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Table of contents

Artur Hłobaż, Piotr Siekierski ANALYSIS OF CLOUD STORAGE SERVICES TO SYNCHRONIZE DATA WITH MOBILE DEVICES USED IN ENTERPRISE	3
Gustaw Konopacki OPTIMIZATION POTENTIAL TRANSPORT OF TRANSPORT COMPANY	14
Rafał Lipniewicz TAX ADMINISTRATION AND RISK MANAGEMENT IN THE DIGITAL AGE	26
Joanna Mączyńska, Anna M. Klepacka LOGISTICS SOLUTIONS FOR E-COMMERCE: THE CASE OF THE INPOST SA CAPITAL GROUP	38
Daniel Możdżyński THE CONCEPTIONS OF NEW PAYMENT METHODS BASED ON REVISED PAYMENT SERVICES DIRECTIVE (PSD2)	50
Tomasz Rokicki IT MARKET IN POLAND	61
Krzysztof Stępień, Aneta Poniszewska-Marańda MANAGEMENT AND CONTROL OF SMART CAR WITH THE USE OF MOBILE APPLICATIONS	70

ANALYSIS OF CLOUD STORAGE SERVICES TO SYNCHRONIZE DATA WITH MOBILE DEVICES USED IN ENTERPRISE

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In the paper analysis of available, free Cloud Storage services for company/enterprise applications is presented. The choice of the most appropriate cloud service will be associated with such features as its compatibility in relation to the terms of use, data security, performance and stability. Performed analysis focuses on solutions which the license does not prohibit the use of their free version of the service for commercial purposes, in the company. An important factor, partly influencing for the choice, will also be intuitiveness, additional functionality and ease of use offered by client applications.

Keywords: Cloud storage, Cloud services, Private cloud, Public Cloud, OwnCloud, Cloud security, Cloud services for Enterprise

1. Introduction

Nowadays, a modern model of data storage in companies and institutions increasingly become cloud storage services [1,2]. This type of services is characterized by buying disk space area from hosting companies for the purposes specified by the customer. In this way, the person/company does not have to worry about the entire data infrastructure, required hardware, but only indicates to the service provider requirements for the needed performance and disk space. Therefore, the responsibility for safekeeping and maintenance of data falls on the supplier.

Besides the above functionality cloud storage services can also be used for easy and optimal data sharing between employees in the company, along with

granting the appropriate access levels. This kind of solution, with possible access from both desktops and mobile devices, doesn't only allow for remote work among employees, but also allow them to work together on documents.

In the paper the analysis of available, free Cloud Storage services with the possibility of using them commercially by companies or enterprises is presented. Nowadays, more and more companies plan to "create" its own private cloud, than use one of public clouds [1,3]. To select the most appropriate service there will be taken into account such features as its compatibility for the intended use, data security, performance and stability. Performed analysis focuses on solutions which the license does not prohibit the use of their free version of the service for commercial purposes, in the company. An important factor, which partly influences for the choice, will also be intuitiveness, additional functionality and ease of use offered by client applications to access by the web browser.

2. What is Cloud Storage?

The concept of cloud storage assumes the use of cloud computing to share IT resources via the Internet. Provider of such a service delivers required resources for the customer, so the customer does not have to bear the investment costs in advance. Additionally the customer does not have to worry about costly and complex infrastructure and the necessary staff to support it. Cloud computing services can be used to run virtual operating systems, data storage (data backup), as well as complex and demanding computational techniques.

2.1. Types of Cloud Storage Services

The concept of cloud storage model (Fig. 1) assumes services that enable the storage, management and remote access to user data over a network (typically by the Internet). We can distinguish three types of cloud storage services [4] (Tab. 1):

- **private cloud storage** is a system designed with access for only one person or organization according to the indicated requirements. This type of cloud storage services can occur in two variants: running locally by the administrator of the corporate network or by outside hosting. Both solutions are good, but from a business perspective, the solution running locally is better/secure, because you have full control over stored data [1, 4]. Administrator of the service that is running in the company can control and design system in terms of what the company/organization expects. Mostly private cloud solution is not available outside of the company's internal network.
- **public cloud storage** allows for management of data to a lesser extent than private cloud and allows access to data through the Internet network [1, 4].

Access to data is restricted to authorized users or those users who have a special address (usually web link). Examples of public cloud services are popular sites such as Dropbox or Google Drive.

- **hybrid cloud** is a combination of a private and public cloud storage. It allows to customize the functions and capabilities of the current demand and gives full control of the stored data administration. The most important data can be protected in a specially designated private space, while less important data can be stored in the public cloud and accessed by multiple users at a distance through the network [1, 4].

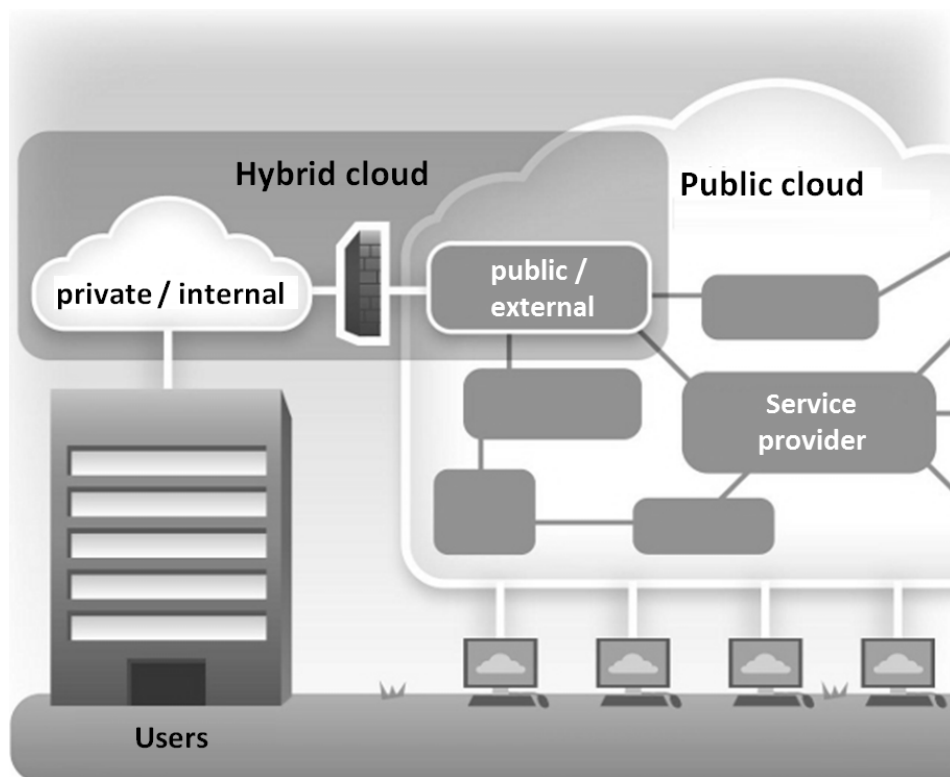


Figure 1. Diagram of the types of Cloud Storage services

2.2. Application of cloud storage services

Cloud storage service can be used for storing important (for the recipient) data. Thanks to this application in the case of sudden failure of customer hardware, there is no fear of losing valuable information [2]. The ability to store data on external servers also allows to quickly share files and documents with your col-

leagues or even work on them simultaneously. Cloud storage services mostly have their own client software to data synchronization so user do not have to worry about sending data to the cloud [1]. Such a solution allows data to be up to date both locally and on an external server.

The main advantage of cloud storage services is the ability of effective and simultaneous work on user or group of users documents. This work can be carried out at the same time from different devices, eg. notebook, tablet, smartphone, without need of manual copy files between two devices. Access to the data is possible from anywhere in the world, you need only access to the Internet, which in the era of mobile broadband (3G / 4G) is not a major problem [3].

Table 1. Comparison of the types of cloud storage services

Characteristic	Public cloud	Private cloud	Hybrid cloud
scalability	high	limited	high
security	good, depending on the security offered by the service provider	well protected, all data available only within the network	very high, integrated options allow to turn on additional layers of security
performance	average	very good	good, depends on the performance of the server on which the service was launched
reliability	average, depending on Internet connection and the availability of the service on the service provider side	high, limited to the performance of the internal network	average, depends on the possibility of use of cache memory for frequently used data and the availability of an Internet connection
cost	low, because user usually pay only for extra space for data or increase of data transfer	average, because it requires additional expenses related to hardware and costs of electricity	average, because it allows to transfer part of data to an external hosting

2.3. For whom are cloud storage services designed?

Thanks to the versatile features of cloud storage, it can be used by both the home user as well as large corporations. For the typical user the use of cloud storage often ends up on using the service to store backups that are important from the data point of view, eg. holiday photos or documents. The available services often easily allow to define appropriate access to selected data for other users. About this access decides the owner of the data [1, 5].

The use of cloud storage services is not necessarily limited to storing copies of important data. Services administrator in corporation can define a number of features for user accounts, such as available space (quota), access to a common pool of data, the ability to simultaneous work on documents/files.

3. Data security

One of the most important factors of entrusting our data to the service provider is security of this data. The customer should be assured that the data he sent are secure and there is no possibility of access to them by unauthorized persons. Therefore, when choosing the right service provider for yourself, the most important thing is to check if he is unable to access the data entrusted to him [7]. Sending a strategically important data or reports by the company, and access to them by unauthorized persons may have serious consequences for the institution.

3.1. Methods of data transmission protection

There are two possibilities for secure data transfer [6]. The first possibility is to trust methods of data encryption used by the service provider. Then the obligation of completeness and correctness of the data security is on the service provider side. Most of commercially available encryption services uses standards such as AES, RSA or protocols like SSL. These security features allow to encrypt data in the way that they are unreadable to potential people who have obtained access to them.

Another way to protect data files during transmission is to encrypt them on the client side before sending to the cloud. In this way, the client can be sure that his data will not be read by unauthorized persons. Data can be read only with special key, defined by the user. For example, user can use to do it TrueCrypt container. The disadvantage of this solution is the need to synchronize the entire data container which size can reach several GB. An alternative way is to use special software to encrypt individual files during synchronization and decrypt in situation when the user wants to use them. An example of such software is Sophos SafeGuard. Unfortunately, the use of that application is associated with the purchase of software licenses.

3.2. Data storage on the service provider servers and its security

When choosing the proper cloud storage services, user should be sure that his data are not analyzed in any way, or indexed by the service provider. The collected information on the stored files and their contents could be used to leakage of strategic data and be used by unauthorized persons. Therefore, important factor when choosing appropriate services for customers is to obtain information about that if the supplier is able to get access to our data or/and if the files are stored in encrypted form inaccessible to anyone other than their owner. It is known that different priority have videos stored in the service by an ordinary user who is using cloud storage as an additional storage for backup, and other strategic financial data, and development plans of the company. The second type of data leakage can cause a lot of damage to the enterprise, and even lead to its downfall [7].

4. Analysis of cloud storage services for company applications

The following analysis was commissioned thesis by the Ericpol company based on scientific cooperation with the University of Lodz. Ericpol is a Polish company operating in the IT industry. Headquarter of the company is located in Lodz but it also has offices in Krakow, Warsaw, Gniezno and abroad - in Sweden (Linköping), Ukraine (Lviv) and Belarus (Brest). Ericpol in Łódź employs more than 2,000 people. The company provides services in the areas of:

- telecommunications - services for the design, maintenance and testing of software for the hardware and software manufacturers from around the world,
- M2M (Machine to Machine) - engineering services, mainly in the design and testing of "embedded systems" software class for the largest manufacturers of automotive, eg. Peugeot and Citroen,
- medical market - including specialist programming package "Dr. Eric" for managing beauty salons and medical clinics,
- ERP sector applications and Business Intelligence - solutions for effective business management, used in industry, trade and production management,
- banking and finance - solutions to support Enterprise Management, sales support and debt collection,

The analysis will be used by Ericpol to start the cloud storage service in the internal environment of the company, among employees. Ericpol needs a solution to synchronizing and sharing data/documents between employees. The company depends primarily on the security of stored data, the stability of the service, and easy access to files using both desktops and mobile devices. Mobile devices are mainly controlled by Android and iOS systems. Because the company is working on customer data, these data can not be stored in the public cloud - it determines the poli-

cy of the company. From the Ericpol point of view the best solution is to create its own private cloud and have control over it. For some data in the cloud access can be only from inside the company (from internal network), and to the less critical data access may be remote. User authentication has to be based on two solutions: Radius and LDAP.

At the beginning the private cloud would be implemented only at the headquarter in Lodz. If the solution will work properly, it would be also implemented in other company locations. Some generally defined requirements let to apply different solutions depending on the location/country like eg. type of service server (Linux/Windows) or client software for workstations (Windows, Linux, MacOS).

4.1. Detailed requirements for service

The selected service should fulfill the following features:

- to store data in the company,
- multi-platform services server,
- multi-platform client software for workstations under Windows, Linux, MacOS,
- multi-platform client software for mobile devices controlled by Android, iOS, Windows Phone,
- granularity of security,
- the ability to enforce quotas for users,
- encryption of transmitted data,
- ability to remotely clean content of user account by the administrator,
- document sharing for certain groups of people,
- the ability of simultaneous work on a document,
- friendly client application for user,
- two-component authentication,
- authentication using a RADIUS, LDAP,
- application integration with other programs on mobile devices (web browsers, file managers),
- stability,
- way of data synchronization - sending only the changed files.

4.2. Overview of available cloud storage services

In choosing the most appropriate service, in accordance to the requirements provided by the company, following cloud storage services are analyzed:

- BitTorrent Sync (version 2.3.1) [8],
- Box (version 4.0) [9],
- Copy (version 1.4) [10],

- DropBox (version 3) [11],
- ElephantDrive (version 2.9) [12],
- Google Drive (version – beginning of 2016)[13],
- Mediafire (version 1.8.12) [14],
- MEGA (version 2.8) [15],
- OpenDrive (version 1.4) [16],
- OwnCloud (version 8.2) [17],
- OwnDrive (version 7.0) [18],
- SkyDrive/OneDrive (version 17.3) [19],
- SpiderOak (version 6.1)[20],
- Storino (version 0.9) [21],
- Wuala (version – Wuala Nadelhorn) [22].

The feature of all these services is that their license does not limit the use of the free version for commercial purposes. This eliminates the need of buying a license, if the available options are sufficient for the service user.

4.3. The choice of cloud storage service

After the comparative analysis of available, free cloud storage services, the best solution for company purposes would be an ownCloud service [5] (Fig. 2). The choice of the specified service supports a high level of security of the stored data, the same as most of competing solutions. Data can be encrypted both during storage on server disk and during transmission over the Internet. A strong argument is the fact that, unlike to other free solutions available on the market, selected service allows users to store data within the organization (OnPremise). In this way, control and physical protection of the data lies on the service administrators within the company [23].

The distinguishing feature of ownCloud from the rest services is corporate functionality in the free version. Support for LDAP solutions and integration with Active Directory makes it easier to control user accounts of cloud storage service. OwnCloud easily allows administrator to manage user data, granting privileges for users and groups of users. In addition, it also allows to use the built-in virus scanner to automatically protect the stored data against to computer viruses.

OwnCloud with support for most popular operating systems allows for seamlessly use of this service. Thanks to the open architecture and a shared API, there is a large number of applications for account managing except the official, provided by the authors. The openness of the code gives the possibility of adding custom functionality (if necessary). The advantage of the chosen solution is also its dynamic development and community support creating additional functionality [17].

Supplier	BitTorrent Sync	Box	Copy	DropBox	Elephant Drive	Google Drive	Mediafire	MEGA	OpenDrive	OwnCloud	OwnDrive	SkyDrive/OneDrive	SpiderOak	Storino	Wuala
Supported stationary platforms	Windows Linux Mac	YES NO YES	YES YES YES	YES YES YES	YES YES YES	YES NO YES	YES NO NO	YES NO YES	YES NO YES	YES YES YES	YES YES YES	YES NO YES	YES YES YES	YES YES YES	YES YES YES
Supported mobile platforms	Android iOS Windows Phone	YES YES YES	YES YES YES	YES YES YES	YES YES NO	YES YES NO	YES YES NO	YES YES NO	YES YES NO	YES YES YES	YES YES YES	YES YES YES	YES YES YES	YES YES YES	YES YES YES
Available disk space		10 GB	15 GB	2 GB	2 GB	15 GB	10 GB	50 GB	5 GB		1 GB	15 GB	2 GB	4 GB	5GB
Data encryption	Supplier site Client site	SSL, AES-256	SSL, AES-256	SSL, AES-256	SSL, AES-256	SSL		SSL, AES-256, RSA-2048	AES-256	AES-256		SSL	SSL, AES-256, RSA-3072	AES-256, AES-256, RSA-3072	SSL, AES-256, RSA-3072
Folder synchronization		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Public catalog		YES	YES	YES	YES	YES	YES	YES				YES			YES
External drives support				NO	YES		NO	NO		YES			YES		YES
The possibility of free additional disk space enlargement			YES (5GB for every invited new user)	YES (500MB for every invited new user)									YES (max 10GB)	YES (max 6GB)	YES (free coupons)
Two-step verification		YES		YES		YES		NO						NO	NO
LDAP support									Mapped network drive	YES					Mapped network drive
Other			Low data transfer												
The possibility of using the free version for commercial use	YES		YES	YES	YES	YES	YES	YES		YES	YES	NO	YES		YES

Figure 2. Comparison of services

Service administrator can easily configure ownCloud with a user friendly web interface (Fig. 3). It allows to quickly create user accounts, assign them to the appropriate groups and giving them the limit of disk space for data (quota). Because the service works on a private machine, the amount of space available to use depends entirely on the capacity of the hard drive installed in the computer, on which ownCloud is launched.

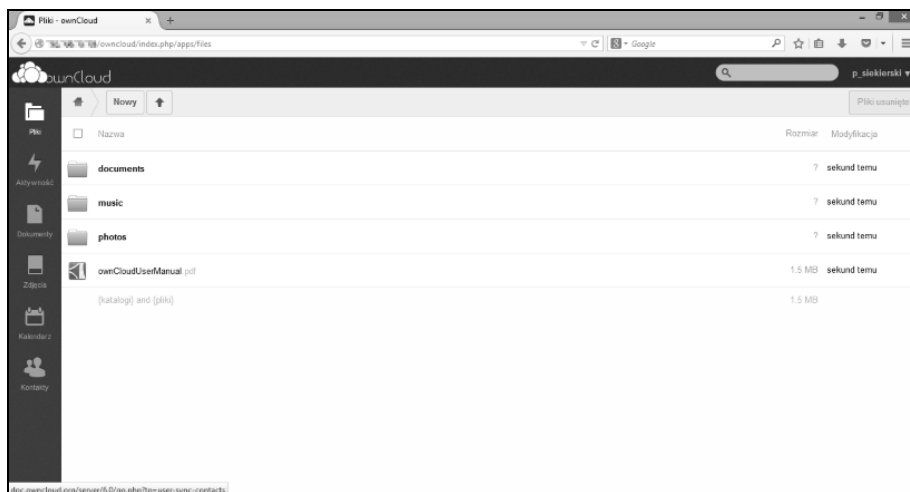


Figure 3. Web Interface of ownCloud service

OwnCloud provides very good data security with versioning of files and encryption of whole directory of each user. All stored data are encrypted using AES-256. As a result, none of the administrators do not have access to the files of people using the service. The file versioning also allows to control changes in files, with the possibility of returning to a previous version of a file. Intuitive configuration interface allows to quickly and efficiently configure the service to work.

In addition to the mentioned above free service capabilities ownCloud developer gives the opportunity to move to a paid Enterprise version, which offers additional functionality and official support for the entire solution [17].

5. Conclusion

In the paper the analysis of available, free Cloud Storage services is presented. The analysis is based on the requirements received from the one of big companies from Lodz - Ericpol. It allowed to get to know possible solutions and to indicate the most appropriate one, with the possibility of its use in the company. The selected service, ownCloud, characterized in that this solution is completely free and can

be used commercially in the company. The results of the analysis were delivered to Ericpol and can also be used by other enterprises that want to deploy this type of a similar service.

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OPTIMIZATION POTENTIAL TRANSPORT OF TRANSPORT COMPANY

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The article presents a method for determining the optimum number of vehicles transport company, depending on the size of the specific demand for transport services and depending on the performance properties of means of transport. Formulated the task of multi-criteria optimization and presents the results of its solution.

Keywords: the transport potential, stochastic process, multi-criteria optimization

1. Introduction

Important role of road transport in the economy should be seen in the fact that, among other modes, it stands out above all:

- mobility: you can get it anywhere where there are no rail, ship, etc.,
- high operability service, involving the availability of a relatively large number of means of transport,
- high availability: getting lower car prices and getting better technical parameters,
- timeliness and punctuality performance of services.

Unfortunately, the major disadvantages of this type of transport are:

- dependent on climatic conditions,
- not very eco-friendly,

- high rate of accidents,
- a relatively small volume of individual means of transport,
- not very low maintenance costs of vehicle.

In practice, however, the advantages of road transport outweigh its disadvantages, what is the reason for its continued presence in the transport market.

One of the basic problems of the transport company managed is to provide its continued presence in the market of transport services, mainly by providing an appropriate potential transport for the anticipated demand for transport services.

The transport potential of the transport company will be identified with the number of cars fit for the provision of transport services at any given time. Reducing the number of cars below a certain minimum (threshold value) will reduce the capacity of the transport company, and thus a loss of competitiveness and, consequently, falling out of the market of transport services.

The rest of this article will be considered a problem to provide the required level of transport potential of transport company, taking into account only the technical aspect of cars: the suitability of the vehicle for use at a time or its uselessness.

2. Description of the problem

Consider the transport company, which has I of the cars (means of transport) for the same destiny (e.g. lorries) and used to meet the demand for homogeneous type of transport services (e.g. transport of bulk cargo). Let $\mathcal{I} = \{1, 2, \dots, I\}$ be the set of numbers of cars that do not need to be the same, i.e. they do not have to have the same design solutions.

It is assumed that from the point of view of the transport company the process of each car can be considered as a succession over time of independent states:

- suitability of the vehicle for the implementation of transport services,
- incapacity of the vehicle for the implementation of transport services (car repair).

Thus, the process of exploitation of each car can be considered as a two-state stochastic process $X(t)$ (Fig. 1), which is a sequence of consecutive (not overlapping in time) states fitness (rectangular pulses), separated states of unfitness. This process will be further referred to as a *square wave*. From the viewpoint of further consideration of the problem magnitude of the amplitude is not important.

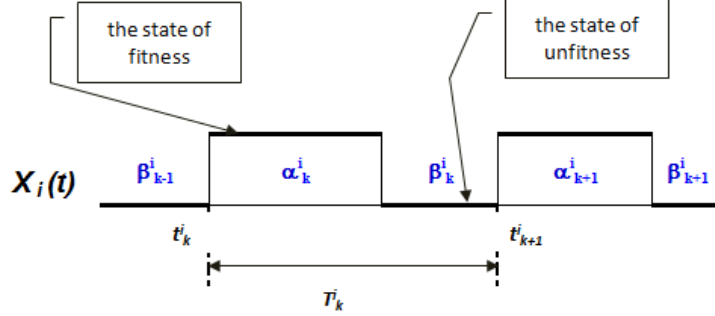


Figure 1. Example of a exploitation process of the i -th, ($i \in I$) of car

Fig. 1 are symbolized $\alpha_k^i, \alpha_{k+1}^i, \dots$, ($k = 1, 2, \dots$) durations of states fitness of i -th car, and symbols $\beta_k^i, \beta_{k+1}^i, \dots$, ($k = 1, 2, \dots$) - durations of states unfitness.

Let that α_k^i , ($k = 1, 2, \dots$) are realizations of continuous random variables, A_k^i respectively, with the same probability distributions. For simplify the notation, each of these random variables will be denoted by symbol A_i . Let that β_k^i , ($k = 1, 2, \dots$) are realizations of continuous random variables, B_k^i respectively, with the same probability distributions. For simplify the notation, each of these random variables will be denoted by symbol B_i . By t_k^i and t_{k+1}^i denoted moments of two consecutive pulses (states fitness of i -th car), and by T_k^i - the length of the interval between occurrences of two consecutive pulses (states fitness of i -th car). Using the designations shown in Fig. 1, exploitation process of i -th car you can be represented as a stochastic process, in which the condition is satisfied:

$$T_k^i = t_{k+1}^i - t_k^i > \alpha_k^i. \quad (1)$$

It is assumed that the processes of exploitation of all cars are stochastic processes, which are independent and stationary in a broader sense. Thus, for the i -th car can be determined the expected length of time between occurrences of two consecutive pulses, which is expressed in the following formula:

$$ET_i = \int_0^{\infty} T \cdot f_i(T) dT \quad (2)$$

where $f_i(T)$ is the density function of the probability distribution of the random variable describing the length of time between occurrences of two consecutive pulses (states fitness) the process of exploitation the i -th car.

Is assumed that are known density functions $f_i^\alpha(t)$ and $f_i^\beta(t)$ of probability distributions of random variables A_i and B_i respectively. It is also assumed that the random variables A_i and B_i are independent from each other and that have finite

variances and finite expected values Ea_i and Eb_i expressed by the following formulas:

$$\begin{aligned} Ea_i &= \int_0^{\infty} \alpha \cdot f_i^{\alpha}(\alpha) d\alpha, \\ Eb_i &= \int_0^{\infty} \beta \cdot f_i^{\beta}(\beta) d\beta. \end{aligned} \quad (3)$$

If the process exploitation of car is stationary, the probability that in randomly chosen time moment ξ there occurs pulse (the state of car fitness) is given by the formula:

$$p_i = \frac{Ea_i}{ET_i} = E\mu_i \cdot Ea_i \quad (4)$$

where $E\mu_i$ - expected frequency of occurrence pulse, wherein

$$E\mu_i = \frac{1}{ET_i} = \frac{1}{Ea_i + Eb_i}. \quad (5)$$

It is assumed that the transport company will have the required potential of lading when in the required period of time in a state of fitness would be no less cars than the threshold number r .

Due to the fact that the transport companies can include a different number of different transport means and to exploit them under different conditions of the threshold number of means of transport in those companies will also be different. The threshold number of vehicles should be set so that:

- was the smallest possible under the given conditions,
- take into account parameters characterizing the evolution of the demand for transport services in the area of the company.

The independence of the process of cars exploitation, this means that it is possible that a randomly chosen moment in a state of alertness may also be more than one car. Let $X(t)$ is the resultant of a process exploitation of cars. It is a process binary (the state of fitness and the state of unfitness), in which the state of fitness, means the state referred to as TE (*technical efficiency*), formed by superposition of states fitness any car in number, at least equal to the threshold number of cars r , ($r = 1, 2, \dots, I$). TE state will be taken as the desired state when its duration is not less than the established value τ . In other cases, the status of TE will be treated as a state indicating the inability to satisfy the demand for transport services at the required level; τ value is determined for each company separately. An example of the process $X(t)$ of cars exploitation is shown in Fig. 2.

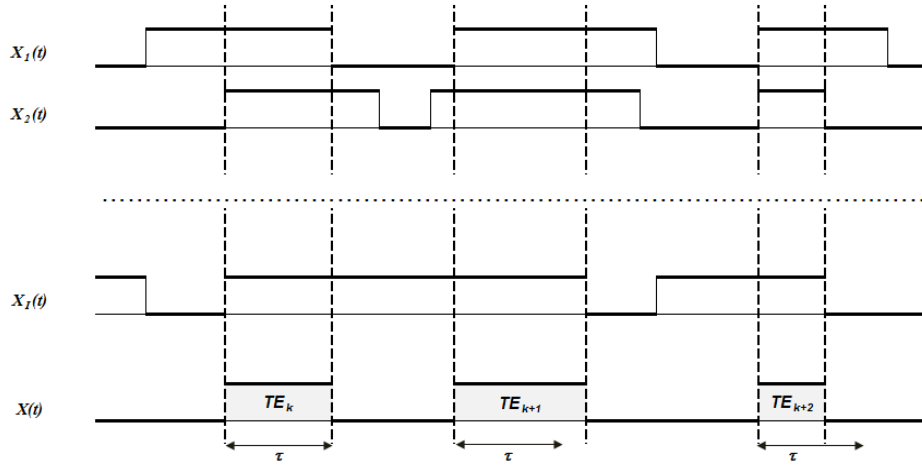


Figure 2. The process of formation of the resultant process $X(t)$ exploitation of cars the company (the duration of the state of TE_{k+2} is shorter than τ which means that transport company does not have the adequate potential transport at this time)

3. Formulation of optimization problem

Considered further optimization task will concern to determine the minimum threshold number of cars r , ($r = 1, 2, \dots, I$), ensuring the satisfaction of the demand for transport services.

The choice of this size would be made taking into account following criteria of minimizing:

- the expected frequency of the occurrence of states of fitness TE process $X(t)$ exploitation the cars in transport company,
- the expected duration the state of fitness TE

taking into account the following restrictions:

- it is known for the number of cars (means of transport) I in the transport company,
- the threshold number of cars (means of transport) can not be greater than the number of cars exploited by the transport company,
- expected value the duration of the state of TE may not be less than a predetermined value τ .

To solve the optimization task is required an ability to determine the expected duration of the TE state of the process $X(t)$.

Let $Y_I(t)$ is the stochastic process of the form [11]:

$$Y_I(t) = \sum_{i=1}^I X_i(t). \quad (6)$$

For the assumptions regarding the exploitation processes of cars, an event that in the random moment ξ^k of cars from among cars owned by the company is able to fitness can be written as:

$$Y_I(\xi) = k, \quad k = 0, 1, 2, \dots, I. \quad (7)$$

The probability of this event is expressed by formula [3, 9]:

$$\gamma_{I,k} = \frac{I}{k!} \frac{d^k}{dx^k} \prod_{i=1}^I (q_i + xp_i) \Big|_{x=0}, \quad k = 0, 1, 2, \dots, I, \quad (8)$$

at the condition

$$\sum_{k=0}^I \gamma_{I,k} = 1, \quad (9)$$

where p_i is expressed by equation (4), and $q_i = I - p_i$.

If the company has cars, which exploitation processes have the same characteristics, there is

$$\forall_{i=1,2,\dots,I} p_i = p$$

and

$$\gamma_{I,k} = \binom{I}{k} \cdot p^k \cdot (I - p)^{I-k}, \quad k = 0, 1, 2, \dots, I. \quad (10)$$

For a further consideration is the important size of the expected frequency $E\mu_{I,k}(\tau)$ the occurrence of states TE of length (duration) of not less than τ , which was formed by the superposition of the states of fitness k , ($k = 0, 1, 2, \dots, I$) of any among I of the cars exploited by the company. Using (8) can be $E\mu_{I,k}(\tau)$ expressed by the following formula:

$$E\mu_{I,k}(\tau) = -\frac{d}{d\tau} \gamma_{I,k}(\tau), \quad k = 0, 1, 2, \dots, I, \quad (11)$$

wherein $\gamma_{I,k}(\tau)$ is the probability that in a randomly chosen moment of the time occurs the state TE of length (duration) of not less than τ , which was formed by the superposition of the states of fitness k , ($k = 0, 1, 2, \dots, I$) of any among I of the cars exploited by the company.

Taking into account the previously mentioned assumptions concerning the exploitation processes of cars we obtain the following expression for the probability $\gamma_{I,k}(\tau)$ [3, 9]:

$$\gamma_{I,k}(\tau) = \frac{I}{k!} \frac{d^k}{dx^k} \prod_{i=1}^I (Q_i(\tau) + xP_i(\tau)) \Big|_{x=0}, \quad k = 0, 1, 2, \dots, I, \quad (12)$$

where, taking into account (5)

$$P_i(\tau) = E\mu_i \int_{\tau}^{\infty} (x - \tau) f_i^{\alpha}(x) dx = E\mu_i \int_{\tau}^{\infty} dx \int_x^{\infty} f_i^{\alpha}(y) dy, \quad i = 1, 2, \dots, I,$$

$$Q_i(\tau) = E\mu_i \int_{\tau}^{\infty} (x - \tau) f_i^{\beta}(x) dx = E\mu_i \int_{\tau}^{\infty} dx \int_x^{\infty} f_i^{\beta}(y) dy, \quad i = 1, 2, \dots, I.$$

Taking into account (11) and (12) finally obtained:

$$E\mu_{I,k}(\tau) = -\frac{I}{k!} \frac{\partial^{k+1}}{\partial x^k \partial \tau} \prod_{i=1}^I (Q_i(\tau) + xP_i(\tau)) \Big|_{x=0}, \quad k = 0, 1, 2, \dots, I. \quad (13)$$

Let $E\lambda_{I,k}(\tau)$ is the expected length (duration) the of state TE of length (duration) of not less than $\tau > 0$, which was formed by the superposition of the states of fitness k , ($k = 0, 1, 2, \dots, I$) of any among I of the cars exploited by the company. It expresses by the following formula:

$$E\lambda_{I,k}(\tau) = \int_0^{\infty} \tau f_{I,k}^{\alpha}(\tau) d\tau, \quad k = 0, 1, 2, \dots, I, \quad (14)$$

where $f_{I,k}^{\alpha}(\tau)$ is the density function of the probability distribution of the duration of the state TE created by the superposition of the states of fitness k , ($k = 0, 1, 2, \dots, I$) of any among I of the cars that is not less than a certain value $\tau > 0$. Taking into account (11) function $f_{I,k}^{\alpha}(\tau)$ can be expressed by the following formula:

$$f_{I,k}^{\alpha}(\tau) = \frac{I}{E\mu_{I,k}(\tau)} \frac{d^2}{d\tau^2} \gamma_{I,k}(\tau), \quad k = 0, 1, 2, \dots, I. \quad (15)$$

Taking into account (14) i (15) is obtained:

$$E\lambda_{I,k} = \frac{\gamma_{I,k}}{E\mu_{I,k}(0)}, \quad k = 0, 1, 2, \dots, I. \quad (16)$$

If the company has cars, which exploitation processes have similar characteristics, $E\lambda_{I,k}$ expresses the relationship:

$$E\lambda_{I,k} = \frac{I}{E\mu} \frac{p(1-p)}{(I-k)p + k(1-p)}, \quad k = 0, 1, 2, \dots, I, \quad (17)$$

wherein p and $E\mu$ express dependencies (4) and (5), respectively, and are the same for each car.

From a practical point of view, may be interesting the following two cases:

- $E\lambda_{I,I}$ - expected length the state of fitness TE , when are taken into account all the cars exploited in the company ($k = I$),
- $E\theta_{I,I}$ - expected length the state of unfitness TN , when are taken into account all the cars exploited in the company ($k = I$).

Formulas defining the above the sizes mentioned are of the form:

$$E\lambda_{I,I} = \left(\sum_{i=1}^I \frac{1}{Ea_i} \right)^{-1}, \quad (18)$$

$$E\theta_{I,I} = \left(\sum_{i=1}^I \frac{1}{Eb_i} \right)^{-1}. \quad (19)$$

Based on the previously adopted assumptions and using formulas (13) and (16) can be obtain the solution of a problem the receipt of the expected frequency the occurrence of the pulses TE and the expected their length, created by the superposition of the states of fitness of cars in number is not less than set their threshold r . Thus, the transport company will have the required potential of lading, when at a random time interval of length t will fulfilled the inequality:

$$Y_I(t) \geq r, \quad (20)$$

where $Y_I(t)$ expressed by equation (6).

Let $E\mu_{i,r}^*$, ($r=1,2,\dots,I$) is the expected frequency of occurrence of the TE state, formed by the superposition of states of fitness at least r cars. This value is calculated from the formula:

$$E\mu_{I,r}^* = \sum_{k=0}^{r-1} (-1)^{r+k+1} E\mu_{I,k}, \quad r = 1, 2, \dots, I, \quad (21)$$

where $E\mu_{I,k}$, ($k=1,2,\dots,r-1$) is the expected frequency of superposition k of states of fitness of the cars from the among I cars, is expressed by equation (11) with the condition $\tau = 0$, i.e.:

$$E\mu_{I,k}(\tau) = - \left. \frac{d}{d\tau} \gamma_{I,k}(\tau) \right|_{\tau=0} = E\mu_{I,k}, \quad k = 0, 1, 2, \dots, I. \quad (22)$$

Let $E\lambda_{I,r}^*$, ($r=1,2,\dots,I$) is the expected length (duration) of the TE state, formed by the superposition of states of fitness at least r cars. This value, taking into account (8), you can express by formula:

$$E\lambda_{I,r}^* = \frac{1 - \sum_{k=0}^{r-1} \gamma_{I,k}}{E\mu_{I,r}^*}, \quad r = 1, 2, \dots, I. \quad (23)$$

If the company has cars, which exploitation processes have similar characteristics, it is possible to adopt the following assumptions:

$$\begin{aligned}\forall_{i \in I} E a_i &= E a, \\ \forall_{i \in I} E b_i &= E b,\end{aligned}\tag{24}$$

formulas (21) and (23) take the form of:

$$E \mu_{I,r}^* = C_I^r \cdot r \cdot p^{r-1} \cdot (1-p)^{I-r} \cdot E \mu,\tag{25}$$

$$E \lambda_{I,r}^* = \frac{1 - \sum_{k=0}^{r-1} C_I^k \cdot p^k \cdot (1-p)^{I-k}}{E \mu_{I,r}^*},\tag{26}$$

where p and $E \mu$ are expressed by the formulas, respectively (4) and (5) provided (24).

Optimization task [5, 7, 8], formulated at the beginning of this point can be clarified as follows:

for car company, which uses I of cars to determine a minimum threshold number of vehicles r , ($r=1,2,\dots,I$) from the point of view of maximizing of expected frequency of superposition of states of fitness at least r from the among I of the cars and of maximizing of expected duration this superposition with the following conditions:

- *number of vehicle fleet of the company is known and equal to I ,*
- *the expected duration of superposition of states of fitness at least r of cars not less than a specified value τ*

This optimization task formulated verbally takes the following form formal [1]:

$$(\Omega, \varphi, R),\tag{27}$$

where:

- Ω - the set of feasible solutions as:

$$\Omega = \{r : r = 1, 2, \dots, I; E \lambda_{I,r}^* \geq \tau\}\tag{28}$$

- φ - vector criterion as:

$$\varphi = (r, E \lambda_{I,r}^*, E \mu_{I,r}^*)\tag{29}$$

- R - the conical relationship dominating as:

$$R = \{(y_1, y_2) \in Y \times Y : y_1^1 \leq y_2^1, y_1^2 \geq y_2^2, y_1^3 \geq y_2^3\}.\tag{30}$$

4. Solution of optimization problem

The task formulated out in point 3 is a nonlinear multi-objective optimization task. The solution of this task will involve the appointment of a set of non-dominated solutions (Pareto-optimal) by the relation of domination (30).

Determination of the set of non-dominated solutions in this case may be difficult due to the non-linear criterion. This makes it impossible to direct application of known methods for solving multi-criteria optimization task [e.g. 2,6,10]. Most often, a small cardinality of set I will be used for a full overview of possible acceptable solutions on the basis of which will be designated non-dominated set of solutions, or in the best case solution dominant. In the event that a full overview will not be out of the question, use the methods of representation or random.

Table 1 shows an examples of compromise solutions (Pareto-optimal) for the case when all the cars of the company have the same exploitation characteristics: $Ea = 20$ [unit time], $Eb = 2$ [unit time].

Table 1. Examples of non-dominated solutions under consideration optimization task

r	$E\mu_{I,r}^*$	$E\lambda_{I,r}^*$	τ
$I = 10$			
5	0,026424	150,4127	8
6	0,070464	36,60317	
7	0,120796	12,47619	
$I = 14$			
5	0,000336	11908,47	10
6	0,002015	1653,399	
7	0,009213	309,3873	
8	0,032244	76,63253	
9	0,085985	24,71084	
10	0,17197	10,11988	
$I = 30$			
15	0,000134	7455,133	20
16	0,000537	1863,45	
17	0,001878	532,0571	
18	0,005744	173,5571	
19	0,015317	64,66726	
20	0,035471	27,46995	

As can be seen from the table above, the threshold efficient means of transport below, which the transport company may lose a substantial part or all its potential transport grows disproportionately more slowly than the number of means of

transport in the company at all. This means that larger companies with greater number of means of transport, can more easily maintain a reasonable level of transport potential than smaller companies, and this is confirmed by the fact, which indicates the usefulness of considered model.

5. Conclusions

In the case of large companies activities exploiting a large number of cars formulas (25) and (26) can be approximated respectively by the following:

$$E\mu_{I,r}^* \approx I \cdot E\mu \cdot \frac{I}{\sqrt{2\pi\sigma}} e^{-\frac{x_r^2}{2\sigma^2}}, \quad (31)$$

$$E\lambda_{I,r}^* \approx \frac{I}{I \cdot E\mu} e^{\frac{x_r^2}{2\sigma^2}} \int_{x_r}^{\infty} e^{-\frac{x^2}{2\sigma^2}} dx, \quad (32)$$

where

$$x_r = r - I \cdot p, \quad \sigma = \sqrt{I \cdot p \cdot (1 - p)}. \quad (33)$$

Fig. 3 is a graph showing the course of size described formulas (31) and (32) depending on the threshold value r for the case when a company uses **100** cars and they all have similar exploitation characteristics: $Ea = 100$ [unit time], $Eb = 25$ [unit time].

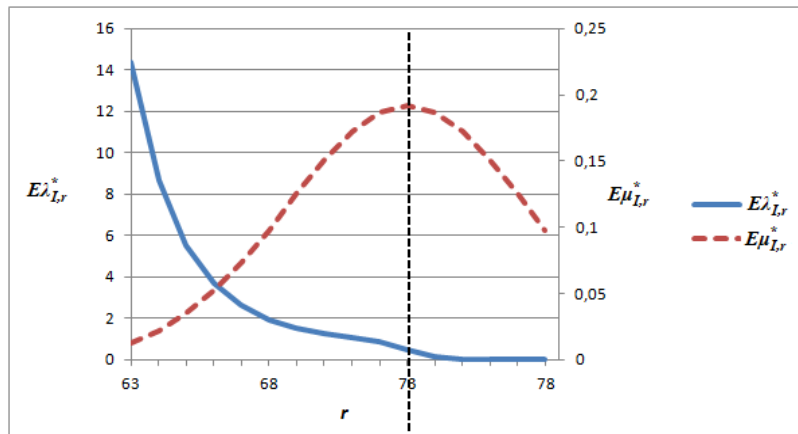


Figure 3. The course of size described formulas (31) and (32) depending on the threshold value r for the above-described data

Fig. 3 dashed lines indicate the right border of the interval containing solutions not-dominated. To the right of this border are dominated solutions by indicated previously: they are characterized by worse values for the $E\lambda_{I,r}^*$, $E\mu_{I,r}^*$ and r in the sense of accepted relationship of domination (30).

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TAX ADMINISTRATION AND RISK MANAGEMENT IN THE DIGITAL AGE *

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Tax administrations have to deal with a large number of risks. These may concern the risk of non-compliance, including risk of tax fraud. The main purpose of this paper is to show how the Internet business models effect on tax administration in the context of risk management. The research problem analysed in the article concerns the adequacy of analytical and control tools used today by tax administration of OECD member countries to counter the phenomenon of tax avoidance using computer networks in business activity. The purpose of research problem framed this way is to verify whether reducing the negative effects of tax avoidance in connection with the digital economy development and ‘dematerialisation’ of many aspects of business activity requires nothing more than making organizational changes in tax administration operations, or whether it is necessary to introduce substantial changes in tax law to adjust legal standards to the requirements of the ‘new economy’. The research integrates a variety of theoretical frameworks and relates to legislation governing tax procedure in OECD member countries, with references made to actions taken by Polish tax authorities. To achieve the goals set, the methods of analysis and criticism of specialist literature and documents, in particular reports published by the OECD, the EU and the Polish Ministry of Finance, will be primarily used.

Keywords: Tax administration, tax risk management, e-commerce, tax jurisdiction

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1. Introduction

National tax administrations around the world perform similar functions. The primary goal of each revenue authority is to collect all tax revenues due in a fair and efficient way. There is, however, a significant asymmetry: the number of taxpayers in each state, in principle, many times exceeds the number of officials responsible for verification of the accuracy of income tax returns of the latter. This means that tax administration must use methods for identifying potential high-risk areas where taxpayers might avoid (or even evade) taxes. The dynamic development of Internet technologies leads to significant changes in business models of enterprises. This, in turn, forces tax administration representatives to take a fresh look at the effectiveness of analytical tools they use with regard to 'traditional' business compared to digital economy.

2. Tax administration in the state tax system

Tax system is a system for collecting taxes applicable at a time in a given country [1]. In legal terms, the structure of tax system must refer to the subject of tax legislation, that is mainly to business transactions conducted under specific political and social conditions. Tax system can also be understood as legal and organizational forms of taxation in their entirety. In fact, tax system rarely is a compact, unified, and logical whole; it has been developing gradually because of formation of new types and forms of taxation on the one hand, and disappearance or transformation of former taxes on the other [2]. From a broader perspective, a properly designed tax system is a guarantee of respect for the rights of individual entities and businesses. It also provides public and social infrastructure necessary for economic development. Tax system consists of several components, interrelated and interdependent [3]. It is the special responsibility of the state tax administration to ensure their efficiency.

The core task of each tax administration is to ensure proper application of tax law, and its effectiveness depends on many external factors, including economic, political and social ones. Macroeconomic factors include the type of fiscal policy model pursued by individual countries (fiscal policy might be passive or active), while microeconomic factors include for instance an access to capital by companies (difficulties in raising capital may encourage businesses to seek tax savings). Political factors include (i) the civil service model along with the resulting procedures for recruitment of staff to work in tax administration and (ii) the degree of de(centralization) of the state administrative structure along with the resulting degree of autonomy of local (regional) tax authorities in tax policy. Finally, the social factors: they include the level of the so-called social capital

which determines the right relationships between the state and an individual and between individuals. It may affect the level of acceptance of government-imposed taxes and the tendency to voluntarily and fully fulfil the obligation to pay taxes.

Tax administration is defined based on objective and subjective criteria. According to objective criteria, tax administration is an area of the state administrative actions (at all levels of administrative structure) taken under the tax law. In turn, tax administration in the subjective sense means a part of public administration apparatus consisting of state authorities and institutions appointed to carry out tasks in the field of tax law [4].

Organizational and functional optimization of tax administration is a prerequisite for proper and effective performance of its tasks, particularly regarding tax and fee collection. Efficiency of tax authorities has considerable impact on the performance of these tasks, and thus the application of tax law in practice. The efficiency of tax administration means the efficiency of its structures, which translates into the efficiency of action. This term is associated with both (i) friendly image of tax administration operating according to transparent procedures and legal powers, and (ii) the desired behaviours towards the addressees of norms of tax law [5].

The core tasks of tax administration are centred around fiscal, economic and social objectives. The fiscal objective is to use technical and human resources to verify the accuracy of tax returns filed by taxpayers under self-assessment system and enforce tax liabilities if taxpayer fails to pay the balance due shown on the tax return by the due date. Voluntary fulfilment of tax liability arising in connection with the occurrence of situations or acts of law ('legal events') specified in the tax law is encouraged in most tax systems because it seems to be the most effective model to ensure the fulfilment of tax obligations imposed on obligors (i.e. a person or entity who is legally or contractually obliged to provide a benefit or payment to another). It is also the cheapest model from the perspective of tax system administration as tax authorities are in fact procedurally involved after an error is made by obligor or deliberate understatement of the amount of tax liability is discovered [6]. Thus, human and infrastructure resources available to tax authorities of a given state may be involved in actions of strictly fiscal nature: if – as a result of procedures initiated to verify the correctness of tax returns filed by taxpayers under self-assessment system – potential irregularities are found, tax authorities take actions, often resulting in additional inflows from overdue tax liabilities. On the other hand, these resources may be used for preventive purposes: taxpayers filing their tax return under self-assessment system are aware that the correctness of their settlements might be verified by tax authorities and that potential arrears will be enforced with the use of state coercive measures.

Full verification of tax returns filed by taxpayers is impossible, especially if it is done in the traditional form, meaning that tax administration employee checks

the accuracy of tax calculations based on tax return filed by taxpayer. For this reason, the correctness of tax return calculation is presumed; if, however, taxpayer applies for tax refunds based on his calculation, such tax return might get a second look [3].

The economic objective is to reduce the costs that each government incurs to collect taxes and enforce tax laws and – in a broader sense – to reduce the costs of running the country. The type of tax administration and its future actions should be economically justified. Finally, the social objective is to satisfy tax administration stakeholders. As tax administration is a part of state authorities, state stakeholders, including internal stakeholders (administrative staff) [7] should also be satisfied.

Effective organizational structure is one of the conditions that tax administration must meet to achieve these objectives. Adopting a linear (hierarchical) organizational structure seems to be the problem of many tax administrations. Even though the hierarchy guarantees a very resilient management structure (subordination), it also 'toughens' operations, for instance by extending the channels of communication between organizational units (information is transferred through all levels of management along hierarchy lines). This is a reason why demands that organizational structure of tax administration should be based on a functional model. Under this structure, the organization groups employees according to a specialized or similar set of roles or tasks that require similar skills and knowledge [8]. Therefore, subordination in such a structure is not based on the hierarchy of individual units within the organization, but on competencies as employees with shared skills and knowledge are grouped together by function. Properly designed organizational structure can improve the verification process of correctness of tax returns filed by taxpayers. It might also help single out those taxpayers who might be at the greatest risk of failing to fulfil their tax obligations (this function is referred to as tax risk management).

3. Tax risk management as a tool for effective verification of tax liabilities fulfilment

Tax authorities directly responsible for collecting tax must face tax risk understood as illegal actions taken by taxpayers to lower tax revenues. The Treasury is losing billions a year because of taxpayers failing to pay taxes due. Such losses pose tax risk, the identification and management of which, as in the case of entities conducting business activity, is to lead to tangible benefits, that is to the achievement of the above-mentioned objectives [9], including the fiscal objective.

Tax risk, from the perspective of tax administration, is defined as uncertainty related to the fulfilment of the fiscal objective. In practice, this risk is manifested in

the existence of differences between tax revenues assumed in the state's annual budget act and factually earned revenues [9]. Tax risk is based on several factors. First of all, as already mentioned, most tax systems are based on self-assessment model (i.e. the model that enables taxpayer to assess their own income tax and capital gains tax liabilities for the year) under current tax law. It naturally poses a potential danger that some business entities required to calculate and pay taxes will either not perform this obligation at all or will do so in a manner that causes substantial understatement of the actual level of tax burdens. Usually, tax administration has limited human and technical resources to respond to this danger. Therefore, the development and implementation of effective methods of estimating tax risk by tax administration is the key to minimize such a risk. This in turn makes it necessary to decide to where (to what areas of the economy) the resources should be allocated, which is burdened with the risk of wrong allocation thereof [3].

Actions taken by tax administration aimed at minimizing tax risk are called tax risk management. The purpose of applying tax risk management is to develop (i) a systematic approach to identification and prioritizing significant risks to increase the efficiency of tax system and (ii) multi-faceted strategies to manage these risks [3]. They may include, for instance: a risk of non-fulfilment of obligations by taxpayers, a risk of planned tax fraud, or a risk of insolvency of taxpayer as a consequence of actions taken by tax authorities. The activity of tax administration aimed at managing risk with regard to identification, assessment, ranking, and treatment of tax compliance risks (also referred to as Compliance Risk Management, CRM) seems to be crucial. Voluntary fulfilment of tax obligations by taxpayers includes primarily: registering as a taxpayer in connection with business activities taken, completing tax returns and filing them at tax authorities in a timely manner, calculating and paying taxes in a timely manner. Most tax systems are based on the assumption that taxpayers fulfil their tax obligations voluntarily and that their tax returns are filled in correctly [10]. Nonetheless, tax authorities acting as institutions responsible for attaining the budget revenue, must be equipped with instruments to verify the accuracy of tax settlements, including tools for managing compliance.

The Compliance Risk Management Process is based on five consecutive steps, which form the Compliance Risk Management cycle. The first two steps relate to risk identification, analysis of risks and the behaviour of taxpayers that cause the risks. The next two relate to treatment planning i.e. making choices – about (groups of) taxpayers, risks and options for treatment – and the implementation of the treatment. The final step relates to measurement, evaluation and learning.

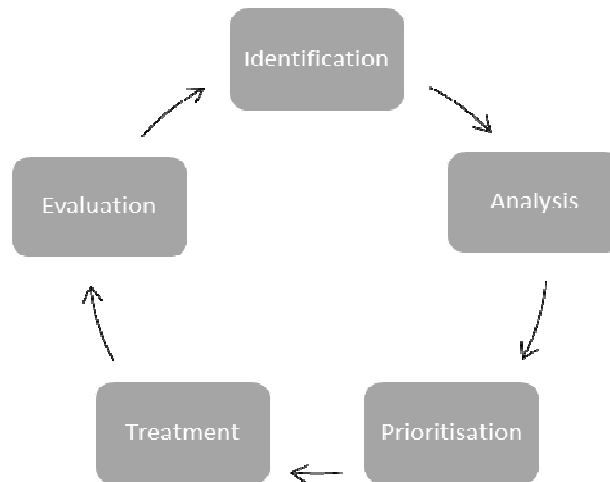


Figure 1. Compliance Risk Management Process.

Source: European Commission (2010) Compliance risk management guide for tax administrations

Proper management of risks as regards the fulfilment of tax obligation allows tax administration to [10]:

- a) treat taxpayers equally,
- b) focus the burden of audit to non-compliant taxpayers,
- c) make best use of the available human, financial and technical resources,
- d) increase the level of voluntary compliance of taxpayers,
- e) adjust available resources to the levels of risks,
- f) weigh the possibilities that a compliant taxpayer could become non-compliant.

Tax risk management concepts used nowadays by different countries are often based on the assumption that all types of tax loopholes (unpaid taxes) have the same importance, regardless of the type of taxpayer, the cause of error, or the type of method to be used in order to eliminate or reduce tax risk [11]. These concepts differ in terms of identification and classification of tax risk. Some of them are focused on individual taxpayers, while others focus on specific types of errors or groups of taxpayers noted for high error rate. The selected concept may focus on all taxes or on some types thereof.

Compliance Risk Management is a process that supports the development and evaluation of tax strategy adopted by tax authorities but it does not contribute to its development. Thus, the implementation of risk management procedures must be preceded by development of such a strategy. If its main purpose is to ensure

voluntary fulfilment of tax obligations by taxpayers, it should be based on the following assumptions [10]:

- a) identifying and correcting historical errors are not equally important,
- b) taxpayer is honest as long as nothing else is proven,
- c) there is no need to use extreme measures against one or a few taxpayers in order to influence behaviour of others,
- d) it is better to detect small errors early rather than to detect big errors late,
- e) the strategy must be developed in a way that shows respect and understanding for the taxpayer situation.

The CRM approach is aimed at modifying taxpayers' behaviour regarding fulfilment of tax obligations with the use of improved strategies. The principles of market segmentation are used to divide taxpayers into smaller groups which can be easier managed and verified on the basis of shared characteristics and potential risks. Then risks regarding the fulfilment of tax obligations are identified and priorities are determined from corporate perspective. The purpose of these actions is to provide solutions to the key problems with fulfilling tax obligations. These are the problems that often contribute to the creation of tax loophole [12]. Currently used tax risk management models face a challenge of shifting many elements of business models to virtual space, especially to the Internet.

4. The impact of digital economy development on tax risk management

The last decades have brought dynamic increase in the importance and scope of business done with the use of new technologies. It refers especially to information technology, telecommunications, consumer electronics and entertainment (digital economy is sometimes called the Internet economy, or web economy). These components are used to build modern business models based on information which has not only given a whole new meaning to today's economy but has also made this process more dynamic [13]. The trading in products or services using computer networks is referred to as e-commerce. According to the OECD, e-commerce means (i) all forms of transactions completed solely through electronic measures by both individual and institutional entities, or (ii) business (the buying and selling of goods and services, or the transmitting of funds or data) conducted over an electronic network, typically the Internet and the related infrastructure (telephones, bar code readers, or other electronic appliances) [14].

The Internet, a global system of interconnected computer networks, is characterised in particular by: bidirectional interaction (the user is both the sender and the recipient), multimedia (the ability to transfer signals in different forms, from text, to speech, picture, motion picture, and audio-visual presentations), wide availability (mainly because it is available on various media platforms:

telecommunications, television etc.), time flexibility (communication is available both in real and virtual time), and selectivity (the ability to get specific message to people who express interest and have distinctive features) [13].

These processes create favourable condition for the emergence of new risks of non-fulfilment (partial fulfilment) of tax obligations by taxpayers, which tax administrations of most countries in the world must face. Risk factors associated with the digital economy development include [15]:

- 1) physical location of some sources of income, which helps identify the right tax jurisdiction, is unavailable,
- 2) traditional forms of control, such as physical control of the flow of goods (people) across borders, do not apply to online flow of goods (services),
- 3) websites can be administered remotely and be freely moved to other countries, and thus to other tax systems, such as tax havens where particular taxes are levied at a low rate or not at all,
- 4) development of new business models, which are based on intangible assets made available through the Internet,
- 5) difficulty in identifying entities providing their services online,
- 6) development of payment systems which operate outside the existing bank systems.

One of the main objectives of CRM is to minimize the risk of tax avoidance or tax evasion by entities required to pay taxes under the tax law. Tax avoidance is the process whereby taxpayers apply all exemptions and deductions provided by tax laws to avoid or reduce the amount of income tax owed by means that are within the law or lack thereof [16]. Tax evasion is an illegal practice where taxpayers avoid paying their true tax liability. It may lead to criminal charges as individuals who intentionally fail to pay proper taxes violate generally applicable provisions of law.

International business transactions and progressive liberalization of international trade entail particular risk of tax avoidance or evasion: taxpayers providing their services in cross-border trade might want to avoid or evade taxes by 'shifting' their income to countries that offer foreign individuals and businesses a minimal tax liability with the use of transfer pricing.

The digital economy seems to 'favour' the spread of such phenomena as tax avoidance and tax evasion: on the one hand, it does create favourable conditions for conducting business activity in a more anonymous way than in traditional economy, while on the other it helps create artificial structures for tax purposes in order to avoid taxation, especially at international level.

The Internet economy is characterized by decreasing importance of territorial factor in relation to business models developed by enterprises. Business transactions are often conducted virtually, therefore, material components (technical resources, human factor) can be physically far away from the place

where intangible resources available through the Internet are used (the digital economy has weakened the link between economic activity and the specific location). This in turn may cause some difficulties: as the cross-border e-commerce expands, it may turn out that both the place of residence for tax purposes and source of income become more difficult to be reasonably determined. It may also lead to a situation where cross-border income is not taxed in any country (unintentionally), thereby causing an additional reduction in tax revenues.

Tax authorities face the challenge of how to use tools to analyse the risk associated with the digital economy. This new approach is referred to as e-tax administration, under which tax authorities should take advantage of opportunities arising from the development of new technologies to: (i) accelerate the process of filing tax returns, (ii) increase the degree of complexity of tax proceedings, (iii) extend the scope of the data about taxpayers, (iv) make analyses faster, (v) provide taxpayers with tax information and finally (vi) lower the costs of tax administration operations [17].

According to the OECD, actions that tax administration should take in order to adapt to the challenges of the digital economy include:

- a) maintaining their ability to secure access to reliable and verifiable information in order to identify taxpayers and obtain the information necessary to administer their tax system,
- b) adopting conventional identification practices for business engaged in electronic commerce,
- c) developing internationally compatible information requirements, such as acceptance of electronic records, format of records, access to third-party information and other access arrangements and periods of retention and tax collection arrangements,
- d) developing Internet web sites where information, such as tax legislation, rulings, case law, revenue statistics and forms can be viewed and downloaded.

Adaptability of tax administration to virtual reality should include two main areas. The first one is the use of electronic tools in order to reduce the existing technological asymmetry between e-business models and tax risk management models applied by tax administration, which often are designed to reduce the dangers coming from traditional business activities. The use of Big Data for estimating tax risk of e-commerce transactions and selecting entities to be inspected should be particularly important. The '3Vs' model is used for describing Big Data: volume (large amounts of data to be processed), velocity (high variability and dynamics of processed data, in particular those processed in near real-time), and variety (great variety of data, especially unstructured data) [18]. The use of Big Data seems necessary to analyse vast amounts of data available on the Internet. Traces left in IT systems by individuals who conduct business activity

using such systems, traces left by technological devices operating automatically, and also private databases, represent a huge collection of information [19] which – if properly filtered – may constitute an effective tool for managing tax risk.

The second area of operations involves changing the rules on the exchange of information between tax authorities on an international scale. This means the need for intensive cross-border cooperation between tax administrations of individual countries to effectively prevent tax avoidance and tax evasion of entities providing their services online. Rapid exchange of tax information is a necessary tool to verify the declared basis for taxation in the case of cross-border income, which in turn contributes to the enforcement of domestic tax law. This is an effective measure to preserve the sovereignty of states' tax bases and to ensure proper exercise of powers to tax income assumed by states under international agreements [20].

Apart from actions to be taken by tax administration, it seems necessary to adjust the tax law to technological challenges. This concerns in particular the provisions of international tax law which apply to demarcation of tax jurisdiction between states. Today's regulations are based on the paradigm of territoriality, according to which the state has the right to tax certain income derived from sources within its boundaries (source principle of taxation) or the income of an entity is taxed according to the laws of the jurisdiction where it is resident (residence principle of taxation). The paradigm of territoriality loses its impact when it comes to transactions carried out in virtual reality (meaning that no material good is the object or effect of such transactions). This is a reason why such legal concepts as 'virtual permanent establishment' emerge. Such a fixed place of business would allow tax authorities to allocate taxing rights on business profits derived by foreign enterprises in respect of only virtual (not physical) presence (activeness) associated with business activity conducted on the Internet.

5. Conclusion

The digital economy development changes traditional business models that companies used to adopt as it facilitates conducting business activity internationally, using the Internet. The state tax administration is responsible for ensuring that all taxpayers pay their fair share of taxes. This goal can be effectively achieved when tax avoidance and tax evasion are prevented. These two practices are particularly common in the case of cross-border trade where two (or more) tax jurisdictions meet. This makes it necessary for tax authorities to change traditional models of tax risk management for new ones, based on the use (and analysis) of large amounts of data available on the Internet and electronic tools for effective cooperation between tax authorities of the countries around the world. However, adapting approaches and methods used by tax administrations to specific nature of

business activity conducted via computer networks cannot be considered sufficient action. It is also necessary to verify many of the 'traditional' institutions of tax law in terms of their adequacy in transactions carried out in the digital economy. Special attention should be paid to international tax rules used by network-based businesses operating across borders to avoid tax. This problem is indeed subject to assessment as part of the OECD project called *Base Erosion and Profit Shifting (Action 1 – Addressing the Tax Challenges of the Digital Economy)*, but analysis of recommendations presented therein leads to the conclusion that it does not cover fundamental changes to international tax rules in the context of challenges of the digital era, which seem necessary to ensure fair trade on an international scale.

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LOGISTICS SOLUTIONS FOR E-COMMERCE: THE CASE OF THE INPOST SA CAPITAL GROUP

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The paper aims to present logistics solutions in Poland's e-commerce market using the example of the rapidly growing InPost SA Group. The group's development strategy focuses on the e-commerce market and the expansion of services including innovative solutions. The subject literature, and documents and information provided by the research subject, the InPost SA, are the sources used in this study. The paper presents the specificities of the e-commerce sector, especially courier services, express and parcel deliveries. Receivers of shipments in the e-commerce market are a demanding group of customers, who continually pressure the courier market operators to expand their range of services. The study also identifies drivers of competitive advantage in the changing logistics services sector associated with e-commerce.

Keywords: E-commerce; B2C e-commerce market; logistics services; courier, express and parcel sector; InPost; Parcel Lockers; E-commerce Registered Mail

1. Introduction

This paper presents logistics solutions of entities operating in e-commerce market, such as Parcel Locker deliveries, courier deliveries and InPost E-commerce Registered Mail based on services provided by InPost SA Capital Group (Group). Based on Group's financial reports from 2013 – 2016, changes in its revenue structure have been analyzed, that are mostly the result of the evolution of the Group's strategy. Since 2015 the Group has been predominantly focusing on

servicing the e-commerce market, which involves receiving, transporting and distributing deliveries based on network of the Group's departments, Customer Service Offices and network of Parcel Lockers.

Furthermore, in order to analyze the Group's business environment, the author has presented specificity of e-commerce industry in Business to Customer (B2C) market (below also named as e-commerce market, e-trade market, internet trade market) and related logistics services sector (so called TSL – Transport, Shipping, Logistics), focusing principally on courier, express and parcel sector (CEP). It is underlined, that the intensive growth of e-commerce and consequently CEP sector has resulted in increased competition. The drivers of competitive advantage on the dynamically changing market of logistics services related to e-commerce have been indicated with innovation being one of the most crucial factors.

2. Research purpose, scope, methodology

The purpose of this paper is to present the specificity of the e-commerce market and CEP sector in Poland and to recognize logistics solutions for the e-commerce market in B2C sector on the example of dynamically growing InPost SA Capital Group.

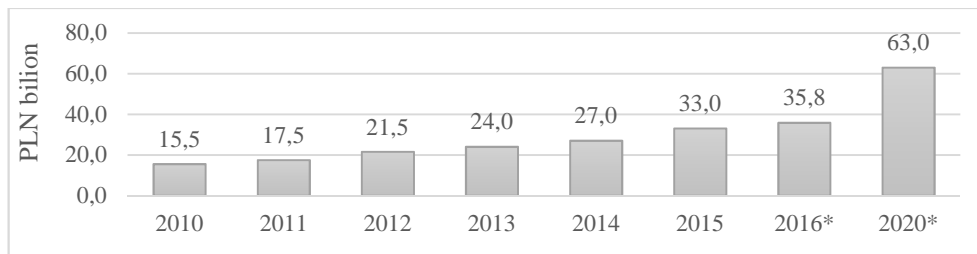
The research covers the e-commerce market between 2010-2020, the CEP sector between 2011-2018 and the Group between 2013-2016.

Based on the case study, innovative logistic solutions for the e-commerce market and changes in revenue structure of the object were analyzed. Research topics related to the object, the e-commerce market, the CEP sector and the logistic concept has been discussed and implemented based on content analysis of secondary sources.

3. Information regarding the e-commerce in B2C sector and the CEP industry

Continuous technological advancement and improving access to the Internet result in a steady increase in its user numbers. In 2016 there were 25.8 m Polish internet users, representing 76,6% of the population [1]. Web users are at the same time potential customers of e-commerce market in B2C.

According to an estimate (*Barometr e-commerce 2016*), at the end of 2016 the e-trade industry in Poland was valued at PLN 35.8 bn (more than double the 2010 figure), whereas in 2020 it will exceed PLN 63 bn [2]. The growth of e-commerce industry is also forecast in estimations related to retail sector, in which the share of products sold on the Internet will double, reaching 10% by 2020 [2]. The development of the Polish e-commerce market, in terms of value, is shown in Figure 1.



* Forecast

Figure 1. Poland e-commerce market volume from 2010 to 2020 (PLN bn)
 Source: own preparation on the basis of [2]

The sale of products on the B2C e-commerce market can occur via different organizational forms, among others internet stores functioning as independent entities not related to conventional retail channels, internet stores set up by conventional distributors with the purpose of diversification of sale channels, advertising websites, group buying, m-commerce, social commerce and auction websites. Online auctions are a particularly important part of the Polish e-trade market, accounting for around 65% of its turnover [3]. Internet stores, with their growing numbers and a more attractive and diversified offer, control a large share of internet shopping. In 2016, over 23,500 internet stores are expected to be operating in Poland [2], a 2.5-fold growth in relation to 2010, whereas by 2020 the figure will settle at a level exceeding 30,000 [4].

Among 25.8 m internet users, a growing proportion uses this medium to shop. Results presented in *E-commerce w Polsce 2016. Gemius dla e-Commerce Polska* report show, that 48% of internet users (a 5% growth in relation to 2015 [2]) have used e-trade services at least once in their lifetime. Internet users participating in the research see numerous benefits of this form of shopping, the most important of which are: convenience, time- and cost-saving and also bigger choice of products in comparison with traditional brick and mortar stores. The main factors indicated by the interviewed consumers as having potential to induce them to shop online more often are related to costs, that are borne by the buyers [1].

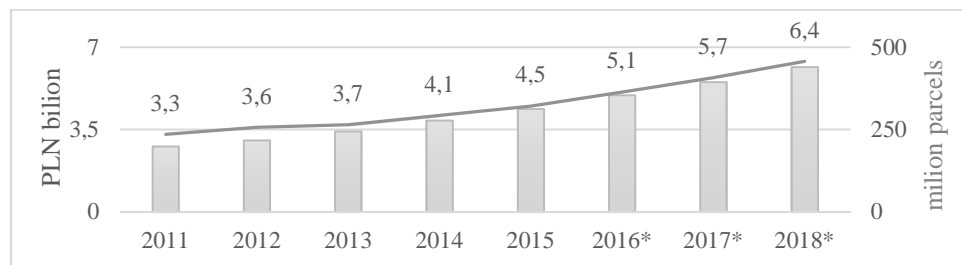
The presented forecast figures unanimously indicate continued, intensive growth of the segment, and consequently steady increase of number of transactions made with use of the Internet. This means more innovative logistics solutions are needed to meet constantly increasing demands of e-customers.

In management theory, Logistics, as an interdisciplinary science, is perceived as the ability of combining all of the organization elements in an efficient and reliable functioning whole. In addition to minimizing operating costs, it emphasizes maximizing cost-effectiveness and optimization of all flows. Due to the specificity of the logistic concept, it is often treated as a management category, and in this way its management aspects and ability to apply to different levels of the

organization are emphasized. Sometimes, it is seen as a concept which primarily concerns the problems in the operational area. In that case, it shows such an area associated with the processes and information related to the movement of physical goods. This is usually reflected in taking care that the right product of the right quality and quantity is delivered to the right place at the right and the right level of cost. Moreover, Logistics can also be identified as a concept connected with strategic solutions [5]. In the world, there are companies which have built strategic competitive advantages around unique logistics solutions.

Logistics is a key area of every business. In an era of increasing competition in the e-commerce market, it can be a decisive factor for the success of entities selling online. Nowadays, attractiveness of the product and the quality of its promotion, are not enough guarantee success. The right time, price and the quality of product delivery to the final consumer, are also critical [6].

Consequently, e-trade development translates into growing logistics services industry and primarily its biggest and the most competitive sector - courier, express and parcel deliveries [7]. According to advisory firm PwC (*Perspektywy wzrostu rynku KEP w Polsce do 2018 r.*), CEP sector was worth PLN 5.1 bn in 2016 with 355 m parcels sent and delivered. It represents a 14% growth in relation to 2015 and a two-digit growth rate is expected to persist over following years. It is estimated, that in 2016 around 35% of revenues and around 46% of the market volume depended on B2C sector of e-commerce. These figures are expected to grow steadily. According to experts' estimations, by 2018 this industry will be valued at PLN 6.4 bn with around 440 m parcels delivered [8]. The development of the Polish CEP is shown in Figure 2.



* Forecast

Figure 2. Poland CEP sector development from 2011 to 2018

Source: own preparation on the basis of [8]

With intensive growth comes an increasingly stiff competition. Currently, in Polish CEP industry there are around 200 foreign entities varying in size, scope and geographical range of services [9]. In *Branża przesyłek kurierskich, ekspresowych i paczkowych. Wpływ na polską gospodarkę* report specific factors were presented, that are necessary for acquiring and retaining a competitive position in the CEP

sector, including elasticity (considered as the ability to adapt to surrounding changes), potential in terms of modification, widening and improvement of the set of offered services (adaption of solutions to customers' needs), cost reduction and rationalization as well as the ability to implement innovative solutions (e.g. technological). The report states that innovative solutions and equipping customers with convenient ways of collecting deliveries are as important as success factors in the CEP sector as timeliness and reliability of deliveries [10].

The recipients of e-commerce deliveries constitute a specific, conscious and especially demanding group of customers, which intensifies competition and leads logistics companies to invest in modern and innovative solutions and services. These innovations relate to the many areas of the organization, including the implementation of new services, the use of latest technologies and the creation of new business models.

Innovative services in logistics, including a focus on e-commerce market, are in line with trends observed in the other service companies. For example simpler product returns, demand forecasting, automated restocking, additional services (e.g. the installation of electronics / domestic electrical appliances during delivery) or a greater flexibility of services as a standard (e.g. to allow a change of date and time of delivery in real time). Technological innovations include issues associated with delivering and receiving packages (e.g. the use of drones, particularly in areas difficult to access), automation of warehouse processes (e.g. computer modelling of processes and the use of robots) and further development of existing technologies (e.g. replacing traditional scanners with mobile devices or using electric courier vehicles). Innovations in the area of business models include the increasing popularity of shared services (delivery service performed by the customers), the expansion of public network of service points for B2C (self-service machines used for delivery and receipt of shipments) and the implementation of logistics services to the standard operations of large multinational companies (international trade companies building their own supply chains) [11].

4. Activities of InPost SA Capital Group directed at e-commerce

One of the most innovative and dynamically developing entities operating in e-commerce industry offering logistic support of transactions made on the Internet is InPost SA Capital Group. The company specializes in delivery services for corporate and individual clients. Since 2015 the Group has been focusing mostly on e-commerce services. InPost implements cutting-edge solutions for personalized customer services and IT [12].

Table 1 presents changes in InPost's sales revenue structure resulting changes in the Group's activity profile. This information is based on InPost's mid-year shortened consolidated financial reports. Data in the Table include the period

between 2013 and 2016. Financial results of the Group in preceding years are not in the public domain (in 2015 the Group became listed on the Warsaw Stock Exchange, therefore it has been obliged to publish financial reports since then). In InPost's revenues structure following customer groups have been specified: public administration, big enterprises, collection agencies, small and medium enterprises, e-commerce and other distribution channels.

In 2013 big enterprises (56%) accounted for the biggest share of the Group's revenue structure. In the following year the revenue structure changed significantly with public administration having the greatest share (45%). Such a shift was the result of a deal, according to which since January 1, 2014, InPost SA Capital Group has been receiving, distributing and delivering mail and returning undelivered mail for Polish courts. The revenues from sales to public administration continued to be the biggest source of income until the end of 2015 (41%). The situation changed in the first half of 2016, when the share of customers from this group dropped significantly to 19%. This was caused by the termination of the deal for providing deliveries for courts on February 29, 2016. Since 2015 there has been major increase of e-commerce share in revenues from sales.

Table 1. Revenues from sales in different groups of customers in 2013 – 2016 (mln PLN)

	Pub. adm. *	Big enter. **	Coll. agenc. ***	S&M enter. ****	E-commerce	Others *****	Total
2013	6,18	103,64	10,01	37,94	21,38	6,00	185,15
Share in total	3,34%	55,98%	5,40%	20,49%	11,55%	3,24%	100,00%
1H2014	99,47	55,23	4,51	16,90	10,37	26,00	212,48
Share in total	46,81%	25,99%	2,12%	7,96%	4,88%	12,24%	100,00%
2014	198,55	104,84	10,25	56,99	30,96	41,79	443,38
Share in total	44,78%	23,65%	2,31%	12,85%	6,98%	9,43%	100,00%
1H2015	120,53	52,34	7,80	46,81	30,48	11,85	269,81
Share in total	44,67%	19,40%	2,89%	17,35%	11,30%	4,39%	100,00%
2015	231,93	90,94	16,87	105,28	113,85	14,51	573,38
Share in total	40,45%	15,86%	2,94%	18,36%	19,86%	2,53%	100,00%
1H2016	45,24	31,32	7,99	28,5	124,86	-	237,91
Share in total	19,01%	13,16%	3,36%	11,98%	52,49%	-	100,00%

* Public administration, ** Big enterprises, *** Collection agencies, **** Small and medium enterprises, ***** Other distribution channels

Source: own preparation on the basis of [13]

The e-commerce category, as specified in the reports, includes services provided for units operating in internet sales sector, such as internet stores and auction websites. In 2013 revenues in this category included mostly logistic support of the Parcel Lockers network. After a deal with Allegro Group in 2014, the category also includes income from deliveries generated by Allegro users. In relation to the widening of range of services provided by the Group by courier deliveries and InPost E-Commerce Registered Mail, this position also includes revenues from these categories from 2015 [12].

Marketing actions, new contracts, success in the courier deliveries sector, the addition E-Commerce Registered Mail to the range of services and a surge in customer interest in Parcel Lockers packages translated into high volume of deliveries provided by the Group. From January 2016 to May 2016 the Group shipped 16 m deliveries for e-commerce. Among the customers, the most preferred way of delivery was InPost Parcel Lockers. In the analyzed period this form of delivery gained 78.6% in relation to the same period in previous year. Increase of the courier deliveries' volume was equal to 70.6% in relation to period January 2015 – May 2015. For the third most important service provided by InPost and dedicated for e-commerce, which is E-Commerce Registered Mail, growth dynamics in analyzed period was 317.5% year-to-year [14]. The high volume of deliveries provided by InPost in the internet trade sector was a reason why in the first half of 2016 e-commerce accounted for 53% of overall revenues of the Group [13]. What is stressed by the Group's CEO, Sebastian Anioł, InPost offer will be expanded and the Group's strategy will continue to focus mostly on e-commerce – *“We are still expanding our offer and focus on the promising e-commerce sector. In our opinion this sector currently has the biggest growth perspective on Polish market and as such is a potential source of increasing the company's sale value in the upcoming quarters”* [21].

5. Services offered by InPost SA Capital Group dedicated to e-commerce

In the Group's offer directed mostly at e-commerce market participants, the following services can be specified: Parcel Lockers, courier services bundle and E-Commerce Registered Mail. Above-mentioned services have been described in the subsections below.

5.1. InPost Parcel Lockers

This service was introduced in 2009. The idea is to create a solution that allows the entities in the e-trade and mail-order sale sectors to independently send and pick-up at a convenient time and place. A parcel locker is a system of mail lockers (in varying sizes), where one can send or receive parcels 24/7 [10] . Thanks

to this solution logistics costs can be decreased through bulk delivery to a given Parcel Locker instead of every recipient individually [15]. At the moment of parcel delivery to a Parcel Locker indicated by recipients they are informed about this fact by a text message, which contains a code allowing them to open the corresponding locker in the device. This service has the benefits of both mail services (e.g. numerous pick-up locations) and courier services (e.g. quick delivery at a relatively low cost) [16]. Parcel Lockers are located mainly in shopping centres, at petrol stations and 24/7 car parks. At the moment of the service implementation on the Polish market the devices were planned to be located in the 20 largest Polish cities. Nevertheless, the demand for the service was so large, that its range has been expanded to a larger number of cities. A thousand of new devices are planned in 2016, which will result in their number increasing to 2600 [14].

The innovative idea of Parcel Lockers is based on advanced logistics solutions, cutting-edge information, communication and automation technologies and is precisely adapted to customers' needs. The system is based on the following key assumptions: a developed distribution network and a fully automated process, which allows for a significant service cost reduction and hence competitive rates for customers. In principle, the system was supposed to be simple and convenient, making the final phase of internet purchases easier. Customers expect quick and reliable deliveries at a convenient time – in the evening, night, often within a few hours from order placement, which is allowed by the system of Parcel Lockers. Therefore Parcel Lockers is a customer-oriented project. It is a new, as yet unknown way of satisfying identified human needs in terms of deliveries reception. This pioneering solution is an innovation designed and implemented following research, targeted at finding technologies to replace the traditional ways of conducting mail and courier services [10].

Innovative nature of Parcel Lockers has been received numerous awards, including E-commerce Paris 2015 (Logistics category), Engage Awards 2015 (Socially Devoted category) or Ekomersy 2014 (third consecutive distinction in the "Product/services supporting international expansion of e-shops" category) [17].

5.2. Courier services

Courier services offered by InPost SA Capital Group since 2015 have been targeted at individual and corporate clients. Courier services in connection with Parcel Lockers and a vast network of over 8,300 post offices is the only offer in Poland providing a complex and complementary range of logistic services domestically and abroad. The new solution helped expand the cooperation with the biggest Polish e-trade platform Allegro and many other significant e-commerce entities.

Courier services offered by InPost cover parcel deliveries to anywhere in Poland. All of the options in the domestic service are realized to a recipient's door

or one of the InPost Parcel Lockers [12]. Courier services introduced in 2015 immediately proved to be successful. During the first 7 months of operation 3.2 m deliveries were performed. It's worth noting that in the past similar courier operators attained such results after 7-8 years of operation. Such a result confirms, that in the Polish e-commerce market there was demand for an integrated solution allowing customers to order all services at one place. This fact significantly simplifies operations on the e-trade market, mostly through 'Manager Paczek' software, that is used for sending parcels, invoicing and handling returns. Thanks to *Manager Paczek* the sender chooses one of delivery options: door-to-door, which is pick-up of delivery at the sender's and delivering it to recipient's door, or collection from a specified place and delivering to recipient's door, e.g. from InPost Customer Service Offices [14].

Additionally, in 2016 a dynamic forwarding service was introduced. It enables free of charge modification of delivery pickup place, which, depending on client's preferences, can either be an indicated Parcel Locker or a Customer Service Office. This service is in line with the strategy of multichannel supplies and their optimization, what is one of the key objectives of InPost. According to the Group's data (published on InPost website) a quarter of courier deliveries is redirected to Parcel Lockers or Customer Service Offices, which confirms the demand for such services [18].

5.3. InPost E-commerce Registered Mail

In 2015 apart from introduction of courier services, InPost added another solution to its offer of e-commerce services – InPost E-commerce Registered Mail. This offer guarantees customers performing online purchases quick 'to-door' delivery within three working days. E-commerce Registered Mail is an alternative to courier deliveries in the case of small size of shipped products (up to 1 kg, e.g. jewellery, CDs, beauty products, games or books) at a competitive price (PLN 4.99 net). The low price and high quality attract customers looking for good value for their money, who do not want to overpay for a logistic service, especially when the value of the goods is low. The service includes delivery notifications for customers and return to sender free-of-charge if the parcel is not collected by the recipient. E-commerce Registered Mail allows for monitoring of the delivery at each phase of the process – by the sender in 'Manager Paczek' software and by the recipient on the website [19]. This solution can surely be found attractive by entities in the e-commerce industry. This service is cheap, convenient and safe for both e-sellers and e-customers.

InPost E-commerce Registered Mail was implemented in response to current internet trade market needs. Shipping cost minimization is the service's key advantage for consumers shopping in e-stores. The Gemius report shows that lower shipping costs would entice 69% of consumers to buy online more often [1].

Forrester Research (FR) also confirms this claim. According to FR, excessive shipping costs are the most common reason why consumers refrain from shopping online [19].

6. Conclusion

Booming e-commerce directly translates to a growing logistics services' sector, particularly courier, express and parcel delivery industry. E-trade delivery recipients are a conscious, and exceptionally demanding group of customers, which intensifies competition in the CEP market. The analysis of drivers of competitiveness in logistics services has found that innovative solutions and equipping customers with convenient ways of collecting deliveries are becoming as important as success factors as timeliness and reliability of deliveries.

One of the most innovative and dynamically developing entities operating in e-commerce industry offering logistic support of transactions made on the Internet is InPost SA Capital Group. The company specializes in delivery services for corporate and individual clients. InPost as the operator who revolutionized Polish e-commerce industry, systematically realizes its strategy in terms of internet trade solutions. Based on in-depth consumer preferences analyses and as part of optimization process of solutions dedicated to e-commerce, the Group takes actions to increase the functionality and quality of its services.

To 2013 the Group's offer related to e-commerce comprised mostly the logistic support of Parcel Lockers network. In the subsequent year, in relation to establishing cooperation with Allegro Group, InPost expanded its offer by services dedicated for Allegro clients. In 2015, the range of services provided by the Group was expanded by introducing courier services and InPost E-Commerce Registered Mail. These new services in relation to Parcel Lockers and broad network of post offices constitute the only offer providing a complex and complementary scope of logistic services in Poland.

The success of solutions offered by InPost SA Group to e-customers, is mainly reflected in increase in the volume of shipments serviced by InPost, but also in consumer research. Research carried out in 2015 (within the Polish-Norwegian Project GRASS, the contractor – Maritime University in Szczecin) concerning InPost customers' opinions about the Parcel Lockers services showed that 75% of users rated it "much better" or "better" than traditional courier services. At the same time, 89% of respondents were prepared to recommend the terminals to their friends. Among the proposed factors driving the choice of this form of delivery, 75% of respondents cite the ability to receive shipment 24/7 as a reason. Over 70% of respondents considered that the service is competitively priced. Approximately 59% of respondents indicated that their decision to use the Parcel Lockers was driven by a convenient location of the terminals [20].

The InPost SA Capital Group management emphasizes that one of its priorities is the systematic tracking of the needs of online customers and creating a product mix that reflects those needs. According to the current Group's development strategy, its activity will be focused around the e-commerce sector in the near term. The logistical servicing of Parcel Lockers, courier services and the delivery of registered letters for online customers will be the main source of growth and diversification of sales in the years to come, and the pace of development in this sector will have a direct impact on the financial results of the Group [12].

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THE CONCEPTIONS OF NEW PAYMENT METHODS BASED ON REVISED PAYMENT SERVICES DIRECTIVE (PSD2)

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In the paper the conceptions of new payment methods in E-commerce and M-commerce (“1XPay” and “ScorePay”) are presented. The systems are a proposition of one touch payment based on existing banking accounts and postponed payment system based on the credit scoring check, both in compliance with Revised Payment Service Directive.

Keywords: Payment Systems, E-business, E-commerce, M-payment, One Touch Payment, Postpone Payment, Payment Initiation Services, Screen Scraping, Account Information Services, Third Party Payment Service Providers, The Revised Payment Services Directive

1. Introduction

The Payment Services Directive [1] (PSD, 2007/64/EC) is an EU Directive, administered by the European Commission (Directorate General Internal Market) to regulate payment services and payment service providers throughout the European Union (EU) and European Economic Area (EEA). The Directive's purpose was to increase pan-European competition and participation in the payments industry also from non-banks, and to provide for a level playing field by harmonizing consumer protection and the rights and obligations for payment providers and users [2].

On October 8, 2015, the European Parliament adopted the European Commission proposal to create safer and more innovative European payments (PSD2). The new rules aim to better protect consumers when they pay online,

promote the development and use of innovative online and mobile payments, and make cross-border European payment services safer [3].

Commissioner Jonathan Hill, responsible for Financial Stability, Financial Services and Capital Markets Union, said, "This legislation is a step towards a digital single market; it will benefit consumers and businesses, and help the economy grow." [3].

On November 16, 2015, the Council of the European Union passed PSD2. Member states will have two years to incorporate the directive into their national laws and regulations [4].

Changes and major impacts due to PSD II brings to the Third Party Providers (TPPs) non-discriminatory treatment and guaranteed technical access to the banking payment systems. Since the PSD was adopted in 2007, new services have emerged in the area of internet payments, where so called third party providers (TPPs) offer specific payment solutions or services to customers. For example, there are to services which collect and consolidate information on the different bank accounts of a consumer in a single place ("account information services - AIS"). These services will typically allow consumers to have a global view on their financial situation and to analyse their spending patterns, expenses, financial needs in a user-friendly manner. Other third party providers facilitate the use of online banking to make internet payments (so-called "payment initiation services – PIS"). They help to initiate a payment from the user account to the merchant account by creating a software "bridge" between these accounts, fill-in the information necessary for a transfer (amount of the transaction, account number, message) and inform the merchant once the transaction has been initiated.

Until now, entering the market of payments was complicated for TPPs, as many barriers were preventing them from offering their solutions on a large scale and in different Member States. With these barriers removed, more competition is expected with new players entering new markets and offering cheaper solutions for payments to more and more consumers throughout Europe [5].

2. Current state of knowledge - payment systems, Third Party Providers

From technical point of view in electronic payment systems based on the online banking, data access and processing is among others possible, thanks to the 'screen scraping' method, which allows in the previously configured way to look in on the account information and thereafter automatically read and download data as current balance, transactions, crediting and debit history. Via the API interface and the universal tag language intended to represent various data in structuralized way

(xml) these data may be exported and be of use in scoring rate or other linked services, with the consumer acceptance.

For the analysis of the above information may be of use the sophisticated algorithms aggregating data and giving it specified merit.

The example of practical business use of the account information service 'AIS' is the Zaplo company (www.zaplo.pl), which in the competition to bank offers came to the market with the installment loan up to 10 thousand PLN available in 15 minutes online.

Clients may submit an application and sign the agreement via the Internet and after a dozen or so minutes have the borrowed money on their bank account. The service works in a way, that the client provides his bank account login information to the entity which can check the transaction history on his account. On this basis the loan company is able to count the consumer's creditworthiness and make the instant decision about conferring or refusing the loan or credit.

The 'AIS' service is provided in this case by the Instantor company (www.instantor.com), the Swedish company which offers the customer's account history analysis from last 12 months. The Instantor besides Sweden and Poland operates also in England, Spain, Germany, Finland and Croatia.

Similar 'AIS' services are also provided by the Polish company 'Kontomierz.pl' with its 'Kontomatik' service (www.kontomatik.pl), bought in 2015 by the German Kreditech.

The other entity which belongs to the Third Party Payment Service Provider 'TPP' group and works as Payment Institution Service 'PIS' is the Sofort company (www.sofort.com) which belongs to Klarna group (www.klarna.com) being the leader in direct payments in Germany. More than a half of all online shops in Germany are Sofort partners.

The company cooperates with the online shops and designers of e-commerce and shopping platform software in Germany, Austria, Switzerland, Holland, Belgium, Poland, Hungary, Italy, Spain, France, Czech Republic, Slovakia and Great Britain.

The Sofort payment system is one of the direct online transfer methods and works based on the existing online banking systems. It doesn't require registration of virtual account, so called 'electronic wallet'. While doing shopping via Internet, the consumer is automatically relocated to the encoded payment form. The order details are automatically passed. The data is passed to the consumer's online banking and the seller receives confirmation about starting the transfer and can start with the order realization at once. The company doesn't own means of payment at any step of the procedure and is just a technical middleman initiating the service of transfer coming from consumer's online banking.

The automated access to the account works by the background sessions and 'screen scraping' technology without active collaboration and mediation with the interface coming from banks.

The Polish payment system eXpay (www.expay.pl) created by author of this article works in similar way.

A mean of the use of 'Big Data' technology in payment services is Klarna (www.klarna.com) system which provide simple and safe way of making payment for over 25 million users daily. The service works among others in Scandinavia where it mediates with 20% of all online transactions. It also works in Germany, Austria and USA offering conveniences for either consumers and goods deliverers.

An interesting way of payment is 'Klarna Invoice' which allows client to pay after receiving the goods. After the uploading of minimal information and choosing the payment method, the parcel is being delivered along with the invoice (which may also be sent via e-mail). All the invoices should be paid in 14 days time.

The idea of the whole enterprise born in Stockholm School of Economics where the three founders decided to invent a simple and safe payment system which would be comfortable for sellers and purchasers.

The company uses its own algorithm of risk related either with prospective fraud and credit risk, employs 80 data analysts.

The system examines over 200 factors that may affect the risk rating. Among others it is historical data of former transactions, their frequency, kind of purchased service or good and time when the orders are placed, according to the given time zone. The Algorithm can also rate the consumer's unusual behavior and to the risk rating of the postponed payment it uses e.g. correlations between the device's IP address, purchaser's geographical location and his address of residence or the declared delivery address.

The exemplary scenario: if the consumer suddenly orders 100 USB keys on the address significantly different than the one shown by his IP geolocation and what is more – he fills the form in suspiciously long time or an aged person is buying one-time multiple number of video games in the middle of the night, the algorithm allows to decide if it is necessary to attempt additional precaution.

In these cases Klarna may reduce the possibility of purchasing with postponed payment date or ask for more information.

According to the PayPal research with Ipsos [6], m-commerce growth is almost three times faster than e-commerce at a whole. From 2013 to 2016, the year's average growth rate of mobile commerce in Poland will be 32,8 percent in comparison to 10,4 percent growth of e-commerce in all (considering the mobile commerce).

PayPal has implemented some simplification for consumers paying from mobile devices. Its 'One Touch' service is an optional function of the PayPal system which allows to do shopping faster and safer. After logging in the PayPal system from mobile phone, tablet, laptop or desktop computer it is possible to choose an option without logging off in order to realize transaction with all authorized web pages faster and more comfortable. If the user chooses the option without logging off, during the next purchase with the use of the same device and the same web browser, he doesn't need to log in the PayPal system again. Switching on the 'One Touch' function allows direct move to the payment page and fast realization of the purchase. Moreover there is no need to remember the credit card billing nor enter the password to the system.

The answer to the 'One Touch' service on Polish market is the PayU Express Service. This method allows to save debit card and/or bank account data in PayU application and later realization the purchase without logging in the bank account and rewriting the SMS passwords nor providing the card information. The solution works in cooperation with six banks that decided to collaborate that way with PayU.

3. Criticism of solving the problem by the use of current methods

In context of solutions already used it is possible to notice some limitations which either impede the development of mobile e-commerce and the retail systems with postponed payment date.

As far as the case of the systems based on the use of the credit card (PayPal) the issue of ergonomics and payment comfort along with the transaction's high safety level has been majorly brought under control, the use of the payment systems based on the online banking contains some vivid inconveniences.

Not every seller cooperates with PayPal enthusiastically, especially those acting on a market with aggressive price policy because of the offer competitiveness they cannot share a high, even 3 percent commission with payment middleman.

As a barrier in m-commerce development in microeconomic scale and technological aspects for the systems based on the Internet banking, we should consider every-time necessity of confirming the transaction with one-time code sending independently by the SMS. Switching during the transaction between the mobile web browser window and phone message inbox in order to check or copy even 8-digit number is onerous and not ergonomic for a casual user. It decreases

quality of the experience gaining by the consumer while using this kind of transaction and dishearten him to make another purchase in mobile form.

The problem applies either standard e-transfers methods ('pay-by-link') and services which only initiate the 'PIS' payment because the transaction confirmation is analogical in both cases.

The solution proposed by PayU express is not, unfortunately universal. Cooperation with not even a half of the banks and only in the Poland area does not guarantee common use of this method and the active contribution of financial institution in the transaction reduces opportunities to lower the costs of the payment integrator mediation.

In the case of the systems which allow to sell with postponed payment, despite the use by its designers more and more creative and sophisticated behavioral analysis techniques entered to the 'Big data' concept, it is possible to point out lack either in the safety of used methods and their business effectiveness. Assuming any abuse from the user who is aware of protection used it is hard to eliminate frauds and losses. The lack of specific information about purchaser's financial and credit situation along with his unusual behavior may block the transaction as a result of false alarm and influence the decision about the transaction resignation. All at all it may lower the seller's conversion ratio.

There is lack of the research about how the disadvantages and risks mentioned above reduce the advantages coming from the use of sale with postponed payment.

Similarly, to the solution offered by PayPal, quite high commission imposed on the seller affects the competitiveness of electronic business. It can be assumed that its height compensate the risk related with the payment's postponing.

4. Methods of solving problems – author's conceptions

1. New method of mobile payment system – "1Xpay".

The method applies to the mobile payment system in the Internet while using online banking and existing banking software. The operation works by making a purchase with a mobile, direct transfer, using 'screen scraping' technology and transaction actions automation. The system is independent from online banking system platforms used by the consumers. It allows to skip the active bank contribution and what comes with it – to lower the costs in micromanage and raise of competitiveness of the electronic business in macroeconomic scale.

2. New method in payment system with postponed payment date – "Scorepay".

By the use of the existing creditworthiness rating method realized by 'account information service AIS' type systems we can adopt their technological progress

not only to grant credits and loans, but also for the need to build an integrated electronic payment system with postponed payment date service. A system based on that rule could minimize abuse risk for payment system provider who is responsible for transaction payoff. The method would reduce false alarms and refusals and thereby make the service possible to be suggested to higher number of potential purchasers. When the active bank contribution in the transaction is no longer needed, it is possible to decrease sell costs and grow the competitiveness in electronic business.

4. Presentation and characteristics of new methods

1. New mobile “One Touch” payment method “1Xpay” is a working name used in the current project development. Process run is illustrated in Figure 1.

Client installs on the smartphone-type mobile device the '1Xpay' application in which he enters his online banking credential data (login and password). The '1Xpay' application with the user's acceptance encodes and store credentials data in his mobile device. The application also asks during the installation for granting the access to mobile phone's text message inbox. In order to make a transaction it is required to use compatible online payment system by the seller ('eXpay' in this case) and to make doing purchases possible with the system.

Client connects with the sellers via the Internet, using mobile device and indicates his intention to buy some goods and confirms the terms of transaction next. Optionally in the devices equipped with the fingerprint reader the applications request an authorization with placing the finger and then starts a connection with purchaser's bank server by a specific software of the eXpay payment system. The software working in the background with the use of the 'screen scraping' technology fills the form with client's data to the on-line banking automatically, logging on the account without any further client's contribution, it reads the charts in purchaser's on-line banking system and according to the previous disposition sends transfer to the sellers account with the agreed amount. In its next step the bank's server sends a one-time authorization code on his mobile device using the SMS channel. The purchase confirmation comes due to entering the transaction authorization code properly in the on-line banking system. The specific 1Xpay application software, installed on the mobile device reads the incoming one-time code in the purchaser's inbox and remembers it. Next, the software reads the right spaces in buyer's on-line banking system and enters the one-time authorization code remembered before, placing it in the adequate place in banking system and confirms the transaction.

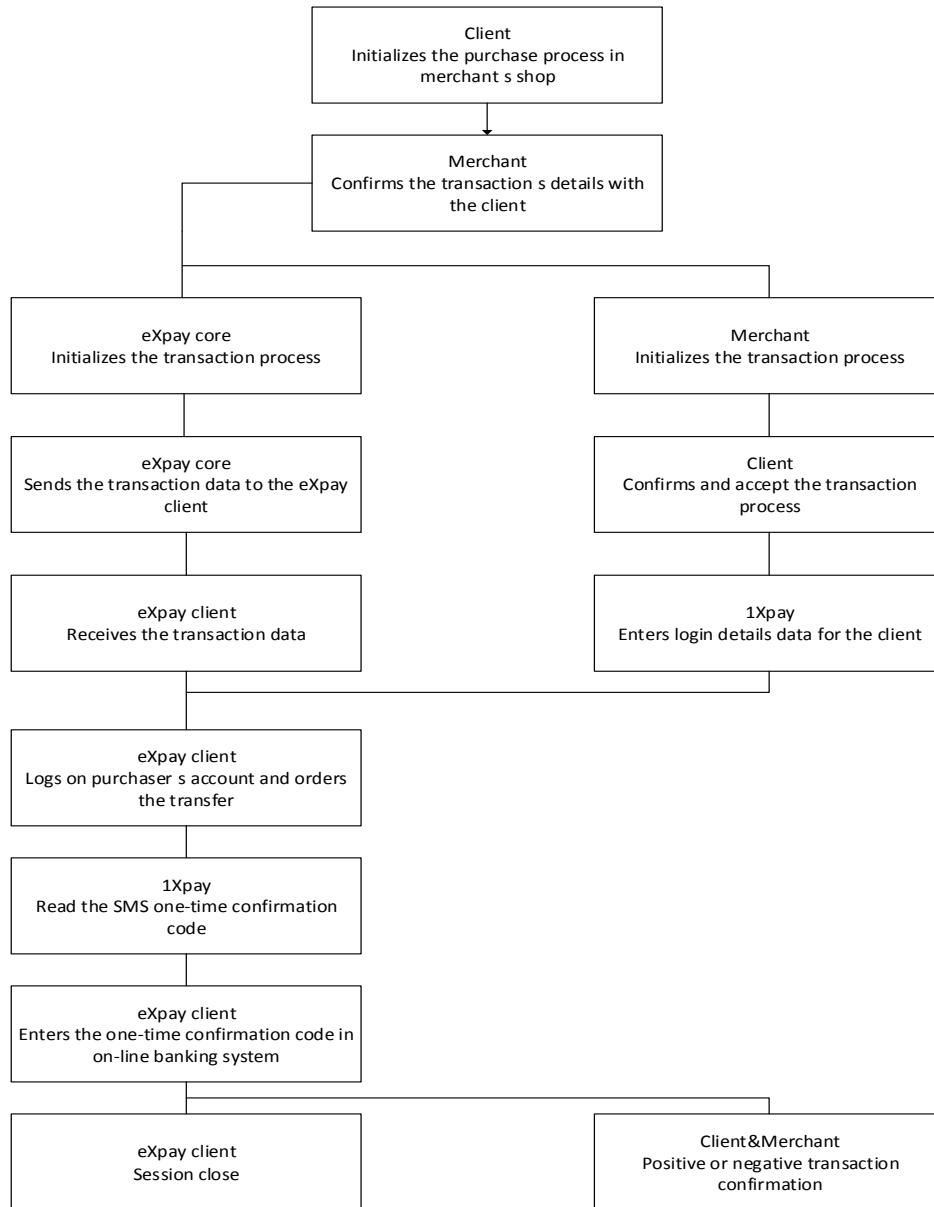


Figure 1. 1Xpay solution

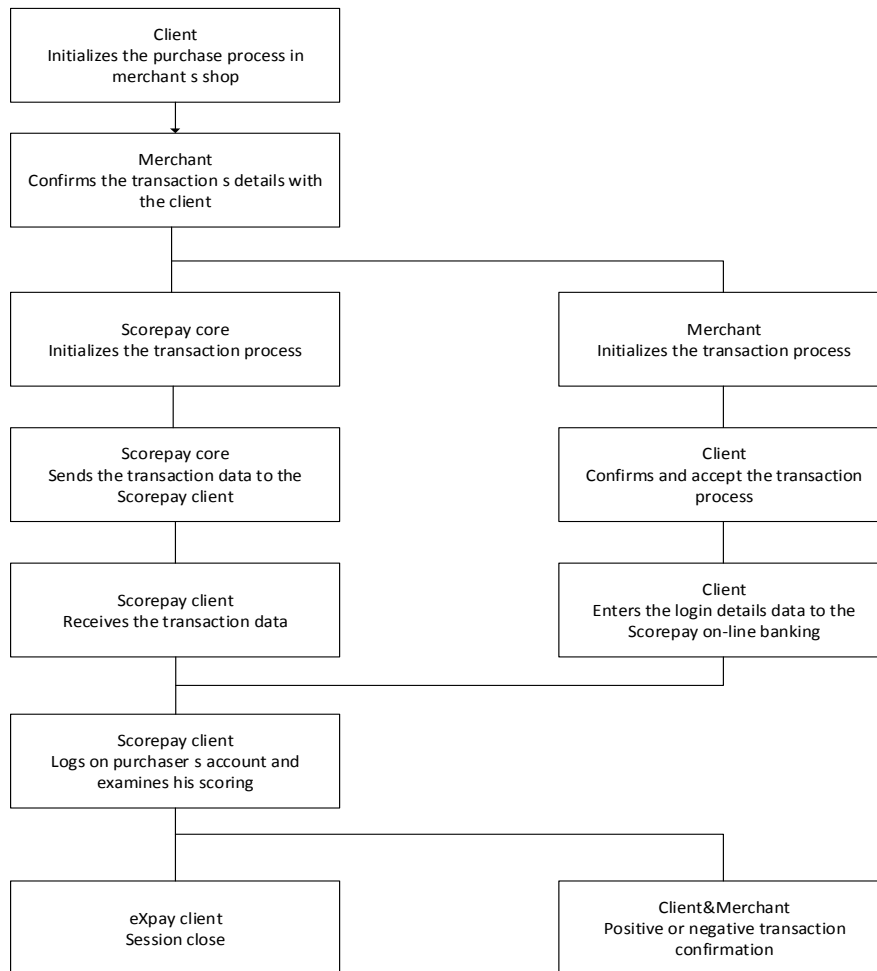


Figure 2. Scorepay solution

2. New method of sale system with postponed payment date – “Scorepay”. The process run is illustrated in Figure 2.

The payment system operating during the use of the on-line banking and already existing banks’ software during which client connects with the seller via the Internet in order to make a purchase and indicates his intention to make a purchase with postponed payment date.

As a result the shop's integrated system of computer application (payment system) asks the client for his on-line banking system login data (login and password), next it connects the bank's server with a help of the 'Scorepay' software. The 'Scorepay' software, working in the background with a use of 'screen scraping' technology enters the login data given before automatically for the client and it reads the clients bank account's history of transactions. With the use of the parameterized algorithm it rates the solvency by analyzing the account data – if the client has sufficient payment scoring (fraud scoring) to complete the transaction with postponed payment date.

For this purpose, for chosen period e.g. 6 months, the software using the algorithms of the 'Scorepay' application and the 'screen scraping' technology performs an automatic check of the data such as balance, crediting regularity, if there was any penalty percentage counted or bailiff executions and other information important from the scoring point of view. If the verification ends positively, the client receives such an information via the 'Scorepay' system – a confirmation of the ability to make a transaction with postponed payment. If it ends negatively, the client receives a message with negation.

5. Conclusion

The new EU rules and the above proposed payment methods should help stimulate competition in the electronic payments market, by providing more convenient in use and easy in adoption solutions. This would then allow consumers to benefit from more and better choices between different types of payment services and service providers. During the past years, new players have emerged in the area of internet payments offering consumers the possibility to pay instantly without the need for a credit card (around 60% of the EU population does not have a credit card)[5]. These services establish a payment link between the payer and the online merchant via the payer's online banking module. These innovative and low cost payment solutions called "payment initiation services" are already offered in a number of Member States (e.g. Sofort in Germany, iDeal in the Netherlands, Trustly in Sweden, eXpay in Poland).

Proposed author's method "IXpay" is during implementation in accordance with "RTS" (Regulatory Technical Standards) published by the European Banking Authority(EBA). These Regulatory Technical Standards on strong customer authentication and secure communication under PSD2 have major consequences on the current standards and established processes with cashless transactions.

The new rules and payment methods will contribute to a better consumer experience when paying throughout the European Union.

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IT MARKET IN POLAND

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The paper presents the changes that have taken place in the IT market in Poland. It was examined both the supply side and the demand side of the market. Throughout the IT sector in Poland in 2014 were employed 400 thousand people. This was a market creating the most new jobs in Poland. The value of the IT services market in Poland represented about $\frac{1}{3}$ of the total value of the domestic IT market. The largest share in sales of IT products and services in Poland had equipment (53.5%), then services (30%) and finally software (16.5%). From Poland were exported mainly services programmers for foreign customers. It is expected that in the coming years, the largest increase will occur in the case of cloud solutions, and subsequently the data center and outsourcing services. Most sensitive to changes in the economic is IT hardware sector, less software and services.

Key words: IT market, hardware, software, ITT services

1. Introduction

Information technology tools include all elements allowing IT to function and develop itself. They involve computers and technical equipment cooperating with them, computer software, methods of communication between computers, methods (algorithms) of solving particular tasks, methods and tools of data organization, storage and transfer as well as programming languages [1, 2].

In the entire IT sector in Poland in 2014, 400,000 people were employed. It is a market creating the largest number of new workplaces in the country. In Poland

there are plants producing computer hardware, however, the number of hardware produced constituted two thirds of the desktop computers sold in the country. About 10% of computer hardware market in Poland accounted for tablets [3].

Firms providing IT services employ more than 140,000 people in Poland. It has been estimated that, in 2013, IT services accounted for 1.7% of the value of the global IT services market. The value of the IT services market in Poland accounted for one third of the total value of the domestic IT market. The number of firms providing IT services which operate in Poland is increasing rapidly as it increased by half, from 40,200 to 60,700, in years 2009 – 2013. The highest increase in the number of firms (by over 60%) was recorded in Wrocław, Kraków, Lublin and Rzeszów. At that time, two thirds of workers were employed in firms with foreign capital [4, 5].

In 2010, HP ranked first in the world in computer sales, followed by Acer and Dell. In 2014, 308,600,000 computers were sold around the world. The leaders were Lenovo (19.2%) and HP (18.4%), followed by Dell (13.5%), Acer (7.8%) and Apple (6.4%). It is worth noting that a yearly decrease in computer sales is recorded, mainly due to the competition of tablets and smartphones. Fewer and fewer desktop computers are being bought, whereas the number of laptops bought remains at the same level. It is predicted that in the next years the entire sector of computer hardware and other equipment will increase in the annual rate of 2-3% [6, 7, 8, 9]. In the case of business software, the world leader in 2014 was Oracle (17.3%), followed by SAP (14.3%), IBM (11.4%), Microsoft (8.4%) and SAS (6.8%) [10].

In 2014, the biggest IT firms in Poland based on sales revenue were consecutively HP Poland, Action, AB, ABC Data, Lenovo Poland, Komputronik, IBM Poland, Asseco Poland, Microsoft, and Dell Poland. In the majority of the firms, their activity was 100% connected with IT. In 2014, the biggest share in the sales of IT products and services in Poland had hardware (53.5%), then services (30%) and, finally, software (16.5%). Mainly programming services for foreign clients were exported from Poland [11].

A barrier to a faster IT market development in Poland is limited capital for IT investment in firms. The biggest chance, in turn, is greater use of European Union funds and raising awareness of the firms about benefits of IT investment. It is predicted that in the near future the largest increase will be recorded in cloud solutions, and subsequently, data center solutions and outsourcing services [12, 13]. The development of the sector in the future will be concerned with the application of solutions within cloud, mobility, Big Data/analytics, social technology, Internet of Things, 3D printing, automation/robotics and cybersecurity [14].

At the beginning of the twenty first century, an increase in the sales of software and services and decrease in the computer hardware sector can be observed.

The situation on the IT market in Poland was dependent on the economic trends. IT hardware sector is most vulnerable to economic changes, whereas software and IT services sectors are less so [15, 16].

2. Research methodology

The main objective of the study was to assess the functioning and changes taking place on the IT market in Poland. The detailed objectives included: presentation of the meaning of IT in economy, specification of changes on the IT market, depicting of correlations between IT market and economic condition of the country. Research encompassed the period of 2005-2015. The source material includes foreign and domestic literature on the subject, numerical data provided by the Central Statistical Office, reports and studies on IT. The work was developed using the descriptive, tabular and graphic tools, as well as the correlation coefficient. In order to determine the relationship between the economic condition in the country and the IT market, the correlation coefficient was applied. The indicators describing the economic condition of the country included indices of changes in GDP, gross value added, domestic demand, import and export. On the other hand, the parameters describing the condition of the IT market included the market value and the dynamics of its changes, the number of computer sales and the dynamics of its changes, the domestic computer production and the associated change dynamics. The demand side of the market was presented on the basis of surveys conducted by the Central Statistical Office.

3. The results

IT market in Poland is one of the most dynamically developing areas of activity. In 1995, the market value was about \$ 1.2 billion, and, in 2015, as much as \$ 15.7 billion, which means a thirteen-fold increase (Fig. 1). In the final years of the twentieth century, the changes were not big. It was only after Poland's accession to the EU that a dynamic market growth occurred. Poland gained free access to the huge European market and also saw the inflow of capital from abroad. As a result, the IT industry began to expand rapidly. Of course, market trends and its structure were changing. In addition to hardware sales, IT services started to gain importance. In years 1995 – 2015, the industry increased on average 14.2% per year. It should also be noted that during the economic crisis there was a decline in the value of the IT market by 9.7%. It was the only year in which there was a decline. The largest increases were recorded in 2004 – 2007, as in each of these years the

value of the IT market in Poland increased at least 25% annually. 2006 was a record year with the growth rate of 36.2%.

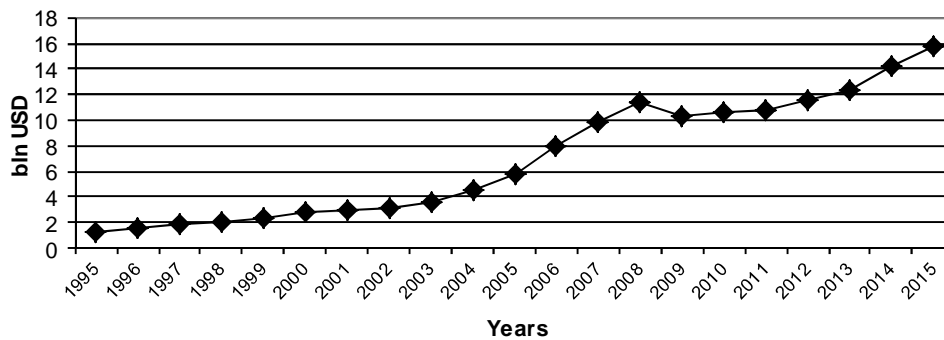


Figure 1. The value of the IT market in Poland in 1995-2015 (bln USD)
Source: IDC Raports.

Computer sales was the most important area of the IT market. Initially, in 2005 – 2007, computers sold were imported (Fig. 2). Since 2008, a large increase in the production of computers can be noted, which is related to the launch of plants in Poland. At the same time, it should be added that domestically produced computers were largely intended for export. Imports of computers also occurred. In 2009 – 2011, Poland produced more computers than it sold. In 2009, there was a decline in their sales, however, their production was increased despite the economic crisis. Peak production took place in 2010, followed by a gradual decline in the number of manufactured devices. In years 2013 – 2015, sales amounted to around 5 million units. On the market there appeared changes in the structure of devices sold. In the 90s of the twentieth century, in the early stages of the development of the IT market, desktop computers dominated in sales. After Poland's accession to the EU, laptops gained a significant advantage and accounted for two thirds of the market. Desktop computers were an important tool not only at work but also for customers requiring the highest quality equipment. In subsequent years, the importance of tablets on the market increased, and they slowly started to replace laptops. Here changes in the structure of the equipment are also observed. Small tablets are replaced with bigger ones or smartphones. The future of the market should belong to large-screen tablets, at least 9-inch, or big smartphones, so called phablets (with screen sizes from 5.5 to 7 inches). In the second decade of the twenty first century, there was a rapid increase in the sales of hybrids, that is tablets with an attached keyboard. The most important characteristics on the market are associated with versatility and mobility.

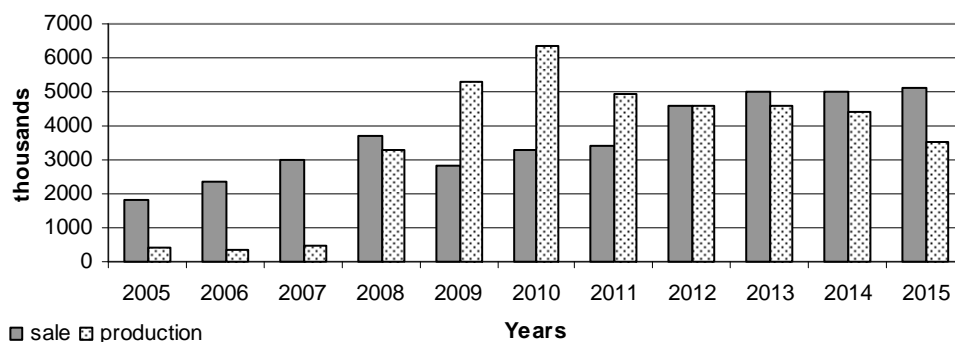


Figure 2. Production and sales of computers in 2005-2015 (in thousand)
Source: IDC Raports, publications of the Central Statistical Office.

The number of computer equipment systematically increased in Poland (Fig. 3). In the case of enterprises, the percentage of entities with computers in years 2005 – 2015 exceeded 90% and it underwent little change. In the final period of the analysis, even a small decline of this indicator in this group of entities can be observed. Changes in households were very dynamic. In 2005, only 40% of these individuals had computers, and, in 2015, as many as 78%. Already in 2005, the computer was indispensable work tool in firms, while private users started to use computers with their greater affordability. Household computer ownership shows how the market changes and what the level of its saturation is. What should also be taken into account is the fact that in some households there is more than one computer, and the replacement of equipment usually occurs every 5-6 years. There is also a group of customers who follow new market developments and replace equipment frequently.

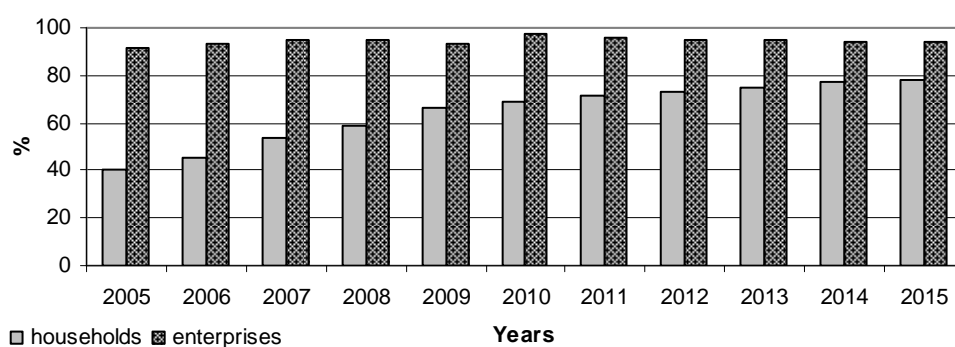


Figure 3. Access to computers in households and enterprises (in% of total in the group)
Source: publications of the Central Statistical Office

The demand side can also be characterized by access to the Internet. The greater it is, the faster demand for devices, applications, and services grows. As in the case of computer equipment, dynamic growth was observed in households (Fig. 4). In 2005, only 30% of these entities had access to the Internet, whereas in 2015 it was already 76%. It can be concluded that the rate of change was similar to this in the case of computer equipment. Internet is, as a matter of fact, a service complementary to computers. In the firms, already in 2005, 87% of the entities had access to the Internet, while in 2015 93%. Saturation with these services took place earlier, already in 2010 (96%). It should also be noted that structural changes occur on the market. New fast broadband Internet services are introduced. As in the case of computers, customers pay more and more attention to mobility.

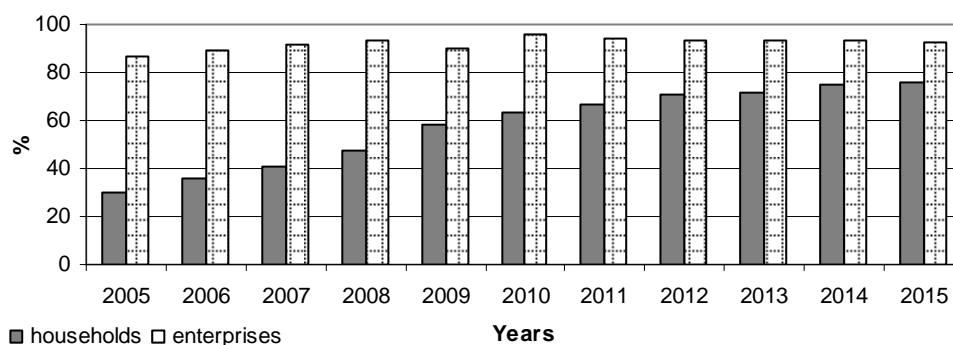


Figure 4. Access to Internet in households and enterprises (in % of total in the group)
Source: publications of the Central Statistical Office.

Table 1 presents results of the Pearson correlation coefficient and p value. The limit value of significance level was assumed to be $p = 0.05$. Significant correlations were marked by grey background of the text. Correlation coefficients were calculated for years 2005-2015.

Very strong positive correlation values were found to exist between the condition of economy and value of the IT market and the computer sales and production in Poland. IT market developed faster and independent from economy, therefore, no significant correlation was found. Only in the case of changes in foreign trade, strong dependencies in relation to the change in the market value and dynamics of computer sales occurred. The relations were stronger for changes in exports than imports. The research confirms only a weak relation between the dynamics of changes in the parameters of the economy and the dynamics of changes in the production of computers. Production and assembly of these devices were transferred to other parts of the world. Additionally, a change in the demand of customers and increased demand for tablets and smartphones as well as decreasing demand for desktop computers and laptops were also mentioned.

Table 1. Pearson correlation coefficients between the situation and changes in the IT market and selected parameters of the economy

Parametrs	Pearson correlation coefficients				
The coefficients of correlation between the value of IT market and					
	value of GDP	gross value added	value of domestic demand	value of export	value of import
correlation	0,935	0,933	0,943	0,951	0,974
p value	0,001	0,001	0,001	0,001	0,001
The coefficients of correlation between the dynamics of change in value IT market and					
	dynamics of change GDP	dynamics of change gross value added	dynamics of change in value of domestic demand	dynamics of change in value of export	dynamics of change in value of import
correlation	0,564	0,536	0,621	0,932	0,722
p value	0,071	0,089	0,041	0,001	0,012
The coefficients of correlation between the number of computer sales and					
	value of GDP	gross value added	value of domestic demand	value of export	value of import
correlation	0,927	0,926	0,898	0,958	0,931
p value	0,001	0,001	0,001	0,001	0,001
The coefficients of correlation between the dynamics of change in the number of computer sales and					
	dynamics of change GDP	dynamics of change gross value added	dynamics of change in value of domestic demand	dynamics of change in value of export	dynamics of change in value of import
correlation	0,300	0,274	0,394	0,753	0,632
p value	0,300	0,444	0,261	0,012	0,050
The coefficients of correlation between the number of computer production and					
	value of GDP	gross value added	value of domestic demand	value of export	value of import
correlation	0,704	0,710	0,736	0,569	0,593
p value	0,016	0,014	0,010	0,068	0,054
The coefficients of correlation between the dynamics of change in the number of computer production and					
	dynamics of change GDP	dynamics of change gross value added	dynamics of change in value of domestic demand	dynamics of change in value of export	dynamics of change in value of import
correlation	0,069	0,074	0,158	-0,201	0,054
p value	0,849	0,839	0,663	0,578	0,882

Source: own research

4. Summary

The market of IT in Poland is among the fastest developing markets – the dynamics of development in years 2005 – 2015 exceeded ten percent of growth annually. The supply side is made up of computers and data processing equipment, software and companies providing services. Rapid and dynamic changes which resulted from the introduction of new products, such as tablets, smartphones and phablets, emerged on the market. The demand side is created by customers who purchase computers and use the software. In years 2005 – 2015, the share of households having computers and Internet access grew systematically. In the case of enterprises, the share of entities with access to computers and the Internet was at a high level, so the changes were little. In the case of households, a correlation between computer possession and the Internet access has been found. As mentioned, the demand for hardware changed fairly quickly, as was the case with the Internet, which offered better services over time, such as broadband and mobile Internet. A very high level of correlation between the market value and the number of computer sales in years 2005-2015 and the measures of economic condition of Poland was found. No correlation was found when comparing the dynamics of market changes and economic condition. IT market had developed faster and independent of economy.

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MANAGEMENT AND CONTROL OF SMART CAR WITH THE USE OF MOBILE APPLICATIONS

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Nowadays electronic world is being introduced into every area of our life. The smart car is a new generation of smartphone, very useful and necessary for many of us to live. That is why a lot of producers try to thrive in this area. Over the last twenty years people experienced a rapid progress in the telephone branch, probably in over next twenty years they would expect the same situation on cars field. The problem presented in the paper concerns the possibility of creating a mobile application for management and control of a smart car.

Keywords: Smart Car, Mobile Application Development, IOS Platform, Android Platform

1. Introduction

Nowadays electronic world is being introduced into every area of our life. Recent ten years abound with devices using new technologies and broaden their functionalities. One of them is simply telephone. Within last years it evolved into Smartphone – modern device replacing big sort of other devices. Today most of people are using this tiny computer, therefore software producers are outrun by customers with providing better and more innovative software for home or corporate user. However, there are still some undiscovered areas which unravel plenty of features that could be very helpful in everyday life. One of them is smart-car – an area which still turns out to be more mechanical than electronic.

Currently, there are more than one billion of cars in the world; one third of them is actually used for business, but only 2% of them are permanently connected and monitored online. People become accustomed to use smartphones the whole day. Ever since the introduction of the smartphone, automakers have been catching up with introducing similarly useful electronics in the dashboards of new models. With even the newest model of cars hobbled by slower development and production timelines, however, drivers found the navigation applications on their phones more capable and up-to-date than the ones in their dashboards.

The main problem is to provide a suitable application which can contain all useful tools and provide them to the user as a single one. Sometimes when people experience the contents of modern cars, they notice complex navigation system (which is certainly not an option for the money-conscious) is riddled with too many options such as menus which are so complex and unintuitive that in usage should require a pilot's license. Therefore, instead of keeping driver eyes on the road, one splits his time between fidgeting with the screen and fighting with the robotic woman's voice emanating from the dashboard. But even if do not notice any infotainment system, it gets worse. We notice driver with his smartphone in his/her lap instead of concentrating on the road and trying to set destination on Google Maps.

Android as a dominant mobile operating system has already been used as the basis for several in-car entertainment systems, but this initiative will see the OS embedded into the cars' dashboard. Nowadays leading "smart car" solutions such as *AndroidAuto* [2] or *CarPlay* [3] do nothing but add an extra layer for drivers to access the same features we already have access to. In other words neither *AndroidAuto* nor *CarPlay* are actually the operating systems specified in this area, but rather driver-facing applications that create mirror to their simple phone applications.

The problem presented in the paper concerns the chosen aspects of creating process of own mobile application, called *EnjoyYourCar*, for management and control of smart car. Smart car will be simply each model of car fulfilled the technical requirements. The application was written in Java language for Android devices. To manage the communication between car and Android device, OBD-II (*On-board diagnostics*) service port and Bluetooth wireless interface between car and Smartphone/tablet were used.

Moreover, *EnjoyYourCar* application was extended by separate application – *CarTracker* that is responsible for tracking a car. Application should be installed on separate device hidden inside car.

The presented paper is structured as follows: section 2 gives the outline of smart car concept and approach of OBD-II interface. Section 3 presents the proposed solution for management and control of smart car. Section 4 deals with architecture of created solution, while section 5 describes its logic aspects.

2. Idea of smart cars

Nowadays each smartphone user has a possibility to manage their home equipment, work appointments and such like at any-time. People even do not imagine that these features could extend to car. General idea of *smart car* is to bring the power of our smartphone to relatively dumb nature of vehicle infotainment. Car multimedia systems often have quite a poor number of features. Moreover, this sort of systems is fairly new and often unavailable for most of the cars [9]. Some of car and audio producers try to create mirror between car multimedia and smartphone.

Unfortunately, there are no rules to standardize this sort of activity, so most of the solutions are not sufficient. For years, the centre consoles of cars have been dominated by "infotainment" systems, which have been designed to control everything from music, navigation, to climate systems. Though they have got better over the years, these systems have been boycotted with confusing interfaces, slow response and an overwhelming number of options. As a result, the best in-car navigation and entertainment system is often the smartphone in our pocket [7, 11].

Timeline of Automobile Computerization



Figure 1. How modern technology came into car through last fifty years [1]

Smart-car is a new generation of cars which implements integration of the newest operating systems into a car (Fig. 1). These are simply habituating advantages of mobile phones into car interior. Nowadays, due to smartphones we can get closer to a variety of areas. Smart-car will be the comfortable bridge connection between a car and a user. Moreover, this sort of integration would help in car diagnostics, detecting corrupted parts, etc. Digital dashboards have long included Bluetooth or smartphone docks, letting the drivers make hands-free calls or play music stored on their phone. However, car producers have to fight with the obstacles such as distraction problems, compatibility and even people's attitude to online car. A visible benefit is that they finally believe that new car buyers want their vehicles to be "smartphones with wheels" [7, 11].

Approach of OBD-II interface

On-board diagnostics (OBD) [4] represents the capability of vehicle's self-diagnostic and reporting without specific service usage. OBD allows driver or mechanic read status about variety of vehicle subsystems. OBD-II represents internal computer responsible for monitoring emissions, speed, mileage, etc. OBD-II is coupled with the Check Engine light, which shines when the internal systems inside car detects a problem [5]. Check Engine Light, depending on the problem can stay on or flashes. Using scan tools, mechanics but even daily users, have possibility to read trouble codes and detects particular problems [8]. OBD-II allows also collecting data concerning vehicle's performance [5].

OBD is an interface to monitor several peripherals inside a car and provide user variety information about car, its conditions, etc. Basic requirements of OBD interface are as follows: standardized diagnostic plug connection, standardized error codes for all users, ability to identify errors by all commercially available diagnostic devices, ability to determine error conditions, standardize error indication conditions on emissions of harmful substances, standardize signs and abbreviations of structural parts and systems.

OBD-II is actually the most current standard for all the cars for monitoring the data. Basically by using *board diagnostic Parameter ID (OBD PID)* codes mechanics or drivers have possibility to obtain the data from cars by establishing connection with the *ECU (Electronic Control Unit)*. Location of the OBD-II connector is common and it is located under the driver's side inside the car [6]. The newest OBD implementations are standardized. They use a standardized series of diagnostic trouble code (*DTCS – Data Trouble Codes*), which allow driver to identify and repair any malfunctions inside every vehicle [6, 10].

3. Solution for management and control of smart car

Nowadays smartphones come into nearly every section of our life. This boom was caused mostly by price of these devices. The same situation slowly comes to car area which tries to adapt the existing solutions into car environment. Unfortunately, existing frameworks are not helpful here. All interfaces and services to manage the connection between car and phone and other functionalities have to be written by developers what was presented in the below section.

World surrounding us is constantly changing and unfortunately attacks us with enormous number of information demanding on us lot of attention to chose which are significant and memorable. It simply forces us to focus on many things simultaneously. Car is one of them where we spend a lot of time. Smartphone is very helpful device, although it cannot be used in car with existing interface. The main idea is to provide the working interface and functionalities which can be easily used in a car and the functionalities which the drivers actually need.

Based on current consumer needs application for management and control of smart car should gather all missing and all not well polished factors to combine one solution which will improve drivers' life:

- *Connect to car* – to use this functionality OBD-II Bluetooth microcontroller is needed. User can access all information about car such as speed, RPM (Revolutions Per Minute), temperature of engine and temperature outside. Moreover, in case of any engine fault codes, the user can read them and receive information which car part causes any particular error.
- *Manage car navigation* – user can access Google Maps with his localization and park the car. When it is needed he can click on marker to access location and then reroute to Google Maps application and define the proper route.
- *Phone friends* – user can phone anyone he wants by inputting number or chose one of contacts which are imported from personal account logged in smartphone or tablet.
- *Play music* – application reads all music from device stored on external card. User can see on the screen all information about currently played song.
- *Record drive* – if the used device has back camera, user can use the device as road recorder to capture situation on the road. All movies are stored on the device and can be easily played as any Android video player.
- *Manage Car events* – user can add his cars to the application and define information about them. Then everyone can add events connected with car such as buying fuel, paying for insurance, repairs, etc. It is also possible to add notifications to remain about important facts such as installment paying

expiration date. Application creates also overall report about driven kilometers and money spent on car investments.

- *Current position of the car* – this feature demands separate phone with built-in GPS module. Phone would be hidden inside given car. It would listen if any new SMSs are delivered. If any new SMS is delivered from provided telephone number (driver's personal number), given phone sends return SMS with current location of the car. Moreover, when driver parks car somewhere and send SMS with body containing "start protection" message, given phone start checking car's position every 10 seconds. If car change parked position, it again starts sending SMSs to the driver with current location.
- *Voice recognition* – to preserve safety, user manages the application functionalities by voice commands. Using a voice the driver has possibility to access particular elements of an application by simply giving voice command. *EnjoyYourCar* using Google Speech service tries to get command containing the words connecting application dictionary to perform specific action.

Presented requirements covered all the functionalities that are not the only ones. Application to be fully functional needs to be planned and created according to several rules which are compulsory nowadays: ensuring offline communication between smartphone and car, comfortable design, application available for most of Android versions, efficiency and scalability.

4. Architecture of created application

The main element of *EnjoyYourCar* application is an Android application capable to run on most of Android devices which are currently in use (Android 4.4 and newer). Application needs Internet connection to use the particular functionalities (e.g. to download Google Maps), but in overwhelming the most functionalities can be used offline. To connect with car, the application needs enabled Bluetooth and plugged into car *ELM327 Bluetooth microcontroller*. The rest of functionalities run independently (Fig. 2).

Database contains the information of user's car, its properties and logbook with history about the car. *OBD module* is responsible for maintaining the connection between car and smartphone. Application sends a request to the car via OBD PIDs. Particular PIDs receive the following information: voltage of storage battery, distance travelled, VIN (Vehicle Identification Number) of the car, current RPM (Revolutions Per Minute), current throttle position, fuel type, consumption rate, fuel level, current speed, engine coolant temperature, engine oil temperature.

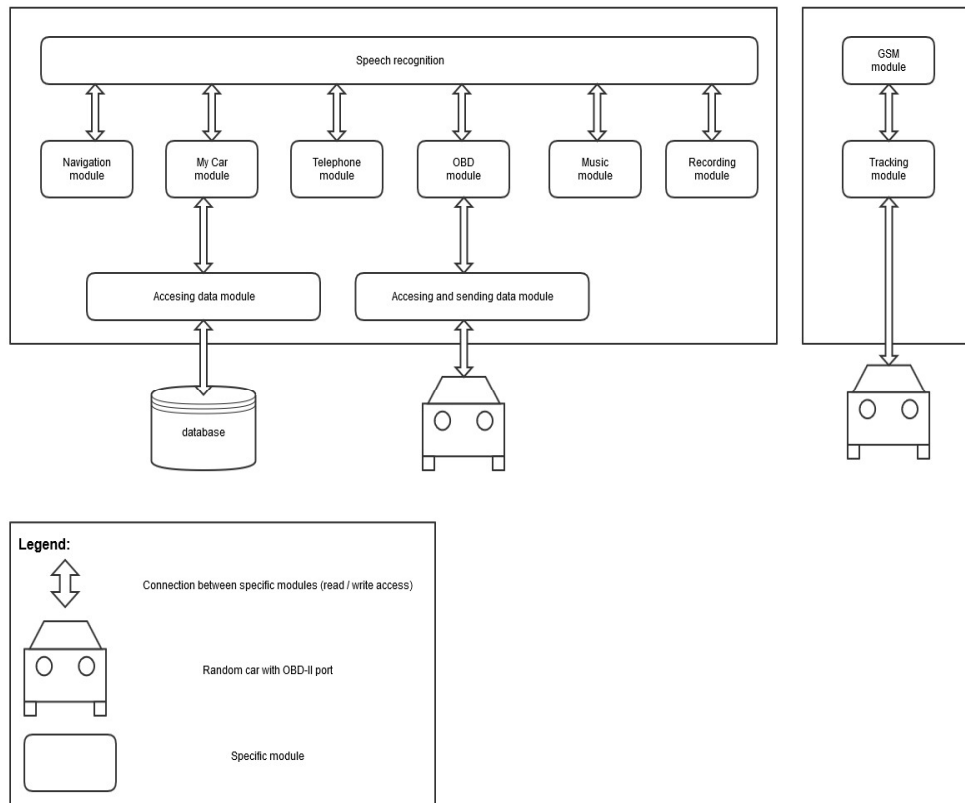


Figure 2. *EnjoyYourCar* application schema

Navigation module is responsible for maintaining the current position of the user and car, and designate route from driver to the parked car. *Telephone module* is responsible for downloading the current contacts from phone and manages them by user while driving. *Music module* plays all songs which are currently saved on the device. It shows all information about a song and enables the driver to manage music while driving a car. *Route recording module* is video recorder to stream road while driving a car when the used devices has built-in rear camera.

My car module connects directly with the database inside smartphone and it is responsible for managing all events connected with driver's car. User can add new random events (such as buying insurance) or specified fuel events. Moreover, he can create specific notification to remind about important events.

All the modules presented above stays speech recognition which is responsible for managing voice commands to enable an user to manage *EnjoyYourCar* application while driving without touching anything on smartphone/tablet.

Another module responsible for tracking car presents separate application – *CarTracker* which should be installed on another smartphone (compatible with Android 4.4 or newer). Application tracks given car due to the specific conditions which can be described further.

Data requested via OBD-II port is not stored anywhere. All of data are showed on the screen live. To store the temporary data *EnjoyYourCar* application uses *ArrayList* which receives objects that further enable the application to request data via OBD-II PID's. Each object holds OBD-II PID – to request data the OBD-II needs four digit hex: first two numbers are responsible for mode (show data, request Data Trouble Codes, etc.), next two numbers are responsible for specific data which the user wants to get. Firstly, user initializes the connection with car by sending request via Bluetooth. Then if connection could be established, he sends PID code.

5. Logic aspects of *EnjoyYourCar* application

EnjoyYourCar application was created according to MVC (Model-View-Controller) pattern. MVC tries to make a strong connection between business logic and the presentation layer.

Record drive – this feature is based strictly on *MediaRecorder* class provided by Android API. Most smartphones that has Android on the board have already a camera application that records video, but *EnjoyYourCar* application tries to implement their functionalities according to the requirements and to be more comfortable for the user. Firstly application checks whether there is a possibility to use camera, then initialize audio and video recorder. Thirdly, it configures data source to provide place for videos and finally starts recording

Speech recognizer – as it was presented, speech recognition stays over all the functionalities and it is responsible for requesting the data from a user, checking whether defined word (or phrase) is currently readable from the database and performing specific task. *MainActivity* class is responsible for managing general layout of the application -- it runs specific service which might be enabled on button click. This service allows an access to the speech recognizer. The implementation of this API is likely streaming audio to remote servers to perform speech recognition. This API is not intended to be used for continuous recognition, which would consume a significant amount of battery and bandwidth. Application via service connects to Google server to authenticate voice data, then stops recording and checks whether a defined command is available in dictionary and performs specific task according to rules defined in application.

Playing music – *EnjoyYourCar* application enables the user to play music stored in tablet/smartphone internal memory. The Android multimedia framework

includes the support for playing variety of common media types, so that the developer can easily integrate audio, video and images into his applications. It is possible to play audio or video from media files stored in application's resources (raw resources), from standalone files in the file system or from a data stream arriving over a network connection, all using *MediaPlayer APIs*. Moreover, *FFmpegMediaMetadataRetriever* class is used to access data of single music file. This class provides a unified interface for retrieving frame and meta data from an input media file.

Navigation – user has also the possibility to access Google Maps and store his car position on the device memory. EnjoyYourCar application in this case uses *LocationManager* class that provides an access to the system location services. These services allow an application to obtain periodic updates of the device's geographical location or run an application-specified *Intent* (abstract description of an operation to be performed) when the device enters the proximity of a given geographical location.

Updating location of the phone with Android OS is an asynchronous process. It means that location API does not call a new thread until a new location is really available. Instead of infinite thread, the user creates an object that has specific method (callback) that was invoked when a new location was calculated. In case of *Android Location Manager API* this object is *LocationListener* and the main callback for location updates is *onLocationChanged()* method.

Calling feature – to preserve safety inside a car by concentrating variety of functionalities in one application, the user has a possibility to phone someone using EnjoyYourCar application. To make a phone call the *Intent (Intent.ACTION_CALL)* was used. Moreover, to call the existing contact, *ContactsContract* class was used that represents a contract between the contacts provider and the applications. It contains the definitions for supported URIs and columns.

Tracking car – EnjoyYourCar application provides separate module to track a car. It needs second smartphone with Android OS and built-in GPS device. Whole module was based on *SMS BroadcastReceiver* (class responsible for intercepting new events) which intercepts new messages. When new random message is received, application request current location and send it to the driver. Moreover, if driver sends message "start protection", the application starts a thread responsible for simultaneously checking location every 10 seconds. Main logic of the application bases on two separate threads. First thread checks whether a new message was received, then checks if actually driver sends this message and then send a response with current locations. Second thread simultaneously checks whether body of the message from driver contains "start protection" phrase. If the condition is correct, application checks every 10 seconds current locations. If application receives the

message with body containing "stop protection", the second thread is disabled until "start protection" would be again received.

OBD-II functionalities

EnjoyYourCar application uses ELM 327 microcontroller to manage the connection between car and smartphone/tablet. The OBD commands are made up of hexadecimal codes written in ASCII characters. Generally, these commands contain two or more pairs of hexadecimal numbers; however, there are a few commands that require only one hex pair. The first hex pair in the OBD command represents the OBD mode which should be used. The general workflow of the application functionality is as follows:

1. Connect to the OBD-II adapter through Bluetooth.
2. Initialize OBD-II adapter with AT commands (AT is a specific command language to manage modems and other equipment). The command set consists of series of short text strings which can be combined to produce commands for operations such as dialing, hanging up and changing the parameters of the connection.
3. Continuously get data from the vehicle through using the corresponding PID codes.
4. ECU (Electronic Control Unit) responds with the data, the OBD-II adapter relays the reply back to the software.
5. Application decodes the reply and displays it to the user.

EnjoyYourCar application has variety functionalities. It consists of two drawers. First one is located at the bottom of the screen and allows driver to manage most important functionalities during driving a car. Navigation drawer located on the left provides rest of functionalities (Fig. 3).

6. Conclusion

The smart car is a new generation of smartphone, very useful and necessary for mostly all of us to live. That is why a lot of producers try to thrive in this area. Over the last twenty years people experienced a rapid progress in the telephone branch, probably in over next twenty years they would expect the same situation on cars field, in which it is crucial to keep reliable price which could go simultaneously with functionalities. But even if developers propose functional solution, it would be very important to think about present cars.

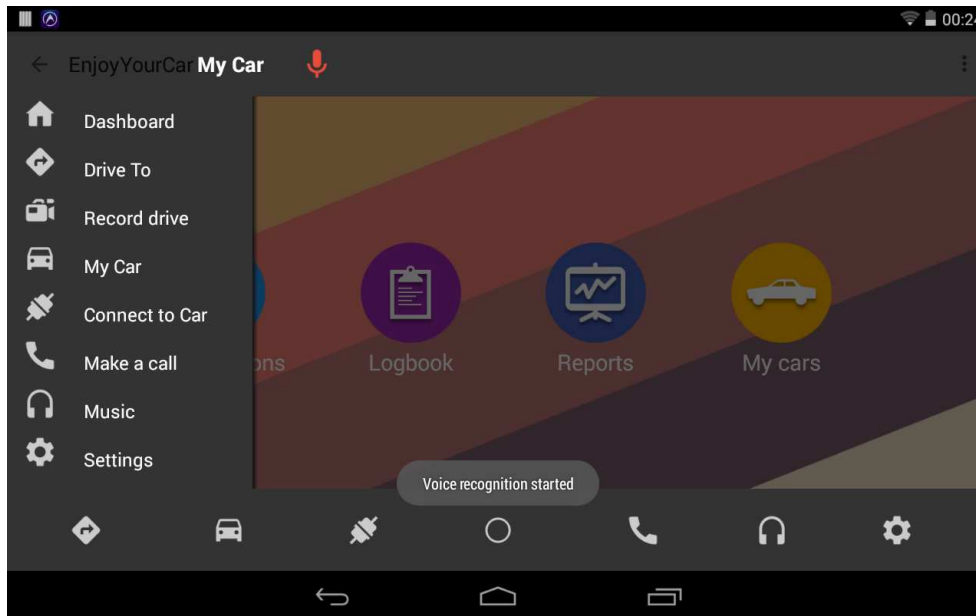


Figure 3. *EnjoyYourCar* application main screen

EnjoyYourCar application is one of the steps which bring closer the idea of smart car to all drivers. Application which would be compatible with the most of Android devices would be a good step for providing universal platform where the single obstacle would be the ownership of any Android smartphone. Each car manufacturers as well as each phone producer has its own approach to this domain, and now it is time to move towards actual applications and services rather than wasting time improving integration between particular products. EnjoyYourCar was obviously planned according to modular architecture, which enabled easy migration from one technology towards the other. During creation of this application other factors were also concerned such as lowest possible costs of migration and the least influence on the User Experience avoiding serious changes in GUI.

The technology used for integration between car and phone would enable safe phone usage. Therefore EnjoyYourCar is focused on gathering all good practices used by existing applications presented by a variety of companies ranging from Google to Apple. Most of existing mobile applications were designed rather for home usage than in the vehicle; that is why EnjoyYourCar tried to create its own UI (User Interface) to provide appropriate User Interface which will be comfortable while driving.

There is no evidence that all vehicles in the future will be connected somehow. However, small revolution on this area has already started. Moreover, it would become a regular topic on many conferences presented not only by Google

or Apple. The future presents an integrated world with variety of synchronized systems such as computers, tablets, smartphones and cars. EnjoyYourCar is one of the steps which could be developed in the future into universal platform capable to satisfy every driver.

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