customer requests, to provide a system which will not include any additional costs to the company, there were a few things that were part of the original idea, but were not implemented. The most important of them is the absence of real-time network connection between busses and company headquarters. That means that CSM, in comparison to PM, does not use network subsystem to connect mKARTE module to the BOS, but instead it uses offline synchronization as described later in the corresponding section. As shown in figure 3, the connection to office system is established through mKARTE docking point.

This chapter will continue with sections, each containing description of main modules being part of CSM - sales modules shall be described with more details, while other system parts are only described in short.

AUTOBUSER - worksheet subsystem application

First of all developed modules, AUTOBUSER, is used for handling most of the OBS functions (excluding TAHO and GPS function blocks). It includes driver and vehicle register, worksheet creation and handling and all functions contained in WO, TB and SB blocks introduced in figure 1.

Even though it takes care of lots of data, its user interface helps operators to find required data and work fluently and quickly, providing all kinds of required reports and document printouts still used in office due to some legislative rules.

This application was developed using Embarcadero Delphi and it is a native Win32 desktop application that can be used on all Windows operating system releases (Windows XP, Windows Vista, Windows 7). It uses reliable open-source Firebird database system. Intranet multi-user office environment is supported allowing unlimited modules to work simultaneously in local area network.

Over time, the application was improved and upgraded to provide additional support for other system blocks - it is now directly connected with mobile (in the bus or other vehicles e.g. taxi) ticketing subsystem mKARTE and shares data with other sales subsystems.

eKARTE - office and agency ticket sales and reservation system

Bus transport companies usually offer their regular line transfers not only directly but also through a network of their regional sales representatives and contracted agencies. Prior to implementation of our BOS, tickets were preprinted and distributed to agencies - until all preprinted tickets were used (in order to justify higher costs of ticket production) there was a need for a simple software tool able to track single tickets and blocks of tickets being distributed. Independent desktop application called DisCARD was developed and used for more than a year in order to accomplish simple and effective distribution and sales (ticket usage) tracking.

However, in order to increase system flexibility and decrease overall ticketing costs (preprint, new regular line introduction without additional costs, distribution costs to remote agencies), a decision was made to create agency ticket sales module from scratch. It was called eKARTE, and it was intended to provide a simple solution for dynamic ticketing and reservation. Due to request for creating tickets with coupons, it was decided that the core of this system would be a Windows based desktop application implementing ticket printout using standard POS printer devices with partial cutting abilities. An unlimited number of agencies can use the systems, with only one requirement - being connected to Internet. Complete agency and agent based access control subsystem was *implemented allowing simple administration and usage tracking. The same application was used in all agencies as well as in company office headquarters - access control levels differ from agent to agent, allowing company operators to have higher rights and manage all the administration from any computer connected to the system with user interface adapted to their rights.*

Schematic overview of possible eKARTE system configuration is given in figure 3. Depicted configuration shows three agencies with different number of agents working on eKARTE system and with different network access technologies used to connect to the Internet and the eKARTE database system. Agencies and agents can connect using wired access technologies such as ADSL or any other (xDSL) digital subscriber line technologies or using fiber optics. Agents can also choose to use wireless access through mobile networks (GPRS, UMTS, HSDPA) or access points for WiFi or WiMAX networks. All available access technologies can be used in NS at office headquarters premises. The system includes following core functionalities:

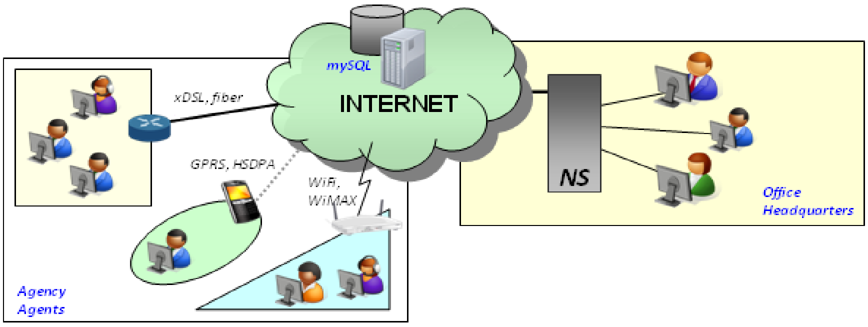


Figure 3 - Possible eKARTE system configuration

□ *user and company access control*

□ *regular line administration, including line merging (connecting lines - multiple ticketing)*

□ *ticket administration - different ticket types (standard, children, students etc.), two-direction (return) tickets, prices, local and international tickets (advanced tax calculation)*

□ *reservation administration - seat reservation - ticket based and independent*

□ *seat management - default bus settings + multiple busses with different seat limits, status reports*

□ *sales management - reporting, tax calculations*

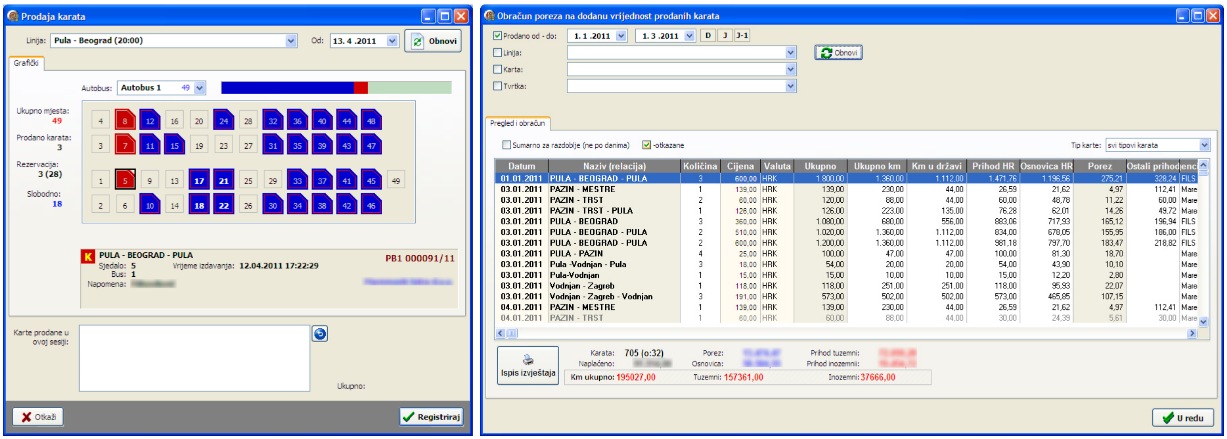
□ *administration - agencies, agents, places and bus stops, cancellations, notes, automatic updates.*

eKARTE can function independently from AUTOBUSER and other BOS function blocks. In our implementation, it is not even connected to Firebird based part of DBS, but uses Internet hosted mySQL database server for data processing and archiving. The reason why databases used in our BOS implementation are not using the same server type is mainly because of higher availability of public hosting servers with mySQL installed, while hosting of Firebird servers requires dedicated hosting services which increases overall system costs. Namely, one of the goals of practical implementation was to decrease additional costs as much as possible, while maintaining high level of system functionality, compatibility and security. Simple manual replication of ticket related data allowed us to prepare eKARTE system to work with the same set of tickets in a matter of minutes.

eKARTE was developed using Embarcadero Delphi with underlying datalink layer allowing connection to both mySQL and Firebird databases with little or no source modifications. As already stated previously, it uses standard low-cost POS printers to create ticket printouts - only additional requirement set for POS printers is to have built-in partial cutter allowing simpler ticket coupons management. Of course, agencies can use their existing POS printers without cutters, even though that is not recommended (it may look unprofessional, rather than cause any functionality issues). Database connections are two-tier based, allowing each agency/client direct connection to database server - this is possible due to small network traffic and usage of disconnected access mode - data is fetched in bursts on-demand, with the connection being inactive the rest of the time, therefore not influencing other clients. Additionally, multi-tier architecture may be implemented if the number of clients rises rapidly, impacting scalability. Another alternative would be deploying self-administered dedicated or virtual database hosting server.

Figure 4 shows examples of user interface used in eKARTE application. The left image shows the ticket sales form - the user selects line and date of transfer and gets a visual overview of available seats in the bus. After selecting a free seat, the requested ticket is selected, payment processed and the customer gets their ticket printout. The image on the right of the figure shows sales and tax calculations for a certain period.

Once more, our goal of decreasing additional costs leads us to use publicly available low-cost solutions. Being risky, it did not show any lack of scalability, functionality or security in a few years of usage. Standard backup and server maintenance procedures have shown a satisfactory level of reliability and availability, with as little as less than few hours of service disruption per year. In total, the transport company achieved huge benefits with total sales surpassing development and maintenance costs with ratio >100, being increased with each new ticket sale. With that in mind, it is reasonable to invest in more professional equipment and dedicated servers



Prodaja karata

Linija: Pula - Beograd (20:00) Od: 13. 4 .2011 Obnovi

Grafički

Autobus: Autobus 1 49

Ukupno mjesta: 49

Prodano karata: 3

Rezervacija: 3 (28)

Slobodno: 18

K PULA - BEOGRAD - PULA PB1 000091/11

Sjedalo: 5 Vrijeme izdavanja: 12.04.2011 17:22:29

Bus: 1

Napomena: [redacted] [redacted]

Karte prodane u ovoj sesiji:

Ukupno:

Obračun poreza na dodanu vrijednost prodanih karata

☑ Prodano od - do: 1.1 .2011 1.3 .2011 D J J-1

☐ Linija:

☐ Karta:

☐ Tvrtka:

Pregled i obračun

☐ Sumarno za razdoblje (ne po danima) ☑ -otkazane Tip karte: svi tipovi karata

Datum	Naziv (relacija)	Količina	Cijena	Valuta	Ukupno	Ukupno km	Km u državi	Prihod HR	Osnovica HR	Porez	Ostali prihod	enc
01.01.2011	PULA - BEOGRAD - PULA	3	600,00	HRK	1.800,00	1.360,00	1.112,00	1.471,76	1.196,56	275,21	328,24	FILS
03.01.2011	PAZIN - MESTRE	1	139,00	HRK	139,00	230,00	44,00	26,59	21,62	4,97	112,41	Mare
03.01.2011	PAZIN - TRST	2	60,00	HRK	120,00	88,00	44,00	60,00	48,78	11,22	60,00	Mare
03.01.2011	PAZIN - TRST - PULA	1	126,00	HRK	126,00	223,00	135,00	76,28	62,01	14,26	49,72	Mare
03.01.2011	PULA - BEOGRAD	3	360,00	HRK	1.080,00	680,00	556,00	883,06	717,93	165,12	196,94	FILS
03.01.2011	PULA - BEOGRAD - PULA	2	510,00	HRK	1.020,00	1.360,00	1.112,00	834,00	678,05	155,95	186,00	FILS
03.01.2011	PULA - BEOGRAD - PULA	2	600,00	HRK	1.200,00	1.360,00	1.112,00	981,18	797,70	183,47	218,82	FILS
03.01.2011	PULA - PAZIN	4	25,00	HRK	100,00	47,00	47,00	100,00	81,30	18,70		Mare
03.01.2011	Pula -Vodnjan - Pula	3	18,00	HRK	54,00	20,00	20,00	54,00	43,90	10,10		Mare
03.01.2011	Pula-Vodnjan	1	15,00	HRK	15,00	10,00	10,00	15,00	12,20	2,80		Mare
03.01.2011	Vodnjan - Zagreb	1	118,00	HRK	118,00	251,00	251,00	118,00	95,93	22,07		Mare
03.01.2011	Vodnjan - Zagreb - Vodnjan	3	191,00	HRK	573,00	502,00	502,00	573,00	465,85	107,15		Mare
04.01.2011	PAZIN - MESTRE	1	139,00	HRK	139,00	230,00	44,00	26,59	21,62	4,97	112,41	Mare
04.01.2011	PAZIN - TRST	1	60,00	HRK	60,00	88,00	44,00	30,00	24,39	5,61	30,00	Mare

Karata: 705 (o:32) Porez: [redacted] Prihod tuzemni: [redacted]

Naplaćeno: [redacted] Osnovica: [redacted] Prihod inozemnii: [redacted]

Km ukupno: 195027,00 Tuzemni: 157361,00 Inozemni: 37666,00

Figure 4 - eKARTE GUI samples

mKARTE - mobile ticket sales system

Even though most of the tickets are being sold using office and agency sales channel (using eKARTE), there is often a need to sell tickets directly on site - in the bus or other vehicles like taxi. Mechanical solutions used for years have one big disadvantage - all tickets sold have to be manually counted and registered in the system in order to fulfil legislative requirements (for each line transfer related WS, a list of tickets has to be created). OBS module AUTOBUSER implements all the functionalities to enter that kind of data manually, but due to an enormous number of tickets, it was decided to abandon that kind of tracking and develop a digital mobile solution.

Result of development is mKARTE sales system. It consists of two parts - mobile application for Windows Mobile based devices and desktop application used for synchronization and administration of devices. As described previously in chapter introduction, mobile devices function independently of other system parts, in so called offline mode. All the ticket and WS related data are fetched from AUTOBUSER database - before going on road, drivers get their devices prepared and connected with their WS. When they come back to the office, devices are synchronized and all sales information is instantly being transferred to the database. Latest release of mKARTE system includes taxi vehicles support - allowing creation of custom receipts for any kind of service. Figure 5 shows mobile devices (both mobile terminal and mobile Bluetooth printer) used and depicts a few touch oriented GUI samples on the terminal.

Any Windows Mobile based device can be used for mKARTE mobile application execution (enterprise handheld Hewlett-Packard IPAQ 214 was selected as the most reliable low-cost device on market). Most available mobile POS printers with Bluetooth communication support can be used - in our case, we decided to use, again, the lowest cost solution on our market from Citizen - printers CMP-10 and CMP-20.

Administration and synchronization module, mKARTEAdmin is a Windows desktop application with just two functions - put the WS data from database to terminal and get the ticket sales data from terminal updating the database. Both modules were developed using open-source development kit Lazarus, which allows native development for ARM processors and Windows Mobile platform.

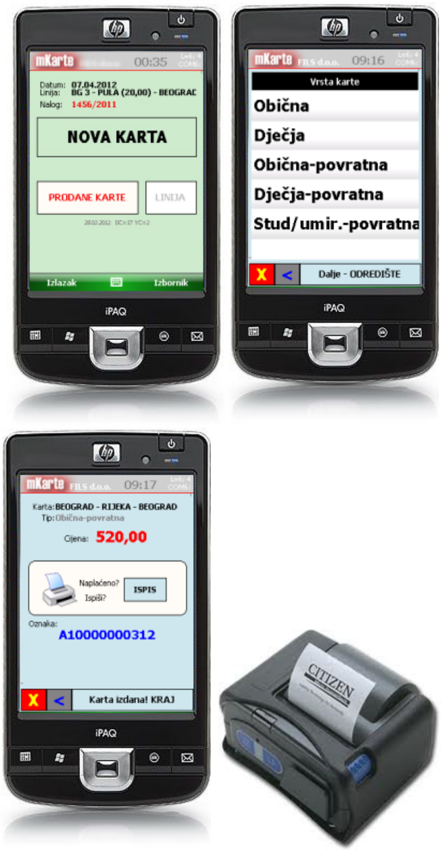


Figure 5 - Mobile devices and mKARTE GUI samples

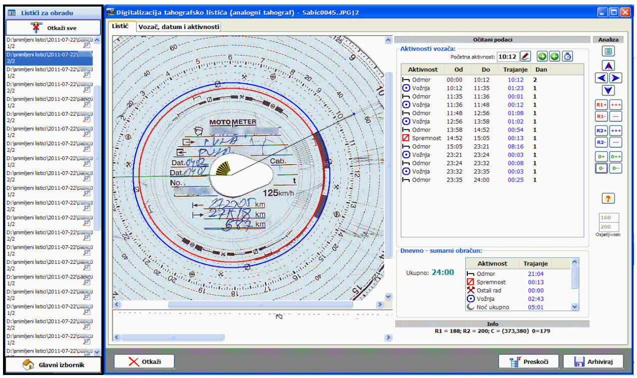
Lately, one of the largest problems in development of the mKARTE system is the necessity for platform and technology changes. Microsoft Corporation decided, a few months after the first mKARTE devices were introduced to our partners and used in vehicles, to abandon further development of Windows Mobile operating system and, even worse, to cancel support and binary compatibility on new Windows Phone operating systems. That left us with no choice but to consider technology changes in future development phases. Currently, Android based handhelds (phones) and tablets are being considered, as well as Windows Phone smartphone devices. The transition to a new platform will most probably occur during 2012.

TAHO – tachograph and driver activity tracking module

Independent module for tracking driver activities was implemented in CSM. Main reasons of its implementation were new legislative rules adopted from EU legislative during the process of Croatian accession to EU. Most vehicles used in public road and cargo transport must be equipped with devices that record driver activities – so called tachographs. All new vehicles have built-in digital tachographs, while older vehicles used analogue tachographs.

Implemented TAHO module includes support for both analogue and digital tachographs, activity analysis, reporting and many other features required by valid regulations. Describing this quite complex module would require a whole new article and therefore only sample user interface screenshot will be given and explained – figure 6.

Figure 6 depicts user interface for processing and digitalization of tachocharts – scanned tachocharts are imported and automatically analyzed – driver activities are read and extracted directly from scanned image. Many algorithms were implemented in order to complete these tasks – image analysis and tachochart positioning, linearization, declination angle detection etc. All the archived activities from analogue and digital tachographs can be easily read and interpreted using different visualization forms – daily or custom-period activity reports are implemented, calendar view is used for simple and effective registered activities overview, AETR attestation forms are integrated in the database, advanced data analysis can be performed on-demand in order to calculate and collect important data etc.



Aktivnosti vozača:

Početna aktivnost: 10:12

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Vožnja	10:12	11:35	01:23	1
Odmor	11:35	11:36	00:01	1
Vožnja	11:36	11:48	00:12	1
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Vožnja	12:56	13:58	01:02	1
Odmor	13:58	14:52	00:54	1
Spremnost	14:52	15:05	00:13	1
Odmor	15:05	23:21	08:16	1
Vožnja	23:21	23:24	00:03	1
Odmor	23:24	23:32	00:08	1
Vožnja	23:32	23:35	00:03	1
Odmor	23:35	24:00	00:25	1

Dnevno - sumarni obračun:

Ukupno: 24:00

Aktivnost	Trajanje
Odmor	21:04
Spremnost	00:13
Ostali rad	00:00
Vožnja	02:43
Noć ukupno	05:01

Info

R1 = 188; R2 = 200; C = (373,380) 0=179

Figure 6 – TAHO module user interface – tachochart digitalization

FUTURE WORK

It is clear that there are many differences between proposed PM and implemented CSM. It is unlikely to expect reimplementation of the whole system in the near future, since all of the requirements are implemented and used on a daily basis by our partner company without any problems. Satisfied customers may increase their expectations with time by including new requests that should be implemented.

Also, CSM may be improved with features like: new mobile platform for mKARTE module – Android or Windows Phone, online real-time synchronization of mKARTE sales and other sales subsystems, more complex seat management in eKARTE sales and reservation module etc.

Currently, eKARTE.net module is being developed and tested – it is a web based ticket sales application with integrated seat selection and credit and debit card payment processing, synchronized with existing eKARTE module.

CONCLUSIONS

A case study and an implementation of a back-office system for a mid-sized Croatian bus transport company were presented in this paper. The implemented model differs from the proposed theoretical model, mainly because lack of a systematic approach when the development started – the implemented model was developed part-by-part through years, without any clear specifications for future development. Satisfied customers increased their expectations with time leading to the development of an entire back-office system instead of the initially developed driving worksheet register application.

From this point of view, there are many ideas that would bring the currently developed system closer to the proposed model, but their realization is questionable due to the fact that all required functions have been implemented and used every day for years without any problems or service disruptions.

It can be concluded that the developed software system fulfilled all the requirements and that it improved and optimized the customer's business and efficiency.

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