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Assoc. Prof. Dragan Peraković

• About:

Dragan received B.Sc. degree at the University of Zagreb, Faculty of Transport and Traffic Sciences (Faculty), Zagreb, Croatia, 1995th and 2005. Ph.D. dissertation named: A Model of Distribution of Information to Users of the Transport System.

Dragan is Head of the Department for Information and Communication Traffic and Head of Chair of Information Communication Systems and Services Management, all at the Faculty, where he is currently associate professor.

Area of scientific interests and activities: modelling of information and communication systems and their applications; traffic simulation; forensic analysis of information and communication systems, services and terminal devices; design and development of new communications services and software modules; possible application of ICT as assistive technologies (for inclusion of people with disabilities) and e-Learning.

Dragan is co-author of 2 (two) CC paper and author/co-author more then 100 scientific papers in journals and proceedings of international conferences and 5 chapters in international scientific books.

He participated in the work of several international scientific projects and R&D studies (CiViTAS ELAN, Harmonized Inland Navigation Transport Through Education and Information Technology - HINT, Green Intermodal Freight Transport - GIFT, etc.). He is also the initiator and main researcher of many important national projects (Research of the Context of the use of Smartphones and Related Information and Communication Services, Research of Possibilities on Applying the IoT Concept to Improve the Safety Movement of Blind and Visually Impaired Persons along the Traffic Network, Information and Communication Services for the Movement along the Traffic Network by the Persons of Reduced and Difficult Mobility, etc.).

He is a full member of TM Forum, IEEE, DAAAM International and SDIWC, Croatian Chamber of Traffic and Transport Technology (board member and president of the professional grade engineers Postal and Information and Communication Traffic).

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Preface

Today's standard of constantly improving quality of life and fulfilled expectations of always available and secure connection attests to significant inclusion of ICT technologies.

Therefore, this conference is focused on advances in technical fields and covers information and communication systems, applied computer science, electrical and electronic engineering, automotive area and other.

These proceedings contain the 11 papers accepted and presented at the 4nd International Virtual Research Conference in Technical Disciplines (RCITD), held at www.rcitd.com , on October 17 - 21, 2016.

Every submitted paper went through a rigorous review process. Each paper received more than two reviews from Scientific and Technical Committees. We thank all the authors who submitted papers and all the members of the Scientific Committee (Reviewers).

Hopefully, the latest research results contained within these proceedings will be able to provide new substantial information to ICT stakeholders and lay the groundwork for more detailed knowledge in this field.

I am very content with the response of researchers willing to share their knowledge and their latest experience (state of art). I firmly believe that the published results shall leave significant trace in education of interested individuals within this field.

At last, I hope that readers of other fields of interest find something valuable and useful within this proceeding as well.

Assoc. prof. Dragan Peraković

Conference Editorial Board
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Development of Fuzzy Relationships between Different Quality of Experience Parameters

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Abstract—**User psycho-acoustic and visual perception of telecommunication service quality depends on a wide palette of objective and subjective parameters. This is especially relevant in the process of evaluation, assessment or prediction of user Quality of Experience (QoE) for specific service, because these processes require the revelation of the correlations between different parameters. Using the User Datagram Protocol (UDP) based video streaming service as an example, in this paper we investigate the impact of three objective parameters (the packet loss rate, the number and the duration of packet loss occurrences) on user perception by conducting subjective quality tests. We then use Fuzzy C-Means (FCM) clustering approach to cluster test subjects' ratings as well as to define degrees of membership of each rating to specific fuzzy cluster. Based on the obtained degrees of membership, the fuzzy relationships between different objective and subjective parameters are approximated using the normal distributions.**

Keywords- Quality of Experience, fuzzy logic, subjective and objective parameters, fuzzy relationships, evaluation

I. INTRODUCTION

One of the paramount objectives of todays' network operators and service providers is to understand the relationship between achieved network performance and user perception regarding the quality of a specific service. This is useful when attempting to improve network efficiency, reduce operating costs and maintain certain levels of user satisfaction. However, defining and modeling the relationships between different Quality of Experience (QoE) parameters has proven to be a difficult task. This is due to a large set of quantitative (objective) and qualitative (subjective) parameters which are important from user psycho-acoustic and visual perspective.

Understanding how a user perceives the quality of a specific service normally requires subjective quality testing. Subjective evaluation that involves test subjects is the only true mean of discovering user opinions about what is presented to them as a service. The subjective evaluation is usually conducted in a controlled, laboratory conditions, however some authors conducted real-life tests; for instance, see [1-6].

Though crucial for discovering the relationships between the parameters, it is clear that the subjective evaluation requires commitment of considerable resources. Therefore, the objective quality assessment models have been developed for different services. Some of these models can estimate subjective quality, as perceived by users, solely from objective quality measurement or indices. They are usually based on different relationships between the network and the application oriented parameters (such as network delay, jitter, packet loss, bitrate, framerate, video artifacts, re-buffering frequency etc.). In the light of this study, we have focused the following review of the related work on the objective video quality assessment models.

ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) in [7] grouped the objective video quality assessment models into three main categories: a) Full-Reference (FR) models for which both the reference input and the degraded (processed) output video signal have to be available, b) Reduced-Reference (RR) models that require access to the degraded output and some limited features extracted from the reference input video signal, and c) No-Reference (NR) models that require access only to the degraded output video signal.

In order to assess the quality of a video signal, the objective models employ statistical models that ITU-T in [8] classifies into: a) media-layer models which use media signals to quantify quality degradation, b) packet-layer models which use only the information extracted from packet headers, c) bitstream-layer models which, apart from packet header information, use payload information, d) hybrid models which combine the features of previously listed models, and e) planning models which include the quality planning parameters of networks or terminals.

It is noteworthy to mention that not all video quality assessment models use subjective data sets for the assessment. Some models or metrics (e.g., Mean Square Error, Peak Signal-to-Noise Ratio, Moving Picture Quality Metrics, Modified Sum of Absolute Difference, Structural Similarity Index and others) assess the video quality solely from analysing the properties of the output signal (image luminance, saturation, structure, etc.).

To model the relationships between objective and subjective parameters different methods may be applied. In [9] the authors showed how the random neural network can be trained with the subjective data set to assess the quality of a video stream at the receiver side. Similarly to [9], in [10] the authors also use the neural network for assessing the QoE of HTTP (Hypertext Transfer Protocol) video streaming. Another example of neural network application for QoE assessment for HTTP video streaming can be found in [11].

A machine learning approach was employed by Menkovski et al. to develop the objective model which can determine the

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extent of video quality degradations that may lead toward unacceptability of a video quality as perceived by test subjects (see [12-13]). In [14-15] the authors construct k-dimensional Euclidian space, where k represents the number of network dependent and independent parameters which may affect user QoE. The authors define zones in the k-dimensional space where different values of various parameters lead to the same QoE rating. Zhang et al. in [16] use fuzzy decision trees to predict user QoE from the log data collected from different Internet video service providers in China.

From this brief literature overview it can be seen that different techniques are employed for modelling the user perception. As discussed earlier, these type of models are based on the relationships between the objective and the subjective parameters. Thus, accurate assessment of user QoE means that these relationships have to be disclosed.

Using the User Datagram Protocol (UDP) based video streaming service as an example, in this contribution we show how the relationships between the values of the three objective network parameters (packet loss rate, the number of packet loss occurrences in the sequence and the duration of those occurrences) and the subjective perception (level of user annoyance) can be modelled. For this purpose, we use fuzzy logic. Based on the developed relationships, in our future research we will develop no reference objective video quality assessment model for assessing the user QoE for UDP-based video streaming service.

The paper is structured as follows. Chapter 2 brings short description of the subjective evaluation of video quality that was used to collect user opinions about specific video quality degradations. The fuzzification process is described in chapter 3. This chapter also presents the developed fuzzy membership functions. Discussion and concluding remarks can be found in chapter 4.

II. SUBJECTIVE EVALUATION OF VIDEO QUALITY

In this paper we develop fuzzy relationships between different objective and subjective parameters which may affect user QoE for UDP-based video streaming service. The obtained relationships, i.e. fuzzy membership functions, originate from the results of subjective evaluation of user QoE which was conducted in real-life environments. Therefore, it is meaningful to firstly discuss the research method and the obtained results from that study.

A. Research method

In order to test user QoE for the video streaming, 72 test sequences were prepared for rating. We used only one type of video (documentary film) that lasted one hour and it was chosen using the entertainment-oriented content selection [17]. The video was encoded using Advanced Video Coding (H.264/AVC) and Advanced Audio Coding (AAC). The video was coded at a bitrate of 9.8 Mbps and a framerate of 50 fps. The resolution of the video was 1920 x 1080 pixels, while the audio was coded at a bitrate of 256 kbps.

The video was streamed in an emulated network environment six times; each time different packet loss rates (PLRs) were introduced (0.05, 0.1, 0.5, 1, 1.5 and 2%) using the emulator client. Six incoming video signals were stored in the same format as the unprocessed video.

In the next phase, 1, 4, 7 or 10 short video clips from a degraded video signal were inserted into the original video signal. The duration of a single inserted clip, i.e., a single packet loss occurrence (PLO), varied between 1, 4 and 7 seconds. Different combinations of the number of PLOs and the duration of a single PLO resulted in different total duration of all PLOs in a test sequence that varied between 1, 4, 7, 10, 16, 28, 40, 49 and 70 seconds.

Test subjects who participated in the subjective evaluation were picked from student population of the University of Zagreb, Faculty of Transport and Traffic Sciences. This is due to two main reasons: a) video streaming services are generally used by users between the ages of 18 and 24, which corresponds with the age group of a typical student population [18], and b) this population was easy accessible for conducting such a survey, i.e. the convenience sampling method was used [19].

In order to deliver the prepared test sequences to the test subjects we considered employing several methods, namely: a) QoE crowdtesting, b) remote performance monitoring during the network streaming, and c) offline evaluation when previously prepared test sequences are delivered to the subjects (e.g., on Blu-ray or DVD disks) and they rate it offline. After analyzing each method, we have decided to employ the offline evaluation using DVDs. The offline evaluation allowed us to prepare the test sequences in the emulated network environment and then distribute them to the subjects for rating in real-life environment. We also concluded that it would be difficult task to pursue the subjects to participate in the survey if they would have to download or stream one-hour video in high definition resolution to their devices from their homes.

Prior to watching the video, the subjects were ignorant about what would be expected from them after watching. They were only asked to watch the sequence in the everyday conditions as they would normally watch television and to open the sealed envelope, that contained the questionnaire, after the screening.

After the data processing, in which some of the methods discussed in [20] were employed for the exclusion of unreliable responses, 602 questionnaires were accepted for further analysis.

B. Obtained results

In this study we analyze the impact of three objective parameters (the PLR, the number of PLOs in the sequence and the duration of those occurrences) on user QoE. In the questionnaire, used in the study, we asked our test subjects to evaluate the level of their annoyance in relation to: a) the observed quality distortions, i.e. video artifacts (we correlated these responses with the values of PLRs and the results can be found in Figure 1), b) the number of PLOs which they have noticed (results of this analysis are depicted in Figure 2), and c) the total duration of all quality distortions in the video (the results can be found in Figure 3).

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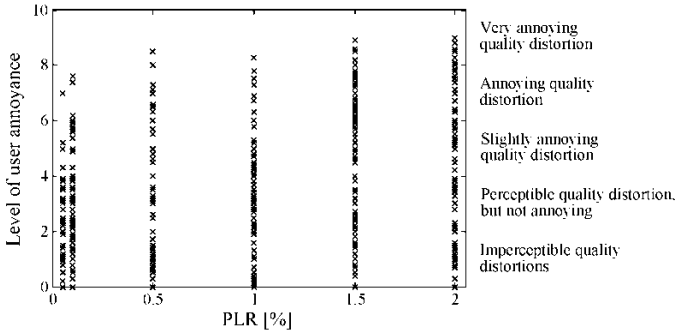

Figure 1. Level of user annoyance in relation to PLRs

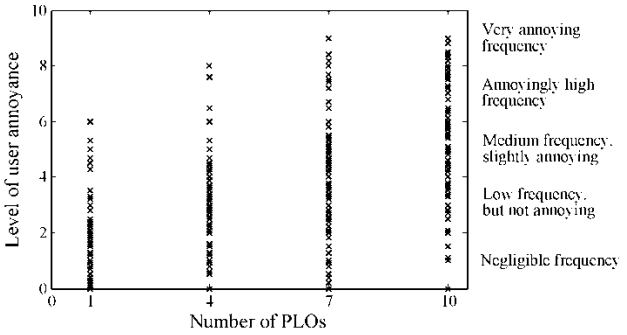

Figure 2. Level of user annoyance in relation to the number of packet loss occurrences (PLOs)

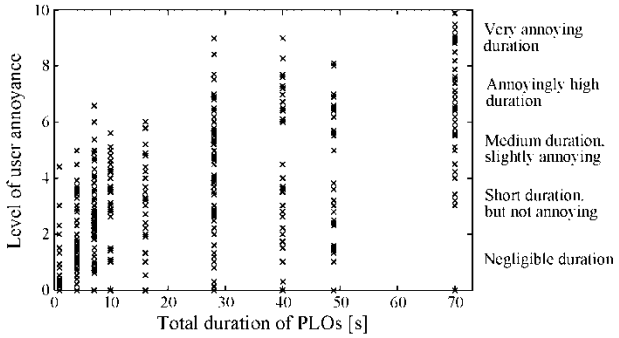

Figure 3. Level of user annoyance in relation to the total duration of packet loss occurrences (PLOs)

The subjects rated the level of their annoyance on an 11-point scales [21], which allow the linguistic meanings of different grades to be added as a help during rating. This feature makes the scale suitable for exploring user opinions, which are usually fuzzy in nature. The meanings that are used in this study are depicted on the secondary y-axes of Figure 1, 2 and 3.

We can observe how the level of user annoyance was sometimes spread over all the annoyance level categories. This is most conspicuous for the data presented in **Chyba! Nenašiel sa žiaden zdroj odkazov.**, and can be explained by agreeing that, e.g., PLR of 2% was perceived as *Imperceptible quality distortion* when the sequence contained only one PLO. Yet, the same PLR may be perceived as *Very annoying quality distortion* if the sequence contains 10 PLO, with 70 seconds of quality degradations. Similar results are reported in [22] where it is stressed how the correlation between the PLR and user opinions cannot be unambiguously defined.

III. RESULTS OF THE FUZZIFICATION PROCESS

A. Fuzzy clustering

In the fuzzification process we have used Fuzzy C-Means (FCM) clustering approach [23] for grouping the data points presented in Figure 1, 2 and 3. The objective was to group the data points presented on the figures into fuzzy clusters and to find centers of those clusters. The FCM method allows the clusters to overlap, i.e., specific data point can be a member of several clusters with different degrees of membership (u_i).

According to [23], the FCM procedure is based on minimization of the objective function J_m expressed by Eq. (1).

$$J_m = \sum_{i=1}^{L}\sum_{j=1}^{C} {u_{ij}}^m \cdot \left\|x_i - c_j\right\|^2 \quad (1)$$

The m in Eq. (1) represents any real number greater than 1 (we have set $m = 2$), u_{ij} is the degree of membership of x_i in the cluster j, x_i is the i-th of d-dimensional measured data, c_j is the d-dimension center of the cluster and $||*||$ is any norm expressing the similarity between any measured data and the center. The fuzzy partitioning is carried out through an iterative optimization of the objective function J_m, with the update of membership u_{ij} (Eq. (2)) and the cluster centers c_j (Eq. (3)). The iterative process finishes when the stopping criteria ε is met (Eq. (4); k are the iteration steps). In our case, we used $\varepsilon = 10^{-5}$. Note that all the equations are taken from [23].

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{\left\|x_i - c_j\right\|}{\left\|x_i - c_k\right\|}\right)^{\frac{2}{m-1}}} \quad (2)$$

$$c_j = \frac{\sum_{i=1}^{N} {u_{ij}}^m \cdot x_i}{\sum_{i=1}^{N} {u_{ij}}^m} \quad (3)$$

$$max_{ij}\left\{\left|{u_{ij}}^{(k)} - {u_{ij}}^{(k-1)}\right|\right\} < \varepsilon \quad (4)$$

The data points presented in Figure 1, 2 and 3 are grouped into three clusters. The FCM procedure for the PLR, Number of PLOs and Total duration of PLOs required 24, 69 and 33 iterations, respectively, before stopping criteria ε was met. The results are presented in Figure 4, 5 and 6, respectively (the centers of the clusters are marked with circles).

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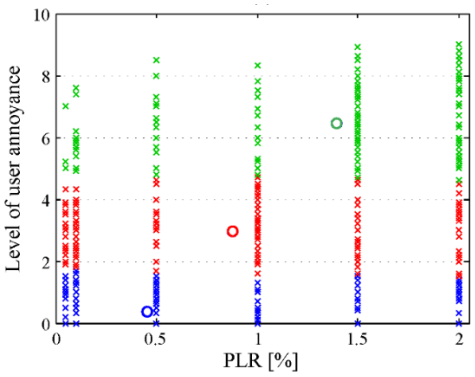

Figure 4. Results of the FCM clustering for the parameter: PLR

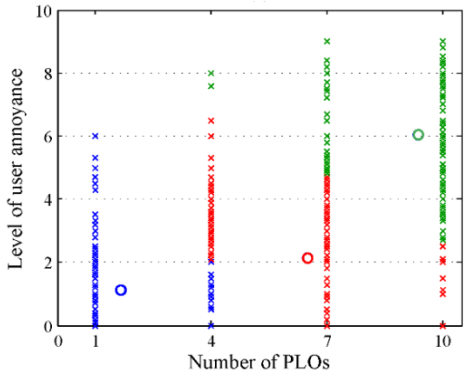

Figure 5. Results of the FCM clustering for the parameter: Number of PLOs

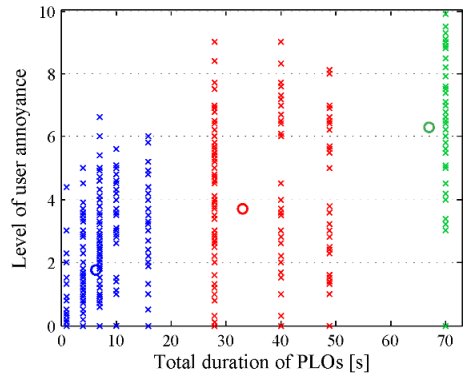

Figure 6. Results of the FCM clustering for the parameter: Total duration of PLOs

B. *Fuzzy relationships*

By correlating the values of the data points, shown on the x axis of Figure 4, 5 and 6, with their degrees of membership u_{ij} to the specific cluster j, the boundaries of the clusters can be approximated. We have used the normal distribution for the approximation, since it is reported in [24] that normal distribution corresponds better with the changes in human perception. The transitions between different user opinions and attitudes are usually happening gradually ("smoothly") and bell-shaped functions can mimic that behavior better compared with, for instance, triangular functions. The boundaries of the clusters, i.e. the obtained fuzzy membership functions for each of the three objective parameters are presented in Figure 7, 8 and 9.

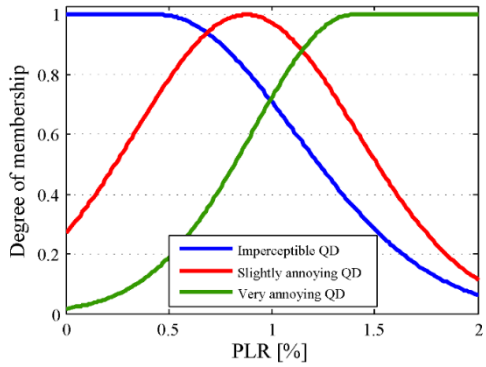

Figure 7. Membership functions of the three fuzzy clusters of the first objective parameter (QD stands for *quality distortion*)

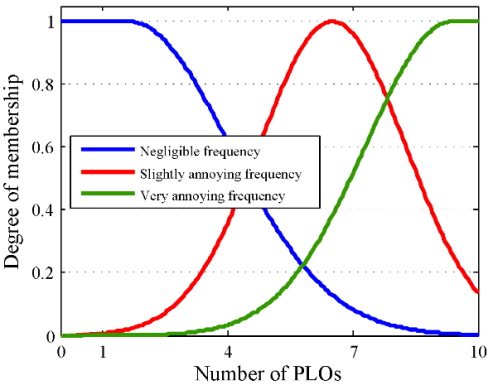

Figure 8. Membership functions of the three fuzzy clusters of the second objective parameter

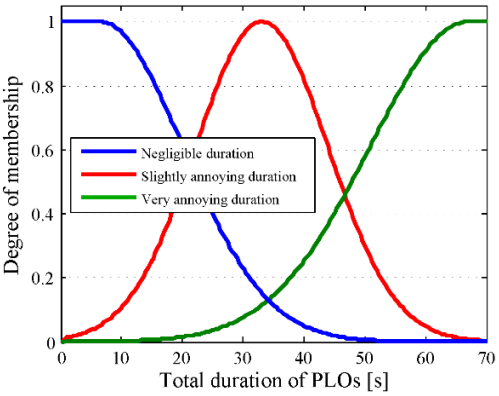

Figure 9. Membership functions of the three fuzzy clusters of the third objective parameter

Each cluster shown in Figure 7, 8 and 9 is named since the fuzzy systems usually use linguistic variables to infer conclusions. Properties of the fuzzy membership functions shown in the figures can be found in Table 1. Note that the blue and the green Gaussian functions of each input parameter are modified so that u_{ij} would be equal to 1 in cases when $x_i < \bar{x}$ (for the blue functions) and $x_i > \bar{x}$ (for the green functions).

TABLE I. PROPERTIES OF THE MEMBERSHIP FUNCTIONS

Figure	Membership functions		
	1st membership function (blue)	*2nd membership function (red)*	*3rd membership function (green)*
7	$\bar{x} = 0.4545$ $\sigma = 0.6574$	$\bar{x} = 0.8758$ $\sigma = 0.5398$	$\bar{x} = 1.3937$ $\sigma = 0.4887$
8	$\bar{x} = 1.6513$ $\sigma = 2.4$	$\bar{x} = 6.5083$ $\sigma = 1.748$	$\bar{x} = 9.3728$ $\sigma = 2.061$
9	$\bar{x} = 6.4254$ $\sigma = 13.73$	$\bar{x} = 33.0713$ $\sigma = 10.92$	$\bar{x} = 67.1134$ $\sigma = 16.33$

The figures are showing how the clusters are overlapping. The overlapping is the most distinctive between the clusters of the first objective parameter PLR. This is due to the previously discussed fact how certain PLRs were evaluated differently by the subjects, depending on the number of PLOs in a test sequence and their total duration.

IV. DISSCUSSION AND CONCLUSIONS

From the obtained results and the developed fuzzy membership functions it can be derived that human perception of video quality degradations cannot be unambiguously correlated with the specific values of the objective (network) parameters. The distinctive overlapping between different fuzzy clusters serves as an evidence to that claim.

As previously discussed, the origin of the overlapping comes from the affiliated effect of the three objective parameters on user psycho-acoustic and visual perception. We recorded cases when higher PLRs were not adversely perceived by the subjects because the number of PLOs in the sequence remained low. However, the increase of PLOs and/or their total duration clearly increased the level of user annoyance, meaning that even lower PLRs may be perceived as *Annoying* or *Very annoying* by the subjects.

Incorporating this fuzziness of the user perception of service quality into the membership functions of the clusters is one of the distinguishing features of this study. This was achieved using the FCM clustering method. The applied method can be considered as a valuable tool for resolving cluster consensus problems in engineering, when a limited knowledge about the number of clusters often exists. Additionally, the method repetition, i.e. iterative optimization of the objective function J_m, is also awarding in terms of gaining the confidence about the significance of the achieved results.

Another possible application of the method would be for the dynamical clustering, a concept discussed in [25], when the membership functions could be updated over time. This could be especially useful, knowing that a given amount of change of the objective parameters has a different impact on resulting change of QoE, depending on the current level of QoE [6].

It is important to stress that the obtained results are highly influenced by the research method that was used. The subjective evaluation was conducted in a real-life test conditions and the subjects rated the video that lasted one hour. This means that test subjects were not focused on noticing and memorizing the quality distortions, as well as the effect on human short-term memory and recency effect must not be ignored. Furthermore, the video used in this study contained video subtitles. Video subtitles may affect user rating by diverting the user focus from the picture to the bottom of the screen. Some quality distortions, thus, remain unnoticed and that directly affects the rating [6].

With this contribution we made an effort towards developing the no reference objective video quality assessment model for assessing the user QoE for UDP-based video streaming service. The inference system of the model will be further built upon the relationships that were investigated in this paper. Since the subjective evaluation and the developed fuzzy relationships are reflecting real-life conditions, we believe that the developed model will stand out in a group of similar models that usually are using the subjective data sets collected in a controlled, laboratory environments.

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Application of the M/G/1/∞/∞/FCFS Queueing System for the Internet Node Performance Analysis

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Abstract—**In this paper we analyze the impact of different packet size distributions on Internet node performances. For this purpose, the input data flow of the node was simulated fourfold. In each scenario 10,000 data packets of various sizes were generated. Namely, we used exponential, normal, Pareto and deterministic distribution to model the variability of the packet sizes. In all four input flow scenarios the inter-arrival times of the packets followed the same exponential distribution. Next, the average waiting and sojourn time of the packets was analyzed in each scenario. Note that the average packet size, packet load and server utilization remained almost equal regardless of the applied packet size distribution; however, the paper shows that the achieved performances varied significantly. The performances were calculated using the mathematical formulations developed for the M/G/1/∞/∞/FCFS queueing system.**

Keywords- packet size, service time, waiting time, sojourn time, distribution, Internet node

I. INTRODUCTION

Nowadays new technologies, Next Generation Networks (NGN) and paradigm Internet of Things (IoT) are enabling vast number of users and devices to be connected to the Internet and use available applications and services. With nearly 3.47 billion and increasing number of Internet users in 2016 [1] the most popular online applications and services are generating astonishing amounts of traffic. For instance, as of July 2015, more than 400 hours of video were uploaded to YouTube every minute [2]. Additionally, in 2015 online video platform Google sites had 924.94 million unique users and Facebook had 617.04 unique users worldwide [3].

While analyzing the shares of specific applications in the aggregate fixed network traffic we can see that in Europe in 2015 the share of YouTube was 21.16%, followed by HTTP 14.94%, BitTorrent 8.44%, Facebook 7.39%, SSL - other 5.81%, Netflix 4.18%, MPEG - other 3.51%, iTunes 2.03%, Skype 1.78% and Flash Video 1.59% [4]. For the mobile network traffic, the shares were: YouTube 19.55%, HTTP 18.98%, Facebook 15.96%, SSL - other 5.28%, MPEG - other 4.54%, Google 2.87%, BitTorrent 2.14%, iTunes 2.07%, Skype 1.96% and Instagram 1.51% [4].

During their usage, these various applications and services generate different packet sizes, thus the variability of packet sizes plays an important role in the performance of the Internet nodes. This paper strives to investigate the exact impact of various packet size distributions on the performances of the nodes.

Usually, the queuing theory and the developed models are used for performance evaluation of the nodes and networks. Different models exist and are used for different purposes. There are many applications of M/G/1 for modeling real systems or Internet nodes, as service times in those systems sometimes cannot be described with exponential distribution. In [5], [6] Web server has been modeled with M/G/1 model. In [7] the measure slowdown has been derived using bounded Pareto distribution to describe service times. Singh et al. in [8] studied the role of buffer size for Internet Gateway Server using a comparative analysis of M/G/1, G/M/1 and G/G/1 queuing models.

Another example of application of M/G/1 queueing system can be found in [9] where the authors model the server connected to the SAN (Storage Area Network). It has been shown that high-order properties of service time distribution for M/G/1 model may have an important impact on performances of Internet nodes [10]. In that paper M/G/1 model has been used to describe an optical network node in which incoming packets vary in size. In [11] M/G/1 model has been shown as the best alternative for instigation of gang scheduling algorithm in cloud computing environment.

In this paper we focus on non-Markovian queuing models, specifically M/G/1/∞/∞/FCFS model to describe Internet node and evaluate its performance. The paper is structured as follows. In chapter 2 we discuss how the M/G/1/∞/∞/FCFS model can be used to describe and analyze the performances of Internet nodes. Characteristics of different input data flows which were simulated are discussed in chapter 3. Chapter 4 brings the results of the performance analysis relative to the specific input flow scenario, while the concluding remarks can be found in chapter 5.

II. UTILIZATION OF THE M/G/1/∞/∞/FCFS MODEL IN THE PERFORMANCE ANALYSIS

In essence, Internet nodes such as routers, gateways, switches and bridges are queuing systems that can be quantitatively described using the developed queuing system models. The utilization of a specific model is tempered by:

- The distribution of the inter-arrival times (t_a),

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- The service time (t_s) distribution,
- Number of servers,
- System capacity,
- Source capacity and
- Service policy, i.e. the queue's discipline.

For M/G/1/∞/∞/FCFS model it is assumed that t_a is distributed exponentially (i.e., the arrival process of the users can be described as Poisson or random arrival process), t_s follows any general distribution (in this study we analyze exponential, normal, Pareto and deterministic distribution), number of servers equals 1 (in our case the capacity of the server is 1 Gbps), system and source capacity are infinite and the service policy is *First-Come-First-Served* (FCFS) which can be applied when describing the best effort networks such as the Internet [12].

Using the expressions from [13] in the remainder of this chapter we will present main parameters that can be employed when trying to analyze the performances of M/G/1/∞/∞/FCFS queuing system, such as the Internet node. The server utilization (ρ) depends on the traffic intensity (a) and the number of servers (c), i.e.:

$$\rho = \frac{a}{c}. \tag{1}$$

In this study $c = 1$, hence we can write:

$$\rho = a = \lambda \cdot T_s = \lambda \cdot \frac{\bar{p}}{C} \tag{2}$$

where λ denotes to packet load, T_s is the average service time of the packets, $\bar{p}$ is the average packet length and C is the server capacity [14]. In addition, service time of specific packet (t_s) is equal to:

$$t_s = \frac{p}{C} \tag{3}$$

for p being the size of a packet. Note that the sum of all t_a equals:

$$T = \sum_{i=1}^{N} t_{a_i} \tag{4}$$

where T is interpreted as total duration of a measurement or simulation and N is the number of users, i.e. data packets [14]. Thus, it can be written:

$$\lambda = \frac{N}{T}. \tag{5}$$

According to [13] the average waiting time T_w for this queuing system can be expressed by:

$$T_w = \frac{a \cdot T_s}{2 \cdot (1 - a)} \cdot \left[1 + \left(\frac{\sigma_{t_s}}{T_s}\right)^2\right] \tag{6}$$

where σ_{t_s} denotes to standard deviation of t_s. Lastly, the average sojourn T_q time is:

$$T_q = T_w + T_s. \tag{7}$$

III. CHARACTERISTICS OF THE INPUT DATA FLOWS

A. Packet inter-arrival times

As discussed in previous chapter, the application of the M/G/1/∞/∞/FCFS queuing system assumes that inter-arrival times (t_a) of the users (in this case data packets) are distributed exponentially. It is important to stress that in this study t_a is simulated only once, i.e. each packet was assigned with unique arrival time which remained fixed in all four input flow scenarios.

Frequency distribution of the simulated inter-arrival times is depicted in Fig. 1. Note that 34.46% of all simulated inter-arrival times varied in the interval $\langle 0{,}2]\ \mu s$, 56.25% was $\leq 4\ \mu s$ and 98.39% was $\leq 18\ \mu s$ (as seen from Fig. 2).

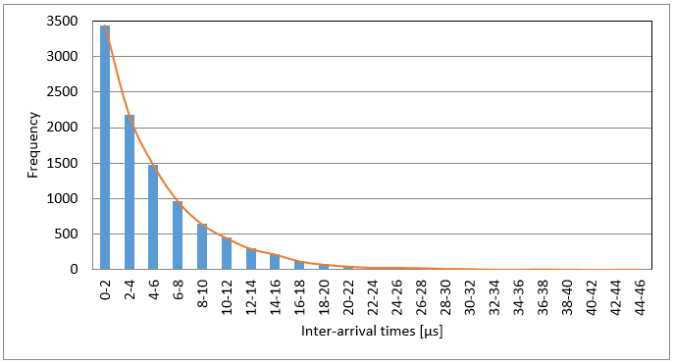

Figure 1. Frequency distribution of t_a

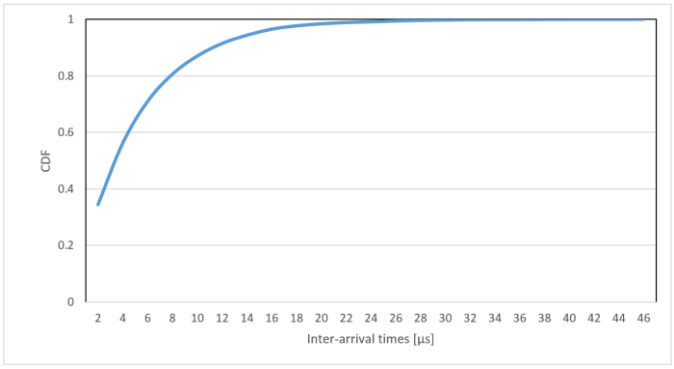

Figure 2. Cumulative distribution function (CDF) of t_a

For the known inter-arrival times and for $N = 10000$ packets, using the (4) we can calculate that the total simulation time equals 0.0489 seconds, i.e. with (5) we derive the packet load λ = 204,302 packets per second.

B. Simulated variability of the packet size

In this study we employed four different distributions to test the impact of the packet size variability on the node performances. Namely, we simulated four input flows where the packet sizes followed exponential, normal, Pareto and deterministic distribution. The rest of this chapter discusses the properties of these input flows, presenting the relevant parameters (service time distribution, $\bar{p}$, T_s and ρ) for each flow.

1) Input flow 1: Exponential distribution

Fig. 3 shows the frequency distribution of the packet service times (t_s) which were calculated for the first input flow. The service times are distributed exponentially with minor exceptions for $(8 \leq t_s < 8.5)\ \mu s$ which is caused by higher number of generated packets whose sizes were between 1000 and 1200 Bytes. The service times were calculated using the (3), for the link capacity of 1 Gbps which remained fixed in all four input flow scenarios. The average packet size in this scenario equaled 423.8344 Bytes and $T_s = 3.3907\ \mu s$. With (2) we can derive that the server utilization equals 0.6927 or 69.27%.

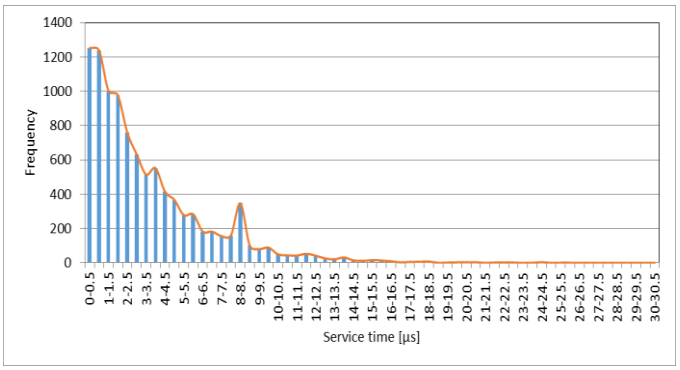

Figure 3. Frequency distribution of t_s for the first input flow

Note that for this input flow, when t_s is distributed exponentially, the queuing system can also be modelled with the M/M/1/∞/∞/FCFS model.

2) Input flow 2: Normal distribution

In this scenario the average packet size was 420.509 Bytes (i.e., 3.3254 Bytes less than in the first scenario), while $T_s = 3.3641\ \mu s$. The server utilization equaled 0.6873. The smallest recorded packet size in this scenario was 22 Bytes, while the largest was 809 Bytes. Frequency distribution of t_s in this scenario is depicted in Fig. 4.

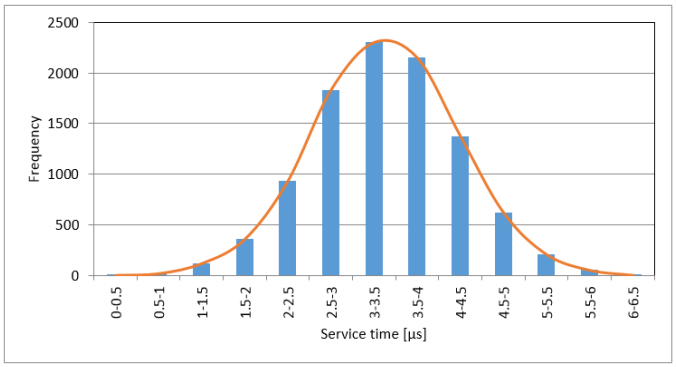

Figure 4. Frequency distribution of t_s for the second input flow

3) Input flow 3: Pareto distribution

Frequency distribution of t_s for this scenario is shown in Fig. 5. The average packet size in the flow no. 3 equals 422.6222 Bytes and the average service time $T_s = 3.3810\ \mu s$. Similarly to the input flows no. 1 and 2, the calculated server utilization is 0.6907.

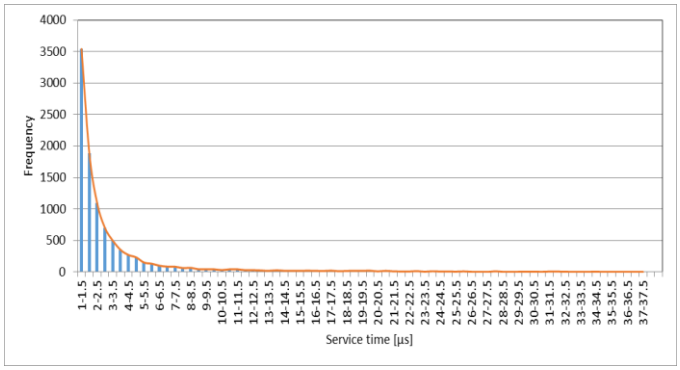

Figure 5. Frequency distribution of t_s for the third input flow

4) Input flow 4: Deterministic distribution

In this scenario all packets were the same size of 422 Bytes. Thus, it is not necessary to graphically depict the service time distribution in this scenario. We can only stress that for this input flow $T_s = t_s = 3.376\ \mu s$ and server utilization equals 0.6897.

It is noteworthy to stress that for this input flow the M/D/1/∞/∞/FCFS queuing system model can also be applied, since t_s is deterministic.

IV. Performance Analysis and Results

Based on the mathematical expressions presented in chapter 2 and using the values for T_s and ρ presented in chapter 3, we calculated the values of key performance parameters of the node, i.e. the average waiting and sojourn time of the packets for each input flow. For this purpose, we used (6) and (7), respectively. Results are presented in Tab. 1.

TABLE I. Calculated values of the parameters for different input flows

	Input flow 1 (exponential)	**Input flow 2 (normal)**	**Input flow 3 (Pareto)**	**Input flow 4 (deterministic)**
$T_w\ [\mu s]$	7.3517	3.9302	9.9624	3.7523
$T_q\ [\mu s]$	10.7424	7.2943	13.3434	7.1283

Apart from using the mathematical expressions (developed for the M/G/1/∞/∞/FCFS queuing system) to calculate the parameters, we also wanted to compare the calculated values with those obtained by the simulation. The values of the parameters obtained with the simulation are presented in Tab. 2. The table is showing relatively small differentiation from calculated values, which was expected.

TABLE II. Simulated values of the parameters for different input flows

	Input flow 1 (exponential)	**Input flow 2 (normal)**	**Input flow 3 (Pareto)**	**Input flow 4 (deterministic)**
$T_w\ [\mu s]$	7.5867	3.89	10.563	3.6784
$T_q\ [\mu s]$	10.9774	7.254	13.9439	7.0544

Fig. 6 and 7 depict frequency distributions of packet waiting and sojourn times, respectively, for specific input flow. As seen from Fig. 6, over 3000 packets had $t_w = 0$ when the packet sizes followed the deterministic distribution. Regarding

the other three distributions, we can observe that for the normal distribution there is a higher share of the packets whose $t_w \in [1,4\rangle\ \mu s$, compared to the exponential and Pareto distribution.

If we analyze the sojourn times (Fig. 7) we can see how the shortest time is recorded when the packet distribution followed the exponential and Pareto distribution. This is because these two distributions have a larger shares of smaller size packets, compared to the normal or deterministic distribution. Therefore, their service times are shorter. For the exponential distribution of the packet sizes, the frequency distribution of t_q has a local maximum at $t_q \in [0.5,1\rangle\ \mu s$ (430 packets); for the normal distribution the maximum is at $t_q \in [3.5,4\rangle\ \mu s$ and equals 914 packets; while for the Pareto and deterministic distributions the maximums are at $t_q \in [1,1.5\rangle\ \mu s$ (1148 packets) and $t_q \in [3,3.5\rangle\ \mu s$ (3191 packets), respectively.

Fig. 6 and 7 also serve as a good indication of the importance of the packet size distribution, since packet inter-arrival times were equal in all four simulations, while $\bar{p}$, T_s and ρ differed insignificantly.

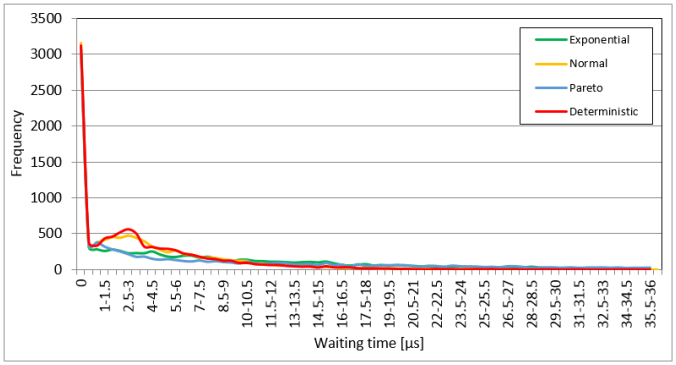

Figure 6. Frequency distribution of t_w for different input flows

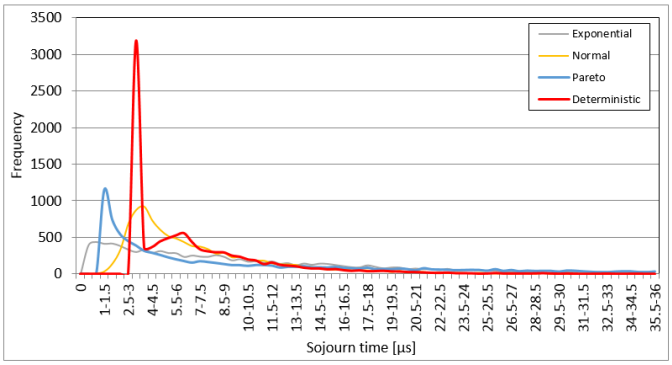

Figure 7. Frequency distribution of t_q for all four input flows

V. CONCLUSION

In this paper we analyzed the impact of packet size distribution on the packet waiting and sojourn time in one hypothetical Internet node. For this purpose, we employed M/G/1/∞/∞/FCFS queuing system model and presented mathematical formulations used for calculation of the performance indicators.

Next, we simulated four different input flows entering the node and discussed their properties. In this process it was important to achieve relatively small differences between $\bar{p}$, T_s and ρ in each simulation, so that the impact of packet size distribution could be identified. In addition, we decided to simulate inter-arrival times only once, so that the impact of t_a distribution and λ would be ruled out as well.

After completing the analysis, the results indicated how the node performances are greatly affected by the packet size distributions, i.e. by the characteristics of the input flows. Given the fact that the average service times differed insignificantly between different distributions of the packet sizes, this leads us to a conclusion that the coefficient of variation (V_{t_s}) is one of the important performance measures as well.

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USAGE OF THE STEGANOGRAPHY WITHIN HIGHWAY INFORMATION AND COMMUNICATION NETWORK

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***Abstract*—In this paper we propose usage of the network steganography within highway surveillance and information system as a transfer method for safety-sensitive information. Steganography methods form a covert sub-communication channel which is invisible without appropriate software support so unauthorized users are unaware that additional type of communication even exists. Each installed device can be connected to the highway surveillance centre via covert channel in order to exchange controlling, signaling or collected data. Main goal of covert channel usage is enhancement of the data and network security. In presented paper, basic properties of the various types of steganography methods and their respective features are briefly described and their utilization within highway surveillance system.**

Keywords- Data security, highway, information hiding, ITS, network steganography, surveillance

I. INTRODUCTION

Steganography is a combination of the Greek words steganos (στεγανός) – meaning "covered, concealed, or hidden" and graphē (γραφή) – meaning "drawing or writing". Literally translated, steganography means "secret writing" [1]. Main aim of steganography process is hiding secret information in such way that a third party observer is unaware that secret message even exist. The steganography methods are applicable to any kind of digitally stored data with redundant structure such as image, audio, video or textual files [1]. Generally speaking, steganography is a procedure of inserting a secret message within a "false" message which transfers information exploiting the characteristics of the human senses. In case of presented subject, redundancy of network traffic is used as a carrier of the secret message. At the destination the transferred information is subjected to the procedure of extracting the inserted message from the "false" message structure. It's crucial that steganography process alters carrier data ("false" message) in such way that observer can't distinguish original and processed carrier data. Only user on the destination should be aware that secret message is concealed in carrier data structure. Network steganography uses overt (open, "plain") network traffic as a carrier for the covert communication sub-channel. Covert channel is invisible to users and network monitoring and network IDS (Intrusion detection systems) [2]. It is important to stress out that any applied steganography procedure, should have negligible impact on overt network traffic. Fig. 1 depicts the network steganography concept.

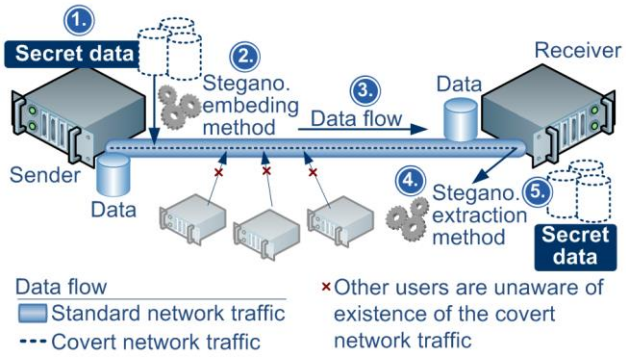

Figure 1. Network steganography concept

Traffic and transportation infrastructure has great influence on economy and functioning of the society. Any kind of disturbance or malfunction of the traffic system can rapidly reflect onto surrounding system and may cause high material and financial loss. Unfortunately, traffic infrastructure may present high valuable target for terrorist activities which can lead to endangering the security of the country and the society. Monitoring and surveillance system is part of modern ITS. Constant monitoring of activities on traffic and transportation system helps the timely response of the competent services on order to maintain normal system functioning. Moreover, according to the ISO ITS standard [3], one of ITS fundamental services in the area of the road transport domain is national security.

In this paper we suggest usage of the network steganography mechanisms as a suitable solution for improved data flow security within ITS surveillance system. Steganography based covert communication sub–channels are invisible for users without appropriate software support. Some advanced network steganography methods are able to bypass network IDS. Covert channel transmits monitoring and control messages between installed equipment on traffic road (cameras, detectors, sensors etc.) and the surveillance centre.

Following topics are discussed in the paper: network steganography methods, comparison between methods and their respective features, methods of detection of presence of the covert communication channel and example of usage of proposed network steganography methods within ITS information systems.

II. NETWORK STEGANOGRAPHY

There are over 100 different network steganography methods developed since Girling [4] introduced the first method in 1987 [5]. Wendzel et al. [6] propose taxonomy of hiding methods organized in groups. Each group has generic description of the hiding method, so any novel steganography method is simply added into the appropriate group. Mazurczyk et al. [7] extend the proposed taxonomy and classify hiding methods in three main groups: storage, timing and hybrid. Storage methods hide data by modifying user or protocol field data, timing methods hide data by modifying timing of packets and messages and hybrid methods are combination of both methods. Fig. 2 shows the network steganography methods.

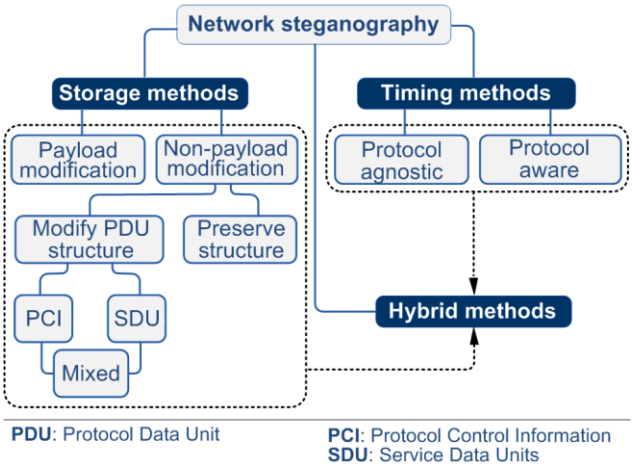

Figure 2. Basic network steganography methods

General example of timing steganography method is presented in Fig. 3. Timing methods have lower capacity but they are harder to detect [7] then storage methods. Thru manipulation of timing interval between consecutive protocol messages the receiver can distinguish hidden message (which is sent from the source).

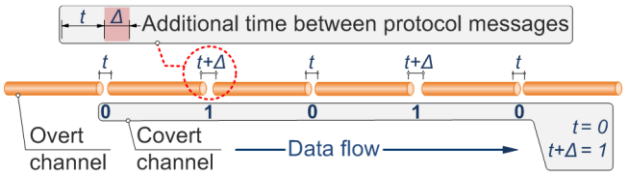

Figure 3. Example of the timing method

Packet and segment PDU (Protocol Data Unit) fields which are suitable for network steganography are presented in Fig. 4.

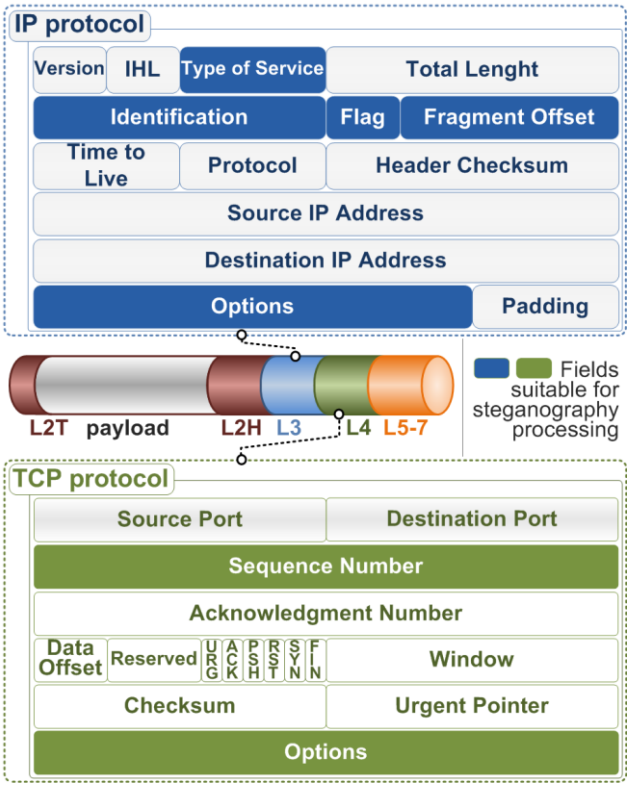

Figure 4. IP and TCP protocols PDU utilization

Presented methods belongs to the group of storage hiding methods which do not alter the payload content but utilize PDU reserved / unused fields for hiding information in IP (Internet protocol) and TCP (Transmission Control Protocol) header [2].

A. *NETWORK STEGANOGRAPHY METHODS*

Basic division on storage, timing and hybrid methods [6] is extended with more detail overview of the network steganography in Fig. 5 [7]:

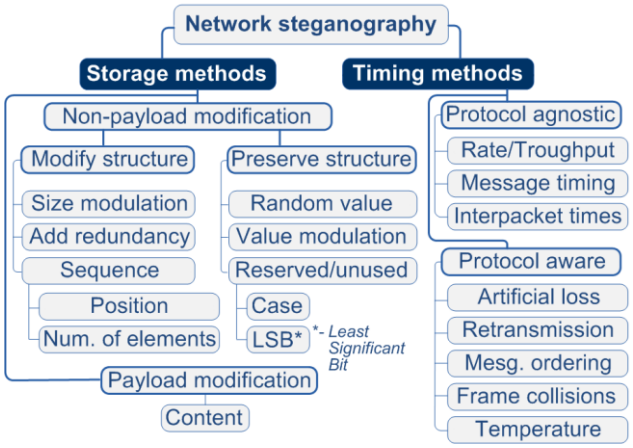

Figure 5. Overview of the network steganography methods

Comparison of previously displayed steganography methods is presented in table I. [7, 8].

TABLE I. STEGANOGRAPHY METHODS COMPARISON

Method	Advantages	Drawbacks
Modify PDU/PCI[1]	• High steganography bandwidth • Easy implementation • No sender-receiver synchronization required	• Potential loss of some protocol functionalities • Easy detection
Modify PDU/SDU[2]	• Harder to detect than PDU/PCI method • No sender-receiver synchronization required • High steganography bandwidth • Hard to detect • No sender-receiver synchronization required	• Lower bandwidth than PDU/PCI • Harder to implement than PDU/PCI • Possible deterioration of user data
Modify PDU / Mixed	• High steganography bandwidth • Hard to detect • No sender-receiver synchronization required	• Harder to implement than PDU/PCI and PDU/SDU • Possible increased transmission error rate
Modify time relations between PDU's	• Easy implementation • Hard to detect	• Very low steganography bandwidth • Required sender-receiver synchronization • Increased transmission delays
Hybrid	• High steganography bandwidth • Hard to detect • No sender-receiver synchronization required • Easy implementation	• Possible deterioration of user data

Mazurczyk et al. [7] also classify previously hiding network steganography methods according to the OSI reference model as is shown in the Fig. 6.

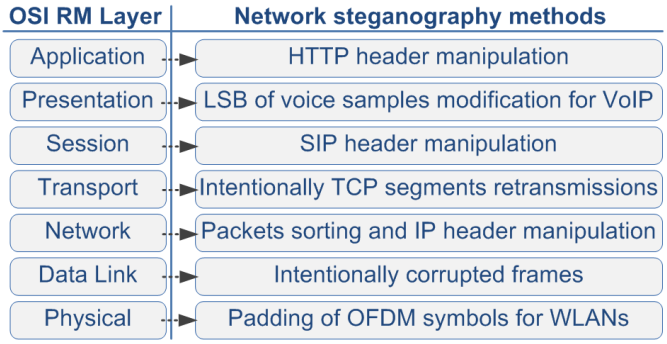

Figure 6. Steganography methods according to the OSI RM [7]

Sekhar et al. [8] list the following methods: HICCUPS (Hidden Communication System for Corrupted Networks), LACK (Lost Audio Packet Steganography), RSTEG (Retransmission Steganography), SCTP (Stream Control Transmission Protocol), PadSteg, TranSteg (Trancoding Steganography), SkyDe (Skype Hide), StegTorrent and StegSuggest. HICCUPS method intentionally sends frames with corrupted checksums, LACK method replaces payload of intentionally delayed voice packets, RSTEG method does not acknowledge successfully received from source but intentionally invoking its re-transmission (instead of payload, source sends the secret data). SCTP method sends secret data within payload streams, PadSteg method replaces padding bits of short Ethernet frames with secret message bits, TranSteg method compresses VoIP data in order to make space for secret data and SkyDe method replaces Skype-encrypted silent packets with encrypted secret data. Finally, StegTorrent method uses modified BitTorrent [9] clients in order to share secret data between group of users and StegSuggest method uses Google Suggest service [10] as hidden data carrier by intercepting messages from Google server and adding an additional word to replay. After receiver extracts the appended (hidden) word, method removes the appended word and user can see the original message from the Google Suggest service. Furthermore, Collins and Agaian [11] list network steganography tools in chronological order and examine their features and concepts.

Previously mentioned steganography methods are applicable to wired network infrastructure. Szczypiorski et al. [12] state the following steganography methods for Wi-Fi (wireless) networks: intentionally corrupted checksums, padding at physical layer, controlling intervals between OFDM (Orthogonal Frequency-Division Multiplexing) symbols, CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) controlling transmission rate or beacon mechanisms and steganography techniques focused on the header. Listed methods are also usable for LTE (Long Term Evolution) and WiMax (Worldwide Interoperability for Microwave Access) communications standards. Laka and Maksymiuk [13] propose new steganography method which successfully hides data in physical layer of the optical networks. Furthermore, Frączek and Szczypiorski [14] presented a framework for the creation of network steganography methods called StegBlocks. StegBlocks is general purpose framework and it is not designed exclusively for a particular network technology or medium. Utilizing this framework two methods were developed: StegBlocks TCP method, which uses parallel TCP connections between two devices, and very similar StegBlocks SCTP (Stream Control Transmission Protocol) method, which is more robust.

B. NETWORK STEGANOGRAPHY FEATURES

There are four network steganography communication features [14]: bandwidth, cost, robustness and undetectability. Bandwidth, robustness and undetectability are mutually dependent [15]: requirements for higher robustness and undetectability result in a lower bandwidth and vice versa. Cost is considered as degradation of the carrier caused by the insertion of the secret data [12]. In case of steganography processing (regardless of the medium) the most desirable feature is undetectability. Authors of the StegBlocks [14] theoretical have proven that described framework helps in the creation of perfectly undetectable network steganography methods.

Covert channel bandwidth rate depends on the applied network steganography method, medium, type and working conditions. Authors conducted a series of tests and state the following values: 802.11n Wi-FI with OFDM method (with respective modulations) 3,25 Mb/s (BPSK), 6,5 Mb/s (QPSK),

13,0 Mb/s (16-QAM), 19,5 Mb/s (64-QAM) [16], Wi-Fi 802.11g with HICCUPS method 1,27 Mb/s, CSMA/CA with beacon mechanism 2 kb/s [12], optic network 20 kbit/s (@ 25 km fibre length) [13] etc.

Simultaneously with development of the concealment techniques, various covert channel detection methods were developed. Main condition for successful detection is deep understanding of TCP/IP as well as knowledge about network steganography and detection methods. Mazurczyk et al. [17] list problems which are obstacle to successful network steganography detection: large traffic volume, difference between expected and real conditions in the network, behaviour of network services and applications, user actions and possible adaptability of the steganography method. Detection process requires significant computational resources especially in real time processing. Furthermore, network services and applications may vary over time due their nature and purpose and user actions are not intentionally malicious so there is possibility of false network steganography detection. Additional obstacles are new usage of new steganography network algorithms and methods which are still unknown to detection system. Main issue related to the covert communication channel detection process is in question: how to detect anomalies or patterns in network flow which indicate that covert channel exists. Methods for classification of network traffic flow anomalies can be divided in three groups [17]: supervised, semi-supervised and unsupervised methods. The supervised detection method has datasets of normal and abnormal network traffic patterns, semi-supervised methods has datasets of normal traffic patterns while unsupervised method has no datasets of network traffic patterns. All mentioned methods are time consuming, complex and require significant computational resources.

Steganography detection methods are divided into the following groups [17]: statistic steganalysis, computational intelligence analysis (usage of neural networks, genetic algorithms, fuzzy logic system etc.) and hybrid steganalysis which are combination of two previously mentioned detection methods. Listed methods and procedures are not dependent on any network technology. Szczypiorski et al [12] propose "The Moving Observer" technique for evaluation of the covert channel undetectability in Wi-Fi 802.11n wireless network. Presented technique scores undetectability in three grades: good - observer can't detect hidden communication from message origin, bad - observer detects hidden communication from origin when it's physically close but not when it moves away from the message origin, and ugly - observer detects hidden communication at any position in the network. Mazurczyk et al. [17] developed novel steganalysis method called steg-tomography which visualize network traffic and detect anomaly caused by applied steganography method.

C. USAGE IN SURVEILLANCE SYSTEMS

Hidden communication channel can be utilized for transmission of monitoring, controlling or safety-sensitive information between installed equipment and road surveillance center. Beside open communication, each device can send data through covert communication channel. Secret communication channel can be used for data exchange between participating subjects in ITS system in order to detect unauthorized access, intentional jamming and intrusion of ITS network system.

Usage of the steganography network channel within highway surveillance system is shown on Fig. 7.

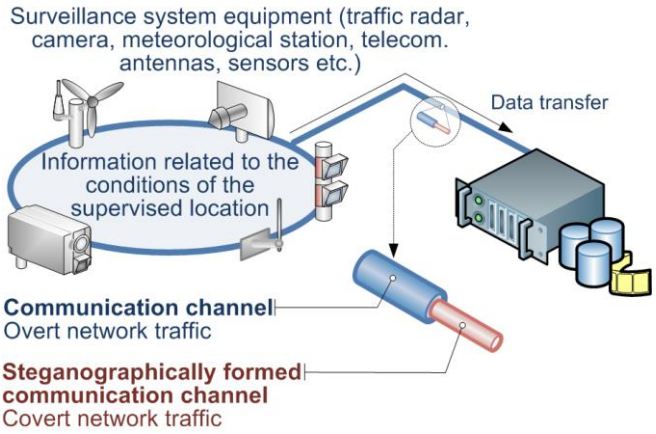

Figure 7. Surveillance system overt and covert communication channels

Each installed device on location communicates with the highway surveillance center in order to send collected data. Covert channel can be utilized for transmission of device monitoring and controlling data, device setup, software upgrades, definition of working parameters, log status information or even sending of the collected data, etc.

The main aim of using the secret communication is enhancing system security and hiding any kind of information which can be used as a possible attack vector. In Fig. 8 displays a standard situation of normal and secret communication between devices and surveillance centre.

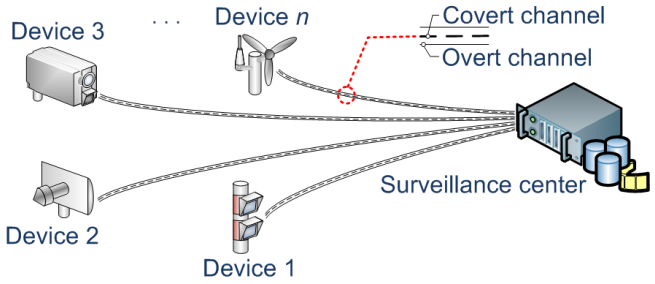

Figure 8. Communication between devices and surveillance center

Malicious user can perform various way of attack on highway network infrastructure in order to access the data or to take control of device. Network IDS should be able to detect and alarm surveillance about malicious activities. IDS should not "react" in way that the attacker is also alarmed so that the surveillance system can have sufficient time to analyze origin, type and extent of the attack, and to initiate counter measures. Alert procedure and all valuable data can be sent thru covert communication channel.

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Highway informational network protection and network forensics can be carried out in many different ways. Khan et al [18] list review of the network forensics taxonomy at Fig. 9.

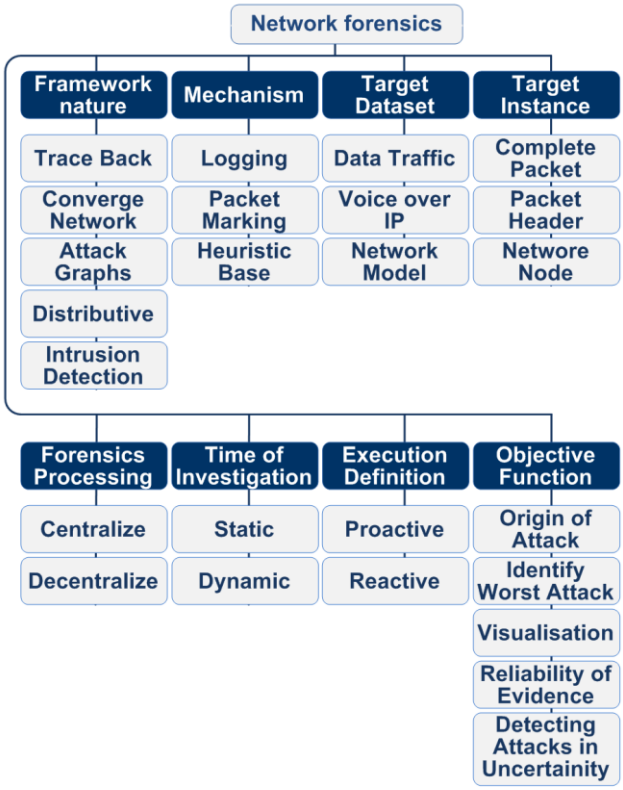

Figure 9. Network forensics thematic taxonomy

Furthermore, due the fact that covert channel is in full-duplex mode, attack counter measure procedures can be performed via covert channel. Fig. 10 depicts the mentioned scenario.

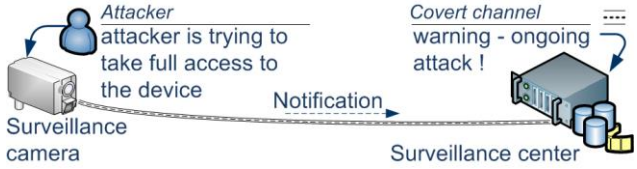

Figure 10. Alert notification sent thru covert channel

In case that the attacker takes partial control of the device, the installed covert channel can secretly send valuable notification and information towards surveillance center. If surveillance center detects that covert channel is missing, the system should be consider such device is malfunctioning or is a victim of an ongoing network intrusion activity.

Figure 11. Lack of a covert channel

In any case, lack of the covert channel indicates a possible problem in a communication channel or the fact that the device is malfunctioning. Fig. 11 depicts mentioned scenario.

Steganography methods are part of the modern network intrusion detection systems. Fan and Wang [19] use steganography techniques to embed log files into the image structure in order to hide them from a possible attacker.

III. CONCLUSION

This paper proposes usage of the covert communication channel within highway surveillance system. Covert channel transfers valuable and sensitive information inside overt network communication between installed devices and highway surveillance centre. Installed network intrusion detection system may use covert channels in order to gather information related to intrusion activities. Due the fact that large number of network steganography methods are developed proposed covert channel system can be used within highway surveillance system regardless to the used network infrastructure. Bandwidth of the covert network steganography channel is highly dependent on required communication undetectability and applied steganography method. Usage of steganography methods requires deep knowledge related to the TCP/IP protocol, applied steganography algorithms and various types of the network intrusion. Future researches are focused on new network steganography methods which can provide high bandwidth but at the same time taking into account undetectability, robustness and minimal content alteration of the payload or protocol data units.

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Employee's awareness on security aspects of use bring your own device paradigm in Republic of Croatia

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Abstract—**Within this paper, a conducted survey analyses the knowledge on the term of the use of personal device in the corporate environment and employee awareness of security issues that arise with introducing BYOD trend in business. BYOD represents a risk to business, usually present as the risk of data theft, unauthorized access to applications and systems of corporation, loss of reputation and such. BYOD, like any other system, must be systematically planned, implemented, monitored and improved. Employees are not sufficiently educated and aware of the security risks that BYOD brings.**

Keywords- BYOD, terminal devices, security, corporative data, security issues

I. INTRODUCTION

With the rapid advancement of technology, smart mobile terminal devices (smartphones), are becoming an integral part of every organization. The usage of personal devices in the corporate environment is introduced as Bring Your Own Device (BYOD) concept, which means the linkage of employee's devices to the corporation's network. Employees mostly bring their own terminal devices, such as smart mobile terminal devices, tablets and laptops for use in the working place.

Today, smart mobile devices are the most widely used terminal devices. They are widely used and are no longer used only for classical communication, i.e. for calls and text messages, like it was the case ten years ago. The amount of data stored on mobile devices is large, and users are often not aware of it. Compromised data can greatly damage the owner, there is a risk of identity theft, financial damage, reputational damage or other forms of manipulation of data by malicious users. Particularly high risk of manipulation of data occurs in a corporate environment, where information stored on the terminal devices can be particularly vulnerable.

With the advent of BYOD model and its integration into the organizational structure there are seem to appear multiple problems while trying to protect such devices. The main goal of any organization is to protect business data and private information infrastructure, but at the same time they are legal and regulatory obliged to respect the privacy of the owner of the device, that is employees. The introduction of mobile terminal devices in business brings many advantages such as access to corporate data on the field, optimization and reduction of operating costs, satisfaction of employees and customers, performing everyday tasks away from the office and so on.

Although BYOD model brings many benefits to employees and employers, there are some security issues regarding sensitive information. The device that is not owned by the organization is used in storing, processing and sending sensitive information, while an unauthorized access to such information could have a huge negative impact on the organization.

This study questions the understanding and frequency of use personal terminal devices in the corporate environment in the Republic of Croatia and the awareness of employees about security issues brought by using personal device at workplace.

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II. TRENDS IN THE USE OF SMART MOBILE TERMINAL DEVICES

Smartphones, thanks to the rapid development of technology and the sale price, have become available for a large number of users. Characteristics of mobile terminal devices become almost the same as those of laptops and personal computers, and therefore they are not used only for personal but also for business purposes [1].

The term of smartphone is introduced to the market as a term that included a new class of mobile phone that offers integrated services, from voice communications, instant messaging, personal information management through to various applications and features of wireless communication [2]. Although there is no exact definition of smart mobile terminal device, it can be said that this is any device that extends the capabilities of the classic mobile device. Additional features that are expected for smart mobile terminal device are not exactly defined and do change over time [3]. Key features of smart mobile terminal devices [4]:

a. operating system (OS)

b. applications

c. full ("software") QWERTY keyboard

d. constant Internet access

e. the ability to exchange messages

Functionalities of mobile terminal devices do not depend only on the hardware, but also on operating system that is being used [4]. Since June 2013 Android is leading operating system for smartphones, as the number of devices sold crossed until then leading iOS [5]. Since that event the dominance of Android OS on the market is evident, which was confirmed by results of research in security aspects of using personal devices in the corporate environment conducted for this study (Figure 1).

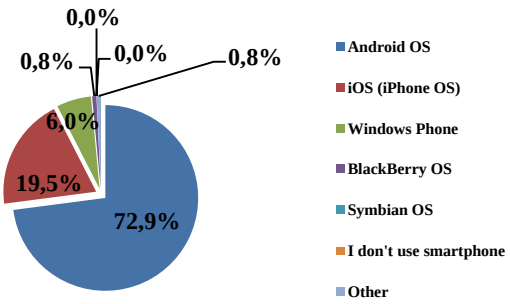

Figure 1. Frequency in the use of individual operating systems of mobile terminal devices

Mobile data traffic will reach the following milestones within the next 5 years [6]:

- monthly global mobile data traffic will be 30.6 exabytes by 2020,
- number of mobile-connected devices per capita will reach 1.5 by 2020,
- average global mobile connection speed will surpass 3 Mbps by 2017,
- total number of smartphones (including phablets) will be nearly 50 percent of global devices and connections by 2020,
- because of increased usage on smartphones, smartphones will cross four-fifths of mobile data traffic by 2020,
- monthly mobile tablet traffic will surpass 2.0 exabytes per month by 2020,
- 4G connections will have the highest share (40.5 percent) of total mobile connections by 2020,
- 4G traffic will be more than half of the total mobile traffic by 2016,
- more traffic was offloaded from cellular networks (on to Wi-Fi) than remained on cellular networks in 2015,
- three-fourths (75 percent) of the world's mobile data traffic will be video by 2020.

III. BRING YOUR OWN DEVICE TRENDS

In the last few years there has been a new trend in the IT environment – BYOD, that many corporations and organizations implemented in their business [7]. BYOD allows employees to bring their own terminal devices to their workplace, such as laptops, smart mobile devices and/or tablets, to work on them and connect them to the corporate network instead of using devices in the corporate property [8].

The introduction of mobile terminal devices in business brings many advantages such as access to corporate data on the field, optimization and reduction of operating costs, satisfaction of employees and customers, performing everyday tasks away from the office and so on [9]. The company can save a lot of money that would be spent on the purchase of expensive equipment if the BYOD is not being used. Thanks to the employees who pay for their own devices, companies can save up to $ 80 per month per employee [10].

A recent survey by Intel performed on many organizations about benefits of BYOD for IT and as follows [11]:

- 28% improved efficiency and productivity
- 22% improved worker mobility
- 17% saving on inventing in new machines
- 9% job satisfaction and retention
- 6% reduce IT management/troubleshooting

However, due to the mobility of devices, their small size and the ability to connect through several available technologies, mobile devices are vulnerable to security threats from other devices such as PCs and laptops. Some of the security threats to mobile devices are [1]:

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- theft or loss of a mobile terminal device,
- attacks on devices intended for recycling,
- attacks through malware (malicious) content (viruses, worms, spyware, adware, ransomware and Trojan horses)
- monitoring data through specific sensors (GPS, accelerometer, microphone, camera)
- phishing attacks
- exploitation of vulnerabilities in web browsers,
- automatic download of applications,
- attacks through falsified information about the network,
- exploitation of network gaps,
- social engineering.

The impact of these threats can affect private information, intellectual property of corporation, confidential information, financial assets, the availability and functionality of the devices and services and the personal and political reputation [4].

In order to preserve the security of information it is essential to maintain the integrity, confidentiality and availability of information system resources [12]. The integrity, confidentiality and availability are the three basic principles of information security. Resulting problem can be solved by separating private and business data in the device and thus reduce the risk of compromising user privacy and unauthorized access to sensitive information of the organization. Such solutions are often implemented within a comprehensive enterprise mobility management system (EMM) [1].

It is forecasted that 200 million out of 350 million mobile device users will be utilizing them in conjunction with the BYOD approach by the year 2016 [13]. In [14] autor have forecasted that, by 2016, worldwide shipments of smart phones will reach 480 million, with 65% being used in bring-your-own device environments. Gartner predicts by 2017, 50% of employers will require employees to have their own device for work purposes. According to Forrester, 50% of 18- to 31-year-old and 40% of 32- to 45-year- old workers believe technologies used in their private life are “better” than those in their professional life[15].

IV. DESCRIPTIVE ANALYSIS OF EMPLOYEES’ AWARENESS ON SECURITY ASPECTS OF USE BRING YOUR OWN DEVICE PARADIGM

This paper includes research on the term of the use of terminal devices in the corporate environment (BYOD). The conducted survey examined the frequency of the use of personal terminal devices in the corporate environment in the Republic of Croatia and the awareness of employees about security issues that come as a result of using personal device at workplace. The target users for this research were exclusively employed persons. The research included 133 respondents, of whom 67 women and 66 men. Respondents are mostly younger, between 18 and 35 years.

According to research conducted for this paper it can be concluded that employees in Croatia often use their own terminal devices in the workplace but BYOD trends are not developed as they are developed in the United States or other countries of the European Union. 12.8% of respondents never use their personal terminal devices in the workplace, 9.8% of respondents rarely use their personal terminal devices, 22.6% use them occasionally, 17.3% often, and even 37.6% of respondents use their personal terminal device at workplace very often. These results are shown in Figure 2.

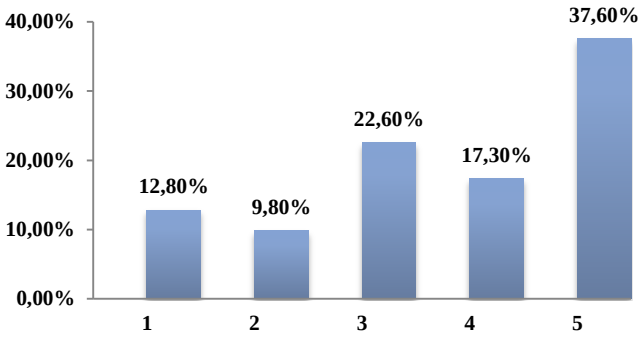

Figure 2. The use of personal terminal device at workplace

Smart mobile terminal devices (66.17%) are most often used personal devices at workplace, followed by laptops or notebooks (17.29%). Types of personal terminal devices used at work are shown in Figure 3.

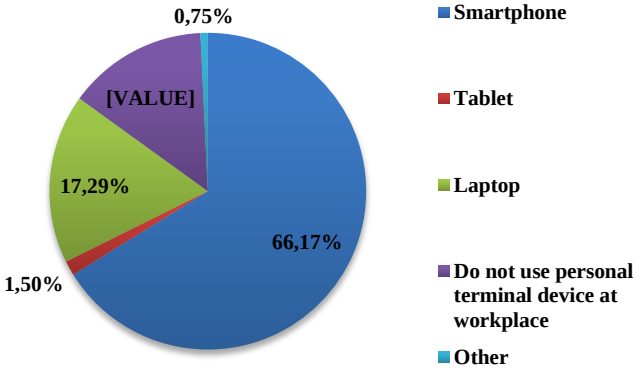

Figure 3. Types of personal terminal devices used at workplace

Conducted research shows that most users (38.35%) connect their personal device to the corporate network very often or never (32,33%) as is shown in Figure 4.

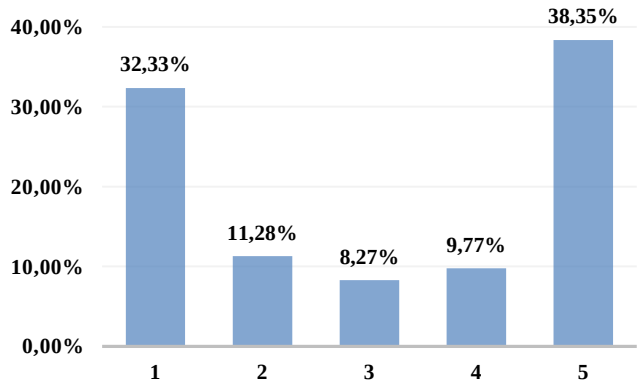

Figure 4. The frequency of access to the network with personal device in corporate environment

Results of the research on the user awareness of security issues of connecting personal terminal device to the corporate network are disturbing (Figure 5). 30,00% of respondents do not even consider (with greater conviction) that the security of company data is compromised, while 38,46% do not consider (with less conviction) that the security of data is compromised. 68,46% of respondents are not aware of security issues of using their personal terminal devices in the corporate environment. 16,92% of respondents don't know is the security of data compromised, 0,77% state it does not matter whether the security of data is compromised, 3,08% think that the security of data is compromised but don't consider it important, while only 10,77% of respondents believe that the security of company data is greatly compromised.

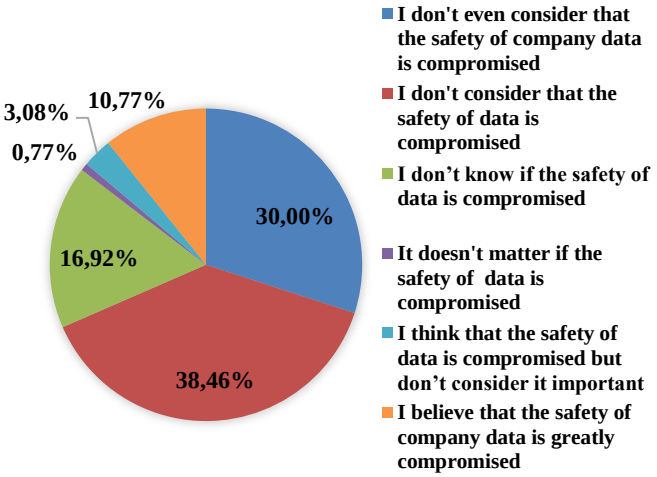

Figure 5. Awareness of compromising security of company data by accessing the network with personal device

More than a half of respondents are not familiar with the term of BYOD (Figure 6). 36.64% of them had never heard of the term BYOD, and 13.74% have heard of the term but are not familiar with it. 16,03% of respondents were poorly informed about the BYOD term. 10.69% of respondents are well aware of the BYOD term, while 22.90% of them stated that they are fully aware of the term.

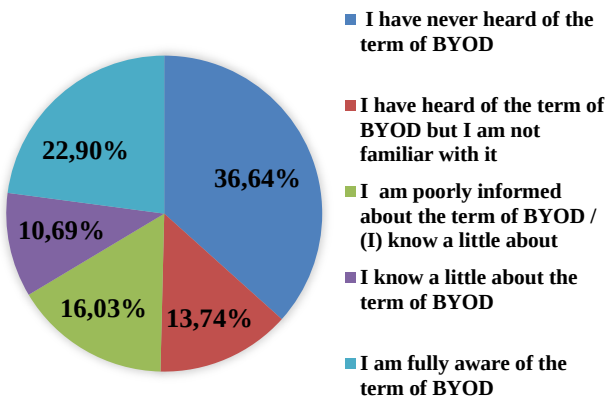

Figure 6. Percentage of the respondents familiar with the term of BYOD

According to conducted research shown in Figure 7 it can be concluded that employees are not educated enough, or they are not aware of security policy of the company and the ways to ensure the security of company data. Even 44.27% of respondents don't know if the company in which they work has a BYOD security policy. 27.48% of respondents claims that the company in which they work is not conducting BYOD security policy, and 12.98% say they do not know what is BYOD security policy. 6.87% of respondents claims that the company has a BYOD security policy, but the employee doesn't know much about it, while only 8.40% say that the company conducts BYOD security policy and the employee is well familiar with it.

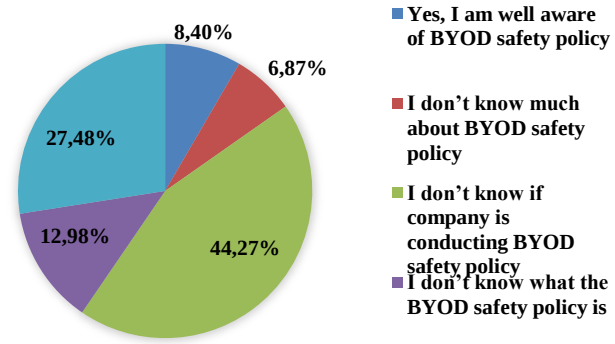

Figure 7. Percentage of the companies conducting BYOD security policy

V. CONCLUSION

BYOD is one of the newer causes of data vulnerability where employees within corporation access to sensitive corporate data using their personal devices, i.e. laptops, smart mobile terminal devices, tablets and similar. According to the results of the research it can be concluded that employees in the Republic of Croatia do not use their personal terminal devices in the workplace as much as employees in the United States and other countries of the European Union. In cases where personal terminal devices are being used, the term of BYOD has not been adopted.

The employees are not educated enough about security risks to corporate data. Employees believe that corporate data

is not owned by them and that their compromise is not going to affect them. The consequences of security flaws can be very high, not only for business but also for its employees, which shows the importance of continuous education of employees.

Companies that allow their employees to use their personal terminal devices should have priority to protect the basic principles of information security (integrity, confidentiality and availability). Nowadays, the information is more valuable to companies than physical assets, and to ensure competitiveness in the market it is crucial that the information is well protected.

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Digital Evidence Investigation Using Habits Attribution

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Abstract—**The acquisition of digital remnants and their use in order to found crime footprints in the digital user places (device, profile, home directory, etc.) is the challenge of this article. This work analyzes attribution, profiling and habits domains and proposes approach for modeling certain issues of digital evidence investigation. The proposed model focuses on digital evidence investigation that uses attributed habits decreasing number of the artifact search sequences from the set of digital user places.**

Keywords- Attribution; Cybercrime; Digital forensics; Habit; Profiling

I. INTRODUCTION

Cybercrime and its interest groups become the part of our digital society [1, 9]. More and more investigations become dependent on digital evidence, the need to assist law enforcement narrows the potential suspects, based on digitally derived salient case points that turn out increasingly important.

As well as identifying direct evidence of a crime, digital forensics can be used to attribute evidence to specific suspects, confirm alibis or statements, determine intent, identify sources (e.g., in social media cases), or authenticate documents [7]. Investigation in attributes are much broader in scope than in other areas of forensic analysis. Meta data and other logs can be used in order to attribute actions for personality identification.

Of is provided the vast majority of the work in digital forensics involves attributing results to individuals; we need approaches for modeling individuals in a manner that is both principled and computable. This abstraction would include representations for simple data elements, such us: like names, email addresses, and identification numbers, but should also extend to ways for formal representing of person's knowledge, capabilities, and social network [10].

Digital profiles are widely used in investigations to link together different crimes, narrow down lists of suspects, and aid the process of investigation [17]. Profiles help building bigger picture and reconstruct the crime, if there are too many unknowns [22]; it can be helpful to sway an investigation or add confidence to existing evidence while a profile cannot be used as direct evidence [12]. This simplifies the investigation process and makes use of profiling to have a successful result.

The ability to obtain reliable, valid offender profiles and better investigative protocols according to recent surveys on law enforcement needs for computer crime investigations, were rated as pressing issues [13].

Digital behavioral analysis is a relatively new field applying the concepts of traditional behavioral analysis to the digital footprints of criminals. The analyzed are known crimes can be digital crimes, or digitally facilitated through re-searching, planning, communicating, documenting, or otherwise enabling criminal activity. Some preliminary work in this field was done by applying a traditional criminological approach to cybercrime. Grabosky [11] proposed a criminological approach to computer crime, providing a categorization of computer-specific offenses.

Taxonomy, relevant to profiling hackers included the most traditional cybercrimes with virus writing, hacking, and proposed professional criminals [16] and further applied the concept of social learning theory and moral disengagement toward furthering the understanding of cybercriminal behavior [3].

Dr. David Canter [2] says that "criminal profiling is a method for identifying the personal and behavioral characteristics of an unknown perpetrator of a crime. Profiling is based on an analysis of the nature of the offence and the manner in which it was committed". Profiles of user behavior on digital devices have been researched. Set-theoretic developed was in there digital profiling approach to building a usage profile of an individual on a device for the purposes of linking profiles across devices [5]. Most of the prior art takes a nomothetic approach to behavioral analysis by attempting to understand the aggregate behaviors of cybercriminals. Majority of today's digital forensics tools implement the same conceptual model for finding and displaying information. This approach may have the terms of Visibility, Filter and Report models. Profiling can be approached from either retrospective or proactive perspectives. Additionally, profiling methods fall into two basic categories: inductive and deductive profiling [15].

This work proposes the model for digital evidence investigation using habits attribution. The main idea there was to identify habits, attribute them, and then create profile of the attributed habits. Created profile, as set of habits and attributes, may be used in digital evidence investigation to reduce the numbers of evidence search sequences from set of digital user places.

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II. General Framework for the Analysis and the Acquisition of Digital Remnants

A general framework for the analysis and the acquisition of digital remnants is shown in Fig. 1. Y-diagram linking together three basic domains: attribution, profiling and habits is depicted at the core of the framework. The framework also outlines a context of the selected domains: for attribution domain it is meta data and other logs can be used to attribute actions to personality identification, the profiles for profiling domain help to reconstruct the crime, when there are too many unknowns, and to approach to examining and classifying user habits for habits domain.

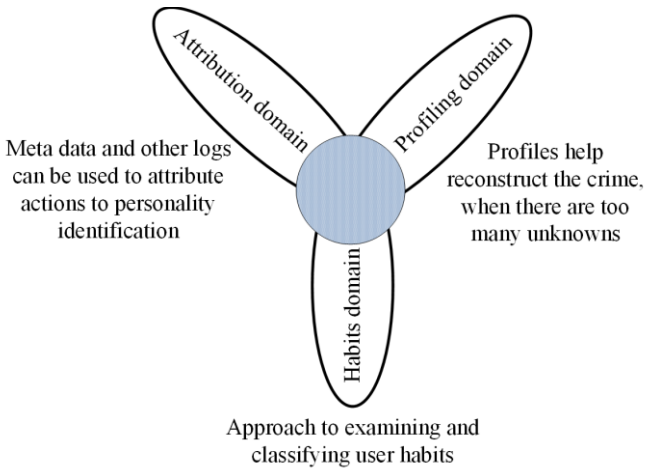

Figure 1. General framework for the analysis and the acquisition of digital evidence

The intersection between the domains (presented by a circle in Fig. 1) identifies the space for the proposed attributed habits profiling model. The space of the attribution domain is to be considered for each user habit from the digital habits domain. Attribution domain (adopted from [8]) is depicted in Fig.2.

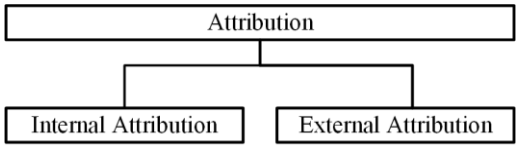

Figure 2. Attribution domain

Attribution domain includes two subdomains. Internal attribution subdomain is the process of assigning the cause of behavior to some internal characteristic, rather than to outside forces. We look for enduring, such as personality traits when we explain the behavior of others (e.g., we attribute the behavior of a person to his personality, motives or beliefs) [8]. External attribution subdomain is the process of assigning the cause of behavior to some situation or event outside a person's control rather than to some internal characteristic. We tend to make external attributions (i.e., situational or environment features), when we try to explain our own behavior [8].

The space of profiling domain has two main approaches: basic approaches to profiling and criminal profiling models. Profiling domain (adopted from [2, 6, 14, 17 and 22]) is depicted in Fig.3.

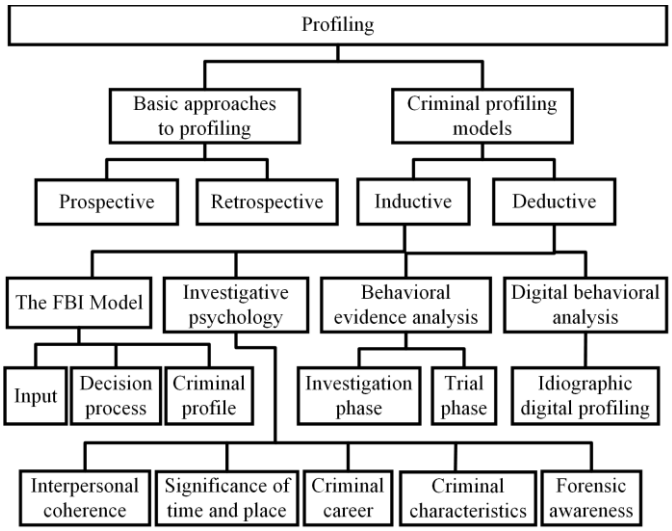

Figure 3. Profiling domain

Basic approaches usually are common to the profiling domain. A template of an offender for a type of crime is used to narrow the pool of suspects in prospective and in retrospective approaches, the details of a crime are used to produce a description of the offender [14].

Criminal profiling models have two main approaches: inductive and deductive. Statistical information about committed crimes is used to generalize the behavior exhibited by these crimes in inductive approach; in deductive approach offender characteristics are derived from the specific case [17]. The main weakness of inductive approaches are the immeasurable error rates, caused by variable levels of honesty and perception bias of questionnaire respondents, or by case studies, taken from a wide range of time and increased possibility of unpredictable external influences on the case [22]. A deductive method takes more personal approach, as it examines every case contextually [22].

The inductive approach following methodologies are: FBI model [6] and investigative psychology [2]. The FBI model consists of three stages: input, decision process, and criminal profile. The crime scene is assessed and evidence is collected in the input stage. The input is organized in decision process and then it is analyzed to establish patterns, crime scene assessment dealing with crime. The offender is described in criminal profile and criminal profile is used to assist the investigation [6].

Investigative psychology uses statistics from offender databases and building of the profile relies on following factors, such as: interpersonal coherence, significance of time and place, criminal characteristics, criminal career and forensic awareness [17]. This model is mostly suited for offline crimes, however, in a digital investigation, not all these factors have equal significance (e.g., estimating the offender's forensic awareness [2] can help estimating the offender's level of technical skill).

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Behavioral evidence analysis methodology [22] is the deductive profiling approach, consisting of two phases: the investigation phase occurs when there is a criminal event, but the offender is unknown; the trial phase occurs when the offender becomes known.

Chad M. Steel [3] was the first to propose an idiographic approach to digital profiling by examining a particular subjects in Internet activities and electronic media for the purposes of using digital footprints, left behind for immediate use in an ongoing investigation. The guidance, presented in Chad M. Steel paper [3], is provided to investigators to assist in creating an idiographic digital behavioral profile in active criminal cases. The profile can be developed iteratively and refined during the course of an investigation. Profiling can assist in subject disambiguation when multiple potential users are involved, as it may be the case with judicially authorized data intercepts of Internet traffic (e.g., from a wireless access point). Ultimately, a successful profile will provide immediate value to investigators in case planning, subject identification, lead generation, obtaining and executing warrants, and prosecuting offenders [3].

The space of habits domain (adopted from [23]) depicted in Fig.4 haves goal system with two main processes: exposure and activation, where three ways of habits interface with goals to guide behavior included are [23].

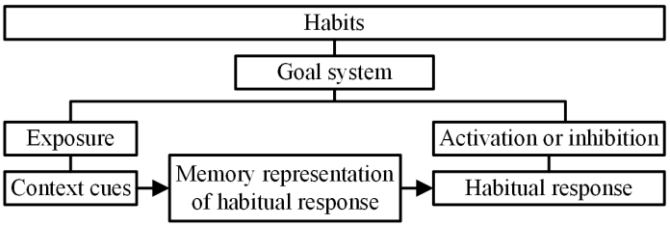

Figure 4. Habits domain

Cues starting from exposure context automatically activate the habit representation in memory and then form habitual response based on habit activation by tailoring people behavior to the current circumstances [23].

Systematic approach to dealing with the problem of attribution, profiling and habits using feature diagram are presented in the next section.

III. Representation of Habits Identification Domain Using Feature Diagram

This section of the habits identification domain (HiD) deals with the profiling technique that is based on the attributed habits. The model of the HiD is outlined by Fig. 5, represented using a feature diagram.

In general, feature diagram is the tree-like notation or directed acyclic graph consisting of a set of nodes, a set of directed edges, a set of edge decorations, relationships and constraints among features. A feature is understood as an externally visible characteristic of an item (i.e., concept, entity, algorithm, system or domain). The root represents the top level feature. The intermediate nodes represent compound features and leave to represent atomic features that are non-decomposable to the smaller in a given context. The edges are used to progressively decompose a compound feature into more detailed features. Edges of the graph also denote relationships or dependencies between features. More about the notation can be studied in [18].

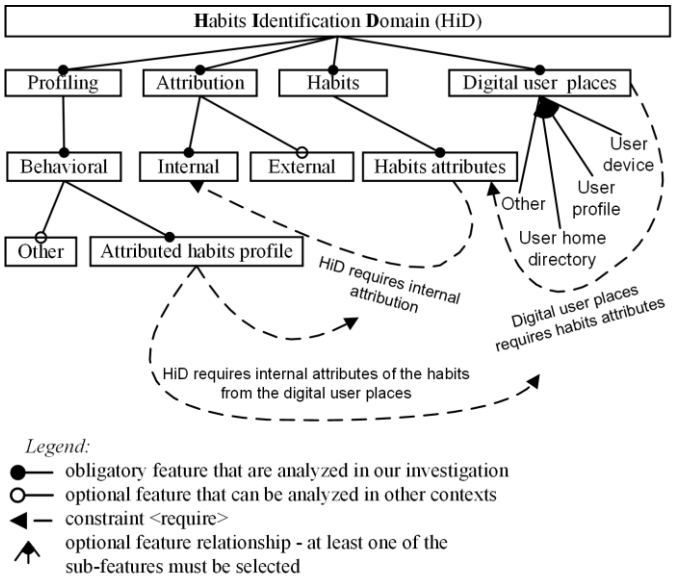

Figure 5. Feature diagram of the HiD

The mandatory features express common aspects of the concept (Fig. 5), whereas optional and alternative features express variability. All basic features may appear either as a solitary feature or in groups. We can speak about relationship among those features if all mandatory features in the group are derived from the same parent in the parent-child relationship. An optional feature is the feature which may be included or not included if its parent is included in the feature model [20].

The presented model focuses on the specialization of the habits, their attributes, and profiles. We permit that for each user the habit is a set of specialized habit attributes. The set of specialized habit attributes is digitally identified from digital user places (see Fig. 5). Every habit from the set of habits is attributed with internal attributes and then saved in the profile, further used in evidence investigation process.

IV. Model for Digital Evidence Investigation Using Habits Attribution

The HiD is based on a model, including mining, comparison, and recognition of digital profiles of user's digital places. Identification is provided through the comparison of a digital first profile, taken from a PC, certainty attached to a known subject and the profiles extracted from other digital devices with which those crimes were committed, but cannot be attributed with certainty to the subject. It should be noted that the model is based on two-way principle, i.e., it can also start from user's digital profile "anonymous" of the device, for comparison with profiles of other devices (also not involved in the offense), attributed with certainty to particular subjects [19]. The creation of the HiD starts from the study of information characterizing the detected areas, such as: computer users, their home directories, files and folders, nicknames, etc. on a PC or digital devices.

In general, investigator uses a set of search rules during examination of a user digital place, (e.g., when the pictures are evidence investigated digital remnants, investigator uses: *.jpg or *.gif or *.png, etc. search rules).

Further, we formalize the investigation task in the way adopted from [21]. Let we have four sets:

artifact (*A*) is a set of the digital artifacts, where each artifact is based on trace, left behind due to user activities and system events;

search (*S*) is the set of the search strings;

profile (*P*) is the set of the personalized profiles, where each profile is based on the analysis of files in the folder, created for the user on the digital user place;

digital user places (*D*) are the set of the user devices, files (folders), home directory etc.

Every set has its own variants. With regard to the introduced sets, consider a search for the artifacts when image files are investigated, as defined by equation (1):

$$\left\{< a > |\exists d(d \in D \wedge \left(\exists p \left(p \in P \wedge \left(\exists s(< s >\in S \wedge s =* .jpg)\right)\right)\right)\right\} . \quad (1)$$

Evaluating equation (1) we will calculate cardinality $|A|\times|D|\times|P|\times|S|$. Sets have constraints, such as: investigator evidence preference or search strings, which might be influential in selecting variants from *D*. Example of investigator's evidence preference may be searched for some types of *.jpg files.

We introduce a set of habits $H = \{h_i\},\ i = [1, m]$ of the same HiD, a set of habit attributes $A = \{a_j\},\ j = [1, q]$ and search rule construction function based on attributed habits (2) for the HiD based model.

$$f(SR) = H \cup A. \quad (2)$$

The function $f(SR)$ construct search strings are based on the following assumptions:

The computer user is a human being, tending to customize all the environments with which they interact based on their habits.

Attributes may be applied to the habit for habit identification.

Attributed habits profile may be used to construct search rules.

Then we replace the set of the search strings $\{s_1, \dots, s_i, \dots, s_m\}$with the set of calculated values (3) of the function (2).

$$\begin{Bmatrix} f(sr_1) \\ \dots \\ f(sr_i) \\ \dots \\ f(sr_m) \end{Bmatrix} \rightarrow \begin{Bmatrix} s_1 \\ \dots \\ s_i \\ \dots \\ s_k \end{Bmatrix} . \quad (3)$$

We will have sequences $|A|\times|D|\times|P|\times|F(SR)|$ when evaluating equation (3). Sequences have constraints, such as: investigator's evidence preference or crime habit, which might be influential in selecting variants from *D*. Files and folders, naming manner may be the example of a suspect habit. We will use proposed equation (3) for further formalization.

The number of sequences due to mentioned constraints is less than evaluated in equation (3). We assume that those constraints can be expressed using the constraint operators: *requires*, *requires_any_of*, *excludes* and *subset.*

Let for user hardware we have variants of artifacts $A\{a_1, a_2\}$, variants of search rule construction functions $F(SR)\{sr_1, sr_2, sr_3, sr_4\}$, variants of profiles $P\{p_1, p_2\}$, variants of digital user places $D\{d_1, \dots, d_i, \dots d_l\}$. We assume that investigator will search for two artifacts; we have four search rule values calculated by (2), two profiles will be investigated (two devices seized for investigation) and a huge amount of files and folders may be found on the seized devices for evidence.

In our case, we have the number of variants *Nv*, evaluated in (4) as sixteen sequences, containing subsets of *D*:

$$N_v = |A| \times |F(SR)| \times |P| . \quad (4)$$

For further research we assume that investigator search artifacts $\{a_1, a_2\}$ (5 - 8), when the artifact $\{a_1\}$ is based on $f(sr_2)$ and $f(sr_3)$ search rule construction function values (6). The artifact $\{a_2\}$ is based on $f(sr_1), f(sr_2), f(sr_3)$ search rule construction function values (8). Selected search rule construction function $f(sr_1)$ requires $\{p_2\}$ profile (11) and search rule construction functions $f(sr_2), f(sr_3)$ requires any of $\{p_1, p_2\}$ profiles (12). According to the selected profiles, file and folders will be investigated for artifacts (9, 10).

$$\{a_1\}\ excludes\ \{f(sr_1), f(sr_4)\}\ ; \quad (5)$$

$$\{a_1\}\ requires\_any\_of\ \{f(sr_2), f(sr_3)\}\ ; \quad (6)$$

$$\{a_2\}\ excludes\ \{f(sr_4)\}\ ; \quad (7)$$

$$\{a_2\}\ requires\_any\_of\ \{f(sr_1), f(sr_2), f(sr_3)\}\ ; \quad (8)$$

$$\{p_1\}\ requires\ \{d_1, \dots, d_i, \dots d_l\}\ ; \quad (9)$$

$$\{p_2\}\ requires\ \{d_1, \dots, d_i, \dots d_l\}\ ; \quad (10)$$

$$\{f(sr_1)\}\ requires\ \{p_2\}\ ; \quad (11)$$

$$\{f(sr_2), f(sr_3)\}\ requires\_any\_of\ \{p_1, p_2\} . \quad (12)$$

Let $SD = subset\{d_1, \dots, d_i, \dots d_l\}$ and we will write artifacts investigation sequences as follows:

$$a_1 \rightarrow f(sr_2) \rightarrow p_1 \rightarrow SD;\ a_1 \rightarrow f(sr_2) \rightarrow p_2 \rightarrow SD \quad ; \quad (13)$$

$$a_1 \rightarrow f(sr_3) \rightarrow p_1 \rightarrow SD;\ a_1 \rightarrow f(sr_3) \rightarrow p_2 \rightarrow SD \quad ; \quad (14)$$

$$a_2 \rightarrow f(sr_1) \rightarrow p_2 \rightarrow SD\ ; \quad (15)$$

$$a_2 \rightarrow f(sr_2) \rightarrow p_1 \rightarrow SD;\ a_2 \rightarrow f(sr_2) \rightarrow p_2 \rightarrow SD \quad ; \quad (16)$$

$$a_2 \rightarrow f(sr_3) \rightarrow p_1 \rightarrow SD;\ a_2 \rightarrow f(sr_3) \rightarrow p_2 \rightarrow SD \quad . \quad (17)$$

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It is possible to reduce the number of subset D sequences (as an example of our case from sixteen to nine) using our proposed model when search rule construction function evaluates sets of habits and their attributes.

V. CASE STUDY

The sample for our case study have two user profiles: the first profile p_1 coincides with all files on the user's hard disk drive and the next profile p_2 coincides with all files on the user's hard disk snapshot. The attributed habits, evaluated by proposed function (2), have four following values:

$f(sr_1)$ is a set of excluded files and folders with the attribute identifying that they belongs to the computer operating system;

$f(sr_2)$ is a nickname, using habit with the attribute "FirsLast" nickname that is used in every digital place (nickname is composed from first four letters of the user's first name and from first four letters of the user's last name);

$f(sr_3)$ is a file name, setting the habit with the attribute "V" in the file name (evaluated because the user has habit insert character "V" in the file name for versioning);

$f(sr_4)$ is a user login habit with the login name attributes: "First Name", "Last Name", "e-mail address".

The case study sample, investigated for two artifacts such as: the first artifact a_1 collected from the files on the user's hard disk drive and the next artifact a_2 collected from the files on the user's hard disk snapshot. It is carried out in statistically by calculating the percentage of coincident search results trade-offs, founded by comparing the general investigation case with the results when search rules construction functions $f(sr_1)$, $f(sr_2)$ and $f(sr_3)$ are used.

Case study sample was tested in two tests:

Test 1. Artifact a_1 was collected from the files on the user's hard disk drive. Search was provided with coincident values $f(sr_2)$ and $f(sr_3)$, from selected 60 files that have artifact;

Test 2. Artifact a_2 was collected from the files on the user's hard disk snapshot. Search with coincident values $f(sr_1)$, $f(sr_2)$ and $f(sr_3)$ was selected from 30 files that have artifact.

Quantitative assessment of the test results presented in Table 1.

TABLE I. DIGITAL EVIDENCE INVESTIGATION TEST RESULTS, USING HABITS ATTRIBUTION

	Artifact a_1 collected from the files on the user's hard disk drive		Artifact a_2 collected from the files on the user's hard disk snapshot	
	Number of files	Trade-offs	Number of files	Trade-offs
Before test	15429	0%	15097	2,2%
Excluded from investigation after $f(sr_1)$ applied	Not applied		332	
Further investigation after $f(sr_1)$ applied	15429		14765	
Files that has evidence artifacts after general investigation	125	48%	250	12%
Files that has evidence artifacts after $f(sr_2), f(sr_3)$ applied	60		30	

Test results indicates 48% trade-offs after the values $f(sr_2)$ and $f(sr_3)$ were applied and used as searching rules for artifact a_1, collected from the files on the user's hard disk drive. Test results indicates 2,2% and 12% trade-offs accordingly after the values $f(sr_1)$, $f(sr_2)$, and $f(sr_3)$ were applied and used as searching rules artifact a_2, collected from the files on the user's hard disk snapshot.

VI. CONCLUSION

In this paper, we have analyzed attribution, profiling and habits domains. We presented systematic approach to dealing with the problem of analyzed domains using feature diagram model. The proposed habits identification domain (HiD) model deals with the profiling technique that is based on the attributed habits and focuses on the specialization of the habits, their attributes, and profiles.

The method based on our proposed HiD model decreases the number of the evidence artifacts search sequences from the set of digital user places. It analyses data and metadata memorized into a digital device by applying specific techniques taken from intelligence and traditional profiling in order to obtain information that helps to create digital profile with suspect user habits attributes and then consider it during evidence investigation.

The profile creation of attributed habits starts from the research and analysis of all information that can be gathered from digital remnants, left on a digital device by its user. The computer user is a human being, tending to customize all the environments with which they interact. Thus, they cannot avoid leaving (even unconsciously) digital evidence artifacts based on detected, recognized and compared habits. The described in this article model is suitable to the digital devices, such as: personal computers, tablets, smartphones, etc. Digital evidence artifacts investigation, using habits attribution technique, can also be applied to the websites or social networks.

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Social Network Customer Requirements Analysis for Visually Impaired People

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Abstract—**For the purpose of this research, questionnaire was conducted in Zagreb area in order to collect requirements of visually impaired persons on usage of social networks. Social networks can be built according to the universal design principles that allows access to services and content to a wider specter of users. The accessibility of Facebook, Twitter and LinkedIn was tested in order to see how their accessibility is managed. The analysis also shows which content is made satisfactorily in terms of accessibility and which one is not. Based on the result are proposed guidelines for improving social network accessibility.**

Keywords- social networks, universal design, accessibility

I. INTRODUCTION

Social networks represent one of the most popular methods of communication between people around the world. Their influence is mostly seen in an online participation of social events. The most popular social networks are Facebook, Twitter, YouTube and LinkedIn. Even though people without disabilities access all content without issues, visually impaired persons often have accessibility issues while accessing online content.

Web accessibility for people with disabilities represents challenges for web designers. With recent advances in information and communication technologies (ICT), more and more attention is given to improving content accessibility. Visually impaired persons are faced with the issue that the screen readers are not showing accurate information. The reason is the fact that the web page they are accessing is not correctly structured and does not have the appropriate position of web elements.

The purpose of this research is to collect information on difficulties with which blind and visually impaired persons face when using social networks. The goal of the research is to provide the guidelines based on the collected data on how to improve social network accessibility and their quality of life (QoL).

II. PREVIOUS RESEARCH

Many researches have been conducted with the aim to collect information on difficulties that persons with disabilities face when using social networks. Even though accessibility of Internet pages for visually imapired persons is a well-known fact, the most popular web pages do not satisfy web accessibility criteria.

The research Can Blind People Use Social Media effectively, that was conducted in 2014, questioned how much is Facebook accessible to visually impaired persons [1]. They use screen readers to read content on social networks but often the problem is that parts of the page are not recognizable which reduces readability of social network. Six students participated in the research that had to complete three tasks using Facebook social network: search for a specific person, communication with a specific person and planning of social event. During the search for a specific person, the biggest issue that arose was uncertainty why they could not find the person they are searching for. Reason for it is that the front page had two search fields – one for searching the Internet and the other to search the social network. Participants were not aware of two search fields so they could not find the person they were searching for. When they tried to achieve communication, they could not find the field for entering text. Also, they were not certain whether they were at the user profile page of a person they need to communicate to. During the planning of social event, participants were not able to define date when the event should happen. When the participant wanted to delete certain pieces of event using the Backspace button on the keyboard, participant was returned to the previous page instead of deleting the content. Analysis of the results showed that participants needed a lot more time to get around certain areas of the web page, to fulfill certain tasks and to understand why they were not able to fulfill certain tasks.

In the research Accessibility of Social Media for Students who Are Blind or Have Low Vision, which was done by the research team The Adaptive Research Network in 2009, was researched what are the reasons why students with visual impairment use social networks, which social networks and assistive technology they use [2]. The goal of the research was to identify accessible and not accessible social networks, accessibility problems and solutions how to improve it. Out of 723 students that participated in the research, 95 of them were blind or had problems with vision. Out of 95 students, 23% were completely blind. Assistive technologies that participants use are screen readers (58%), screen magnifiers (51%) and programs to scan and recognize letters. Out of all social networks, they mostly use YouTube (91%), Facebook (83%)

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and Skype (53%). On a scale from 1 (very inaccessible) to 6 (very accessible), YouTube was graded with 4.78, Facebook 4.48 and Skype with 4.84. Participants stated that most important thing they consider when using social network (4.83) is accessibility. It is also noted that a large number of students access social networks through mobile terminal device (MTD) because accessibility is better than accessing social network on a personal computer (PC). With grade 4.2, students stated that they use social networks to feel less isolated. A large number of participants, 90%, have stated that they use social networks to maintain existing friendships and 40% of them to create new ones. Most of them think that security is important so they pay attention when creating their profiles on social networks (5.30).

The research Privacy Concerns and Behaviors of People with Visual Impairments collected data about what kind of difficulties people with disabilities face when doing day to day activities and their concerns about personal security [3]. Inadequately executed accessibility of web site content is one of the reasons why visually impaired persons do not have the ability to be autonomous but rather have to depend on someone else to read the content for them. Even though there are devices which can enable reading of content (screen readers), there are problems due to inadequate implemented accessibility. Regarding the security on the Internet, strong passwords are key for keeping user accounts safe. Users often save their passwords in audio format and, in some cases, they even need to reproduce them when they are located in stranger's environment. Second case is when they use screen reader in the presence of strangers, which can also cause the same problem. Strangers can hear their passwords and use them in malicious content. Participants use Facebook but have expressed great dissatisfaction about its usage. Reason for that is when they finally get used to where everything is on the page and its meaning, Facebook updates and position or meaning of the elements changes, which is very confusing for them. In most cases, the users did not know whether they are sending the picture privately or publicly due to inadequately organized elements on the page.

III. METHODOLOGY

Modern technologies can greatly improve the QoL for visually impaired persons. According to the 2014 data from World Health Organization, there were 39 million blind and 246 million visually impaired persons in the world [4].

Information and communication (IC) services are usually designed in a way where visually impaired persons have difficulties in their usage. Social networks are based on ICT and belong to a type of IC services. Even though there are guidelines for ensuring accessibility of Internet content, this does not mean that the Internet services will be accessible to everyone. In most cases, design of social networks is not accessible to all users.

For the purpose of this research, a questionnaire was conducted in the Zagreb area to collect user requirements from visually impaired persons when using social networks. Participants were mostly students and middle aged people. A total of 30 subjects participated in the questionnaire.

Largest number of participants was between 18 and 24 years old, 43,33% of total participants belonged to student population. From 25 to 29 years, 26,67% participants participated in this questionnaire. Some smaller numbers were between the age of 30 and 39 years (16,67%) and between the age of 40 and 49 years old (13,33%).

In questionnaire, there were equal number of male and female participants. It is important to identify the level of disability to understand with what difficulties users are faced. Blind and visually impaired do not have same requirements when using social networks. In questionnaire, there were 56.67% blind persons.

A large number of participants, 76.67%, uses social networks while the remainder stated that they are not interested in using them (71.42%) or that they do not feel safe enough while using social network services (28.57%). The most popular social networks among visually impaired persons are: Facebook, YouTube, Twitter and LinkedIn. The results are shown in Figure 1.

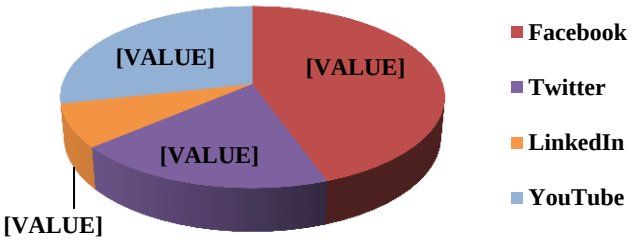

Figure 1. Popular social networks

Blind participants were asked which of those social networks they use and LinkedIn is not used at all. Facebook is still the most popular social network (52.63%), then Twitter (26.32%) and YouTube (21.05%).

Participants were asked how satisfied they are with availability of content that is located on social networks. Scale, which was used in grading the content availability, goes from 1 (very unsatisfied) to 5 (very satisfied). Most of the participants, 47.83%, responded that they are neither satisfied or unsatisfied with content availability, but greater percentage of them were the ones that are not satisfied as opposed to those that are satisfied. Participants were asked how satisfied are they with the availability of pictures and videos and the results are shown in Figure 2.

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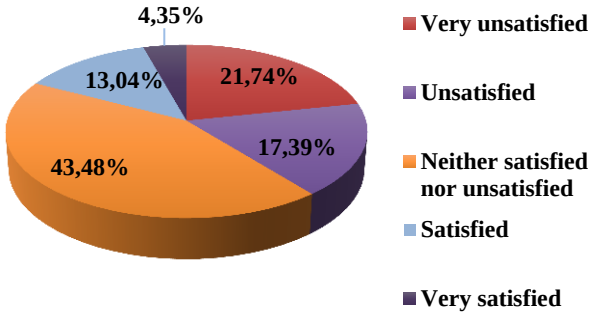

Figure 2. Accessibility of audio and video content

Participants were asked about information on which assistive technologies they use to read social networks content. Screen readers are used by 54.55% of participants, but as it was mentioned in previous researches, screen readers cannot read the whole content on web pages that are not built according to the guidelines for making accessible web pages. The following two assistive technologies that are used are Braille letter (18.18%) and magnifier (15.15%).

Participants were also asked whether they are satisfied with position of web elements on social networks, which implies on readability of information and navigation of user through social network. Most of the participants (36.00%) are neither satisfied nor unsatisfied with web element placement on the page, but there were more participants which are unsatisfied (16.00%) or very unsatisfied (20.00%) in relation to participants that are satisfied. The most of the users were satisfied or very satisfied with the placement of subtitles on video content.

Group travels, adjusted to blind and visual impaired persons, is the content that is currently not located on social networks but participants think it is important. More than a half of the participants, 52.17%, would like to use that type of service. Medical consulting is also very important content for them and 34.78% of them would like to have that service. Volunteer groups that assist blind and visually impaired persons is a content that they also consider it should be available on social networks (30.43%).

Based on the analysis results, it can be concluded that the most of the younger population of blind and visually impaired uses social networks. It is possible that the reasons for it is that the younger generations can adopt more easily to modern technologies than the older ones and the fact that there is no adequate education which will ensure their proper usage. Participants, which do not use social networks, have stated that the reason for it is that they do not feel secure enough. Same problem is stated in the research [3]. Participants have stated that they cannot know with certainty whether they have set up data security properly (for instance if the content on their profile is visible to all users or only to their friends). Facebook represents the most popular social network among blind and visually impaired persons. One disadvantage of Facebook is that it is constantly being upgraded which means that previously available content to blind and visually impaired persons won't necessarily be available after update. It can be concluded that there is a need to improve accessibility of social networks because only a small number of users are satisfied with the current ways of accessing textual content, web elements, pictures and video content.

IV. TECHNOLOGY ANALYSIS

Web 2.0 is a term that describes the changes in the use of web technology and web design in order to increase creativity, secure information sharing, increase user participation in the creation of Internet content and improving the functionalities of the web compared to the previous generation Web 1.0. The most significant feature is the inclusion of users in content creation. Users can use the applications through a Web browser that is defined as a platform through which users have control over the data contained on a website [5]. In addition to being a major cause of interconnection of people from around the world, Web 2.0 also has a significant economic potential. The costs of the availability of tools and Internet access are significantly reduced while the advertising and the development of new business models are increased considerably.

To achieve a well-structured and customized website, it is necessary to use modern web technologies properly, which includes HyperText Markup Language (HTML) and Cascading Style Sheet (CSS) technologies. The last available version of HTML is HTML5, which allows greater accessibility of pages. Accessibility is important because all of the content on a website is accessible to all users, regardless of whether it is a person with impaired vision, dumb person or person without any disability. A key feature of HTML5 technology is that it is supported on all browsers. HTML5 has many advantages over previous generations as shown in Table 1.

TABLE I. COMPARISON OF HTML4 AND HTML5

HTML4	HTML5
Needs Flash Player to reproduce audio and video content	**Has audio and video tags that allows reproduction of audio and video content without the need of Flash Player**
Works online, doesn't have the possibility of local data storage	**Can work offline and online, has a possibility of local data storage**
Not accessible on MTD	**Accessible on MTD**
/	**New attributes and elements for developing a web page**
Complicated syntax, more than 20 lines of code for one element	**Simple syntax**
Complicated to read on screen readers	**Easy to read on screen readers**
Needs a various number of other technologies to improve functionalities of a website	**New forms for developing a webpage, no need to use Javascript in order to make better functionalities of a website**
To determine user location collects information from IP address, Wi-FI network, etc.	**Has geolocation**

CSS is a language that defines the layout of web pages. In previous versions of HTML, layout would be defined in the HTML code but from version 4.0 comes CSS document as a

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separate document. Arrival of CSS many consider the turning point of web design as it allows web developers to control the style and control more HTML pages at once. The latest version, CSS3, in combination with HTML5, can provide a great accessibility of web pages for users with disabilities.

A. Universal design

To develop a quality social network, it is necessary to follow the seven principles that are defined by universal design. It ensures that persons with or without disability can easily use services, products or move through the environment [6]:

- Equitable use refers to the fact that the design must be built in a way that it can be used by persons with different capabilities. For example, elements of social network must be readable to all users, communication and content sharing must be enabled to everyone. There should not be a separation between users in any of the offered services.
- The flexibility in use should be allowed to all users. Visual impaired persons should be given a description of images, voice support for reading the content, quality navigation through a social network so that they could use the social network as everyone else.
- The design of social networks should be understandable to any user, regardless of his knowledge, abilities or experience that satisfies the principle of simple and intuitive use. Social network should be adjusted to a wide range of literacy but avoid unnecessary complexity of the whole social network.
- Visually impaired persons can't see which information is available at some specific parts of a social network and for that reason it is necessary to provide tactile or audio content reproduction. The users have to be able to know the difference between important and unimportant content so it is necessary to create a contrast between them. This provides visibility of information for visually impaired.
- Social network should be designed in a way that all threats that may negatively influence on users should be reduced to a minimum level. It is necessary to provide warnings of the dangers and possible errors. If a visually impaired person sends a public message instead of a private message, social network should have some kind of warning that the message will be sent to the public.
- The user should feel comfortable at any time so the design of a social network should be such that the user can use it effectively with low physical effort. Users shouldn't be bored with repeated messages and demand from them to use more physical effort to get some action done.
- Size and space for approach and use should be provided for approach, reach, manipulation and use regardless of user's mobility, knowledge, posture, etc.

Although different products and services can't meet all of the principles of universal design, it is necessary to satisfy the maximum number of them in order to improve new technologies and promoting the independence of the user. When designing services or products, it is required to include other factors, such as: technical characteristics, environmental concerns, economic acceptability and accessibility.

B. Accessibility and social networks

To fulfil some of the principles of universal design, it is necessary to ensure the accessibility of social networks. Social networks make up a major aspect that changes the way people communicate with each other, how business firms share information or promote products. They can be used for entertainment, video sharing, debate about video games, etc. In addition, social networks can be used for education in a way that users can participate in online courses and share information on taken matters. Possibilities of social networks are limitless and are available to users with no disability. Visually impaired persons are often faced with obstacles that prevent them to use social networks efficiently. To enhance the accessibility of web pages, the set of recommendations called Web Content Accessibility Guidelines (WCAG) should be used. WCAG 2.0 covers a wide range of recommendations for accessibility of Internet content to ensure the availability of content for persons with disability. There are four principles that needs to be satisfied: perceivable, operable, understandable and robust [7].

The term perceivable means that the information and user interface must be presented in a way that users can "see" them. This means that users must be able to obtain information that is presented in the user interface. Operability refers to the fact that the user must have the ability to manage user interface components and navigation. The user interface can't contain activities that the user can't perform. The information and operations must be understandable to the user, and the content must be sufficiently clear so that different software can be reliably interpreted, including assistive technology. Regardless of the advancement of technology, the user must be able to access the content.

All four principles must be fulfilled so that visually impaired persons could use web pages. Each principle has guidelines and criteria that helps in solving these principles. Web page has to fulfill five requirements for obtaining the WCAG 2.0 consent. To satisfy the conditions of the first demand, website has to fulfill at least one of the following [7, 8]: Level A – For level A conformance the web page satisfies all the level A success criteria or provides an alternate version. Level AA – For level AA conformance the web page satisfies all the level A and level AA success criteria or provides an alternate version of level AA. Level AAA - For level AA conformance the web page satisfies all the level A, level AA and level AAA success criteria or provides an alternate version of level AAA.

Another requirement that web page has to fulfill is to be fully developed. Alternative names of elements of a web page are considered as one of the main elements that it should contain so every element that visually impaired person can't read has to have its alternative.

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The third requirement is called the complete process. When the web page is one of a series of web pages that represents a process, all web pages in the process must correspond to the specified or better level.

The fourth request relates to the ways of using the technologies that support accessibility. They are used to meet the performance criteria.

The last requirement refers to that there must be no interference. If the technology is used in a way that does not support the accessibility, the user is blocked and cannot access to the rest of the web page. The web page continues to satisfy the requirements for approval under the following conditions: when the user activates the technology on which web page is independent, when the user turns off the technology on which web page is independent and when the user does not support the technology that is not needed to run the web page. The success criteria apply to the content on the web page, including the content on which the web page does not depend to meet the approval.

V. SOCIAL NETWORKS ACCESSIBILITY TESTING

WAVE tool was used to check the accessibility of social networks. The goal was to gather information about elements on the social networks that are not accessible to visually impaired persons. Since the results of the survey showed that Facebook and Twitter were the most popular social networks, their accessibility was tested. Apart from them, LinkedIn was also examined because none of the respondents was using it and the aim was to discover whether it was because of the inadequate accessibility or some other reason. The accessibility of user login, user registration, sending private messages and element visability on the home page of the user profile was examined.

A. Accessibility testing of the social networks login feature

Facebook page contains user name and password fields for user registration, a description of a couple of Facebook features and language selection. On the Facebook login feature that is shown in Figure 3, non-text content recommendation was violated, which means that the input data in the form must have a description of the functions it performs, and in this case that is not clear. The following recommendations are made to the information and connections between them, i.e. on the <label> element which is not associated with the form data input, but the button that stores the form. Labels and instructions are the third A level recommendation that has not been satisfied in this case. It is necessary to ensure a sufficient number of labels and instructions for the corresponding interactive element, and they must be provided via the example, guidance and properly positioned <label> tag. In this case, the <label> tag is not correctly positioned because it is not on the part of data entry. Also, within the <label> element is a <button> element which absolutely violates the rules of writing HTML code. Last mistake on level AA recommendation, titles and labels, refers to the <label> element which must include a quality description of the form to which it relates which is not the case. Yellow indicators point to a warring about which element should be repaired in order to get a better accessibility. It occurred on the user login page that there is a too small difference in the color contrast which greatly affects the accessibility of content for visually impaired. Adequate contrast is not only important for visually impaired persons, but also to all other users. Level AA, a recommendation on how to solve this problem, refers to that the text and images of text must have a contrast ratio of 4.5 : 1, while large text (over 18pt or 14pt bold) must have a contrast ratio of at least 3 : 1. On the user login page there were three labels with the same meaning. Tab index attribute specifies the order to read the page content when the Tab key is used to navigate the page. It is recommended that the site should be structured in a way that the Tab index is not required, and if present, it is important to provide a logical and complete navigation. Recommendation is defined in level A.

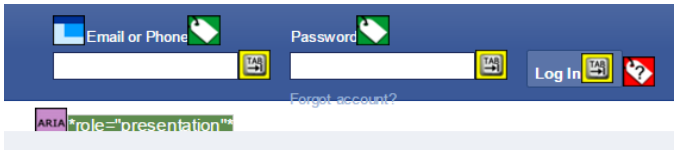

Figure 3. Warnings and accessibility errors on Facebook user login page

Twitter has simpler user login feature than Facebook. When the user presses the button to sign in, a pop-up window opens up in which the user enters their username and password. Two equal errors were shown, concerning the fields to enter the user name and password. Just like on Facebook, the occurred error defined that there is no <label> element that describes what element for entering username does.

LinkedIn, like previous social networks, has user login and user registration on the same page. According to descriptions of users, LinkedIn is considered the most accessible social network. Compared to Twitter and Facebook, LinkedIn did not contain any error nor warnings for the content accessibility at registration and user login features. As for contrast, dark background with white boxes for text input presents well implemented solution for the visually impaired.

B. Accessibility testing of the social networks registration feature

Another feature that was tested was registration page. On Facebook, the registration page is located directly under the login feature. By starting WAVE tool, it was discovered that there are five warning indicators, but no errors. The first warning indicator appeared at the input field for user name. There was a <noscript> tag used as an alternative content to users in the browser that have JavaScript turned off or their browser does not support JavaScript. Recommendation is defined by 508 standard, and the person that wants to register gets the information that he has JavaScript turned off and that he needs to turn it on or use another browser that has JavaScript turned on to be able to register. When entering the date of birth, three warnings appeared with the same message. There was a form element with the title without a <label> element. Screen readers can read attribute <title>, but the accessibility of content is better if the <label> element is used. Level A recommendation is that every form entry has <label> elements instead of titles; text <label> elements are associated with elements of form input. Level AA recommendation defines that each <label> element must be informative. Last warning that appeared on user registration was related to

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gender selection. The user has the option to select a female or male option described next to each radio button. It is recommended that if there are more radio buttons to select, they should be grouped in <fieldset> element. It serves to visually and structurally group related form elements. In this case, it is not necessary to use the <fieldset> because it is clear even without the legend what radio buttons represent.

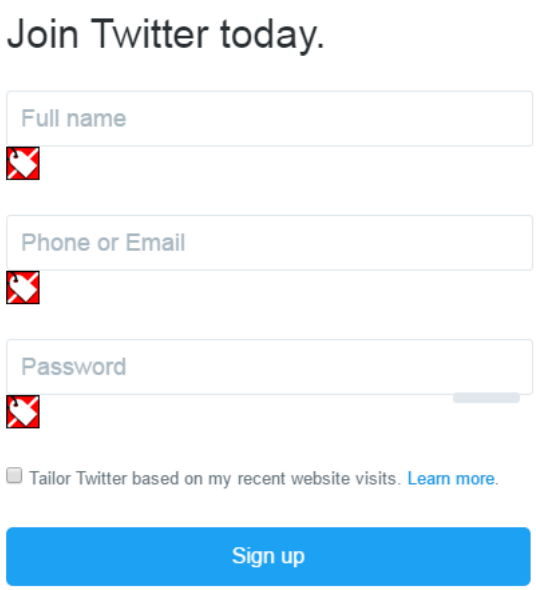

Figure 4. Accessibility errors on Twitter registration page

Twitter user registration appears in a new window, not as a pop-up window. Same mistakes occurred as in the user login and they are shown in Figure 4. It was observed that, compared to Facebook user registration, there is no single indicator warning of possible failures of accessibility which makes Twitter a better built social network from the perspective of accessibility.

C. Accessibility testing of the user home page

Facebook home page indicated two errors and five warnings. The user on the social network sets profile picture that will appear mostly next to his name. The image is located within the links, and if there is no <alt> tag that describes what the image represents, a screen reader cannot read the link and visually impaired persons will not know what the link is used for. This violated the recommendations of A level, which defines that each image must have equivalent and suitable alternative text, which in this case does not exist. Another error that appeared was very similar to the previous. It indicates that the link does not contain a picture or text, so the screen reader cannot know what the link represents. The difference between the previous mistake and this one is that the previous images use tag like <img src = "..."">, while in this one, image is displayed by class within the <i> tag, which screen reader cannot read. It violated the A level recommendation which defines that links must be described. As for the warnings, user name and profile picture are two links that lead to the same location. WCAG recommendation defines that if adjacent links lead to the same location, it is best to connect them into a single link. On the part of the social network that contains frequently used locations and groups was determined that the text that appears on the page is equal to the alternative text intended for the blind and visually impaired. Depending on the type of content and its intended use, it is possible to use the same text in both cases. Headline notification is given an <h6>, which can be confusing to screen reader users because it is the recommended by level A that titles should be structured in the order of <h1> to <h6>. On the news part, content is visible and when hovering over it, there are events that occur only at that moment. Visually impaired persons can still access this information without additional effects that a person with normal vision can see.

On the Twitter user home page, the WAVE tool found four errors and eight warnings that provide information about the possibility that the displayed content is not accessible to the visually impaired persons. The first error referred to a link that did not contain alternate text that describes where the link leads to. It is intended to redirect users to their own profile, but a screen reader cannot get that information. Next error referred to the profile picture. Profile picture did not contain an alternative text to describe what is the picture about. To a person with visual impairment, picture without description means nothing. Identical errors were visible on the user follow recommendations. As for the warnings, the profile name, profile picture and a nickname that is used to include users to Twitter messages, all lead to the same location. As already mentioned above, if the elements are juxtaposed, and have the same link, they need to be grouped into a link that leads to a particular destination. Identical error occurs with the recommended profiles. It has been observed that the link has the same alternative text as the text that was displayed. It is recommended that the alternative text should be more descriptive text that will describe in more details, but in this case, it is not necessary since it is the name of the user profile.

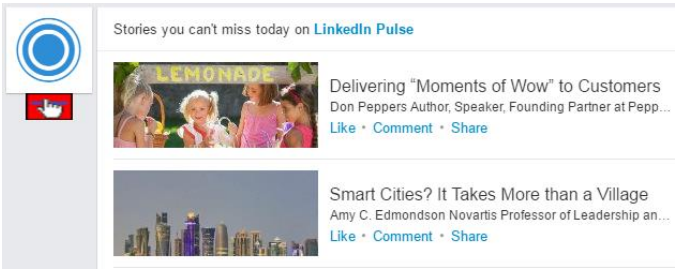

Figure 5. Accessibility error on LinkedIn home page

On the home page of the LinkedIn, only one error occurred that is shown in Figure 5. It referres to the link that does not contain a description that describes where the user is redirected when clicking on a link.

D. Accessibility testing of the chat functionality

When using the chat functionality of Facebook in full screen, accessibility testing revealed five different errors. When starting a video call or conversation settings, an error appears that neither of the two buttons have no alternative text that describes the function of the button. This has violated two rules of level A that were previously described. When searching for conversation, same mistake reappears as in the user's home page, that the screen reader users may not know what the link

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for the search is because the conversation search link does not have a good description. Identical error occurs when the user receives the file or links from another user. When the user sends a message, he has the ability to send emoticons to complement his text. A person with visual impairment does not have available information where emoticons are to be able to choose them to complete their text and send to another user. The error that is present when the user wants to send a file or document is due to the way the input element was structured. This includes an image, text and control that is used to send images. Screen reader cannot read what is in this area, since the elements to send images and documents have their own <label> element, which is available for reading assistive technology. This violated recommendations A and AA levels for the creation of accessible content. When the user searches a list of friends to send a private message, on the side of the chat window there is an option that allows him to block the conversation, turn off sound, launch video calls, etc. A person with a visual impairment cannot get a feedback on mentioned options because there is no alternative text that describes them and, therefore, A level recommendations are not fulfilled to describe the purpose of links. Search structure is set within the <label> instead of using that element to describe what occurs in this part of the page. A and AA level recommendations are not fulfilled which are described in user login section. Only one warning was visible with the name of another user, and it referred to the image and text, as links led to the same location as previously described.

To send a private message on Twitter, user must click on the Messages button, on his homepage, after which a popup window opens. Afterwards, all the messages that have been sent so far are shown and the user has the option to send a new message. The user then chooses whom to send the message, and it can be done by entering user nickname or choosing some of the proposed users, which he has already sent a message. At this point, user can write a message. By using accessibility scan tool, no error or warning has been detected for sending messages, and in this segment, the accessibility of Twitter is better executed than Facebook. As visually impaired persons are in need of a large contrasts between colors, Twitter is not well developed in this regard. One of the new features that Twitter introduced to improve accessibility of content for blind and visually impaired is a description of the picture. Users can add image descriptions to put on their user profile. User that will have descriptions will be at the top of the list when someone searches for a certain image, which increases the popularity of their profile, and the person with visual impairment will have a description of the image available.

Regarding private messaging on LinkedIn, there were no identified errors but only warnings of the same type on the elements for sending pictures and attachments, which is shown in Figure 6. They referred to the fact that the title element is equal to the alternative text of the element as well as in the previous examples.

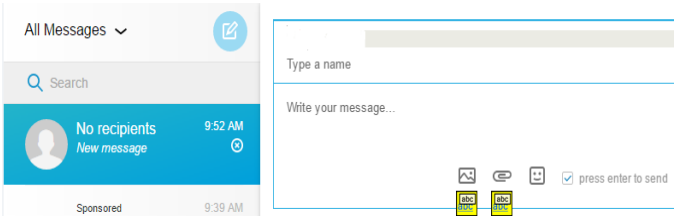

Figure 6. Accessibility warnings on LinkedIn chat functionality

Based on the research of accessibility, LinkedIn social network has the least amount of errors. The reason is not only good element structure but also less complexity of entire social network. Facebook has significantly more errors, but also more features.

VI. PROPOSAL FOR THE SOCIAL NETWORKS DEVELOPMENT

Depending on the purpose of a social network, it belongs to the type of system intended to inform the users, direct them, entertain them or enable them to communicate among themselves. To make a quality design of a social network, the relevant information has to be collected, such as: functionalities that social network should provide, how much are users satisfied with the accessibility of content, which are the suggestions of users about making the social network better, why don't users like certain type of content, etc. The next step is to process collected data: find the most common problems the users encounter, why there are such problems, what alternatives do users use to solve problems, etc. Based on the above, requirements and needs of visually impaired persons are defined and the ways of solving them with the aim to increase the QoL.

When developing any form of an assistive technology, it is necessary to take into account all of the elements that are needed to develop the assistive technology [9]. Fundamental research refers to the hypothesis and research objectives. Under the applied research implies the division and testing of the assistive technology in different environments. The development of a product or a service involves the application of elements of engineering and industrial design, which must be applied to the service. Testing and examination product service is undertaken by the visually impaired persons. Production and distribution of services and products relates to the market distribution through groups of interest (GUI) that represents persons with disabilities. Education is a key element for the development of the assistive technology. It must ensure that the users will use social network independently and at the same time feel safe. Formation of the elements of the social network is very important to provide easy navigation for visually impaired and increase their autonomy and independence.

A. Relevant parameters for developing ICT and services

To ensure a proper formation of social network elements, some of the relevant parameters for development of IC services can be used, such as: speed, time, landmark, orientation and education of users [10].

Speed is the term that indicates the speed at which a user moves from one type of web elements with informative content to another type of web elements, e.g. communication content.

Time describes how long does it take to execute activities on social network, e.g. duration of writing and sending a message. Landmark is an information on social networks that guides users by telling them on which area of the page they are located. It must be available to the users at any time, i.e. on any part of the social network. <alt> element of social network could provide this solution. Orientation refers to the orientation on social network because people do not have the same capabilities of finding information and navigate themselves on the social network. Because of that, it is necessary to provide access to information intended for orientation in various forms - audio, text and tactile information. User education is necessary to know how to exploit the potential of social networks in the most efficient manner.

B. Guidelines for making the social networks accessible

To improve the accessibility of currently available social networks, it is necessary to use a quality tool for the analysis of the accessibility. Known tools are Wave, Achecker, Taw and Web Accessibility Checker. It is necessary to check all the errors that are present on the social network and warnings that can give information to web designers on how to improve current solutions. According to the accessibility disadvantages that analyzed social networks have, guidelines are proposed in order to make them more accessible.

Most social networks do not have the ability to customize the background color and the color of the content on it. Visually impaired persons have the need to use large color contrasts between background and text content that is on the social network therefore it is necessary to provide users with the ability to change that according to their needs. Color-blind persons are also persons with visual impairment and for that reason it is necessary to ensure the change of color contrast. The analysis of the accessibility of social networks has shown that the color contrast of letters and background does not satisfy the needs of visually impaired persons, which is the reason why changing colors of background and text should be implemented in mentioned social networks. Also, it is necessary to enable to change the size of the text, while the minimum size of text should be 12pt with sufficient spacing between the lines. In addition to size, the text must be written in an appropriate style in order not to be confused because of the similarity of letters such as I and l.

As noted in the analysis of accessibility of social networks, most of the elements has no alternative text that describes what the element represents. Alternative text greatly helps visually impaired persons in reading the content on the websites, especially images. In addition, it is necessary to ensure that social network does not depend exclusively on images that are used to navigate through the content. The same applies to audio and video content because most of the participants that participated in the questionnaire were not satisfied with the audio, video and image content.

Navigating through social network should be simple. The users must have the ability to skip to the content that they want to read without the need to go across the whole other content that is not interesting to them. This can be achieved by placing the main content on the main page or by the link that will be placed on the top of the page and will guide the users to the desired content. With exact positioning of elements on the page, users will have easier way to navigate themselves through it [11].

Simple design and basic amount of the content makes a website accessible. If there is a lot of non-organized text, incorrect use of heading elements and animations used to make content site more attractive, visually impaired persons will not be able to read such content. With proper organization of heading elements, it can be achieved a structure of a website that is suitable for them. Links to the other parts of the site or other sites must include a quality and simple descriptions so that users could easily know where will they be redirected to, which was not the case while testing the accessibility of Facebook and Twitter.

By fulfilling the above guidelines, it can be achieved a greater accessibility of existing social networks. The QoL of visually impaired persons will be increased because they will have the ability to access to all the content that the people with no disability can.

VII. CONCLUSION

Social networks greatly influence on the increase of communication between persons worldwide. People that use websites, which are based on Web 2.0 technology, are included in the virtual society where they can share content such as their own opinions, interests, pictures and videos. The development of social networks has increased the connectivity of users, development of business opportunities, advertising, informing about current events and user interests.

Visually impaired persons are faced with problems of accessibility of content. Through seven principles of universal design, social networks can be designed to meet the needs of users and their capabilities. Because of recommendations of WCAG 2.0, social networks content is accessible to visually impaired persons, which makes them included in daily activities that are happening on social networks.

Social network can be designed as an assistive technology that can meet the demands of visually impaired persons. For that purpose, elements for building the assistive technology are described, information about the needs of users with visual impairment are collected and the guidelines for making the accessible social network are proposed. Information about currently popular networks are also collected and the results make Facebook, LinkedIn and Twitter the most popular networks. By analyzing them, it was observed that mentioned social networks have accessibility failures and it is described what it needs to be done to correct them.

The accessibility of social networks content is changing because of the constant development of technologies. Therefore, the new forms of assistive technologies are being developed and make mentioned content accessible. In the future, it is expected an even greater number of visually impaired users that actively use social networks. The development of assistive technologies, guidelines for making accessible web content and web development technologies are important features to meet the needs of users and their abilities in order to increase the QoL of users. The future research will

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be based on finding new methods of making the web content more accessible.

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Information technologies in improving transport companies management

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Abstract—**The development of economic science, primarily management and marketing, has significantly affected the development of all companies, including also the development of transport companies. The contemporary turbulent period has been determined by various factors. The globalisation process has one of the strongest impacts on the development of transport companies. Not only due to the change in the geographic dimensions of business, but also due to the change and quality requirements of the customers who put pressure on the transport companies to constantly improve their service. At the same time, recent financial crisis has significantly limited the budgets, resulting in the customers requiring much lower prices from their logistic service providers. In such an environment many companies have difficulties in handling the set challenges regarding increased quality and concurrent reduction of the prices of their services. Information technology appears often as the potential solution of the problem. It improves the quality of the transport services at the same time providing the users with better information for their decision-making, making it possible at the same time to reduce the logistic costs, primarily when speaking of transportation costs.**

Keywords- management, computerisation, transport, logistics, company, process, technology

I. INTRODUCTION

The task of transport organizations and enterprises is to act efficiently and effectively in order to satisfy the users' needs for transport, i.e. transport of goods, passengers and information. These processes often include participation of many public and private organizations, whose efficient cooperation is extremely important for successful implementation of the set tasks. Therefore, it is very understandable that in the implementation of all the necessary processes in transport organizations, the managerial knowledge and skills are imposed not only as a need but also as a necessity [1].

The operation of transport companies is often connected with logistics, and logistics is a very widespread term, as well as similarly widely defined. For the needs of this paper we can use the definition of the Council of Logistics Management which defines logistics as "part of the supply chain process which plans the efficiency and effectiveness of the flow of inventory and goods, products and services, and related information with the aim of satisfying the user's needs" [2]. As can be seen from the definition, the borders of this concept are very often not clearly defined, but they definitely include traffic, i.e. transport enterprises. Thus, when speaking about business management of transport enterprises, we speak actually about one aspect of the logistic management, which includes "management of transport procedures, distribution, communication, and other activities in the chain from material purchase to the delivery of finished products to the users".

II. ROLE OF MANAGEMENT IN THE BUSINESS OF TRANSPORT COMPANIES

Due to significant globalisation of the past decades the significance of the logistic management has been growing in different areas. In industries the logistics helps in optimizing the existing production and distribution using all the knowledge and skills in the area of management. In this process the key factor of success is the transport system which connects the separated activities of the company. In many companies the logistics occupies 10 to 20% of total costs of the company, whereas the transport accounts for the third of these costs [1], [2]. Therefore, it is evident to which measure the transport system can influence the efficiency of the overall logistic system. Transport is necessary in the overall production process, from the very making of the product to the delivery of this product to the end users. For this system to function perfectly, the relevant processes have to be extremely clearly defined, and the communication between different components has to occur completely undisturbed.

The key guidelines of the logistic management are popularly defined as "7R's" – a concept which emphasizes seven key guidelines on which the logistic management has to focus [1]:

1. Right product
2. Right quantity
3. Right condition
4. Right place
5. Right time
6. Right customer
7. Right cost.

With the aim of implementing all these guidelines, transport companies often define their organizational structure as processing structure. The business of the transport companies which is harmonized with the systemic approach

and processing structure is often observed through three subsystem classes:

1. Executive system – for the executive processes;
2. Information system – for information processes;
3. Control-management system – for control and management processes.

III. FEATURES OF INFORMATION TECHNOLOGY IN TRANSPORT COMPANIES

In the modern world we have been witnessing big globalization changes. These changes have influenced all the commercial, production and distributive systems all around the world, and monitoring the contemporary global trends has become a precondition of the sustainable growth. Parallel with intensive globalization the information technology was developing as well. The impact of technological achievements on the people's lives and company operation has become so intensive that on-time implementation of modern technology has become the determinant of the business life of a company. Technological changes have brought inevitable changes in the way of business of the majority of companies, especially in the following business segments: production; commerce; logistic functions in production and commerce; management; human resources; technical side and organization of production with new machinery, with new programs, or with new software solutions in the logistics of the organization; program orientation of the organization and the information system in the organization [3].

Information systems that are implemented in practice are continuously being exposed to the influence of new technological solutions, both in the field of hardware and in the field of software. With the aim of successful maintenance of the business competitiveness, the companies are forced to constantly follow the technological improvements and ways of their implementation in business. The logistic processes are the ones that are very often exposed to technological pressure, both because of modernization and improvement of logistic processes, and because of the necessity of optimization and to reduce their costs. Logistics is being mentioned more often as a source of competitive edge, especially in modern global markets. Although this primarily refers to the distributive function, i.e. about timely supply with products (goods), logistics is acquiring more and more "the shape of integrative connection and philosophy of managing the entire flow of goods, information, money and services from the offer, procurement, production, distribution, sales to the end user" [3].

A. Information technologies in logistic management

Logistic management represents an integrative function that penetrates the entire business of a company from production, procurement, warehousing, sales, distribution, and all the other business functions. In all these mentioned functions the limited resources need to be efficiently managed in order to achieve satisfactory and sustainable end business results. Proper gathering and processing of data is a precondition for rational allocation of limited resources. Well established information system has to allow undisturbed flow of information through the entire organization.

A well-established information system represents an integrative part of the logistic management. Logistic information system is in the center of the economic system, and it represents the starting base of all the business functions and actions in the system. Satisfactory connection of all the mentioned functions is possible only if the conditions of processing orientation of the business described in the second section of this paper are satisfied.

Establishing of undisturbed flow of information through the entire business process has the following logistic advantages for a company [4]:

- Reduction of order cycles and duration,
- Faster goods turnover,
- Lower warehousing costs,
- Faster delivery frequency,
- Customer-orientation,
- Diversification of products,
- Greater efficiency in business,
- And other more favorable business conditions.

The field of logistics is very dynamic and complex. The added value in this segment is realized by space and time transformation of the goods and services, and therefore frequent changes form the essence of the logistic processes. Logistics is often considered expenditure in the company, and more rarely a possible source of diversification and competitive edge. Such neglect of the true potential of logistics can be applied also in the modern world, but there are more and more enterprises that are beginning to understand the value of logistics in the organizational and marketing orientation of a company.

B. Information technology in inventory management process

Efficient inventory management is one of the crucial tasks of logistic management. The analysis of the entire chain of values, i.e. logistic chain helps in efficiency of implementing the task. Organized cooperation of all the participants in the chain allows gathering of relevant information that are necessary for good decision-making about the level and type of required inventories. Information technology facilitates this process, and thus the organizations that want to manage their inventories efficiently have to use advanced applications. The majority of inventory management programs offer structured methods and calculation of incoming and outgoing inventories. By applying such programs, the companies can reduce the costs of storing excessive inventories, costs of administrative errors and costs resulting from failing to fulfil the orders due to lack of stock [5]. Information revolution in the inventory management is reflected in the multicriteria tools that assess simultaneously the target inventories and more efficient calculation of the variability and interdependence over many layers of the supply chain. The research has shown how the

application of such tools allows reduction of all the necessary inventories by 10-30% [4].

C. Information technology in procurement phase

The procurement process consists of making decisions about the purchase in the conditions of the lack of inventories that consist of delivery, handling, marginal benefits and price flow. In situations when a company has an established good information system it is possible to implement the economic analysis such as cost-benefit or cost-utility analysis. Good information background is also necessary in order to establish good relations between customers and suppliers in the procurement process. More and more companies are connecting more intensively virtually with the aim of better and more rational usage of limited resources. Connecting does not refer exclusively to the field of procurement, but rather includes also integration of the procurement system into other fields. Companies that do not join such systems risk their business survival in the competition on the market.

D. Information technology in warehousing processes

The warehousing processes refer to physical inventory management and they are not the same in all logistic chains. It is important to distinguish the warehouses of finished products, semi-finished products and raw materials. The warehousing process understands collection of inventories, which directly affects the increase in operating costs. Therefore, modern companies are working intentionally on reducing the quantities of the necessary inventories and consequently on reducing the warehouse capacities. Information technology is often imposed as a solution to many problems that occur in these processes. The companies have increasing requirements from their warehousing and distribution activities. They want to have an increased possibility of tracking the status of the order, inventories, and tasks within a warehouse. Also, one expects greater productivity that can support the growth in sales, expansion of the distribution channels, and, mentioned more often recently, improvement of service towards the customers. The establishment of a good information system for Warehouse Management System (WMS) can significantly improve all the mentioned business items. It is precisely because of this reason that many companies invested during the last decade substantial means into updating and upgrading their WMSs. Their application helps in achieving substantial savings, both due to greater efficiency of labour force, and due to the reduction of losses resulting from the inability of detailed monitoring of all activities in the processes. The savings are reflected in the reduction of costs resulting from the losses, obsoleteness, long time of reaction to demand, bound means, etc. Apart from the mentioned WMSs, the significant improvement in warehousing management has been contributed also by the radio frequency identification (RFID) and the hand-held terminal (HHT).

E. Information technology in return process

The return processes are analyzed separately within the logistic chains of the company, since they represent a completely reverse process of the flow of products through the distribution channel from the usual one. The information technology in the return processes has the role of registering the requests and reasons of return and based on the obtained information organize the return process. For these processes to proceed smoothly, the information systems of logistic have to be first of all very flexible. The return process automation presents often a big challenge for the company, due to many exceptions in the very process. The return process includes mainly several companies, which complicates additionally the process computerization process [6]. However, in spite of many return process challenges, its good implementation represents a very strong marketing tools in term of enabling the guarantee deadlines. Therefore, many companies opt for introducing trial and guarantee deadlines in order to attract the maximum number of users.

F. Information technology in transportation phase

The transportation process understands physical movement of material, semi-products, and products between two or more points within the logistic chain. Transport represents the key item in the logistic process participating in the overall logistic costs with a share of as much as two thirds. The application of information technology in the transportation system is multiple. The primary advantage are the geo-information systems that ensure a good base for improvement and optimisation of the transportation process. The efficiency of managing transport represents a big challenge for many companies. In spite of high availability of advanced technologies, a low percentage of companies manages to continuously reduce their costs of transport. It is also important to emphasise that the installation of modern technological solutions is often financially very demanding, which represents an excessive expenditure for many companies (especially in less developed countries). The systems used by the majority of transportation companies include: planning of the delivery routes, tracking the vehicle and driver operation, and monitoring of the vehicle maintenance. Frequent usage of information technology in logistics, by increasing competitiveness among providers of technical solutions and recognizing benefits from implementing information technology in logistic processes affect the growth of demand for new solutions. High demand and investments lead to integration of individual solutions into unique systems thus achieving significant synergy effect. Such integrated solutions are called “transport management systems”, and on the market they are better known under the designation TMS (*Transportation Management Software*).

IV. Role of Information Technology in Transport Companies

Modern transport companies have to adjust more and more to the more complex requirements of their customers, primarily regarding shortening of the delivery times, first of all by extending and expanding the supply chain to widely dispersed partners and locations. These requirements put great pressure on transport companies. One can highlight two key sources of pressure on the transport companies [6]:

- Pressure from customers – the strongest pressure on the improvement of transport services come from the users of transport company services. Customers constantly require better and better as well as high quality information related to transport services in order to achieve qualitative changes in the intensity and time of the procurement cycle, and in order to

reduce the overall supply costs. The transport service providers that do not manage to respond to these requirements increase the probability of losing their customers, who will entrust an increasing volume of transport to more reliable and flexible enterprises.

- Pressure caused by changes in the supply chain – the pressure on transport companies caused by changes in the structures within the supply chain and production companies are more and more substantial. In order to mitigate the effects of the mentioned pressure, the clients of transport services try themselves to influence the relations towards their transport service providers.
- An increasing number of transport companies feel the pressure to improve the transport processes and technologies that are caused by changes in the structures within the supply chain of the production companies. In order to mitigate these effects, the clients of transport services try themselves to influence the relations towards their transport service providers. Instead of the classic relations based on the pressure to lower the prices of transport services, the modern way of doing business requires from production companies the development and fostering of partner relations with their suppliers and joint action to improve quality and reduce transport costs.

Due to the mentioned pressure the transport companies have to accept and implement innovations such as [6]:

- Automation –transport companies are required to automate the entire transport process. This includes the implementation of the latest information and communication technology that supports the electronic receipt of orders, fast response to business opportunities, identification and correction of potential failures and fast and accurate invoicing.
- Reducing the time of unloading – using modern technology the time necessary to unload a truck and container can be substantially shortened. If we add also the shortening of the process in which the drivers wait for certain documentation to be issued, such as control documents, insurance, customs, health inspection of goods, etc. – the savings of time are really substantial.
- Delivery schedule publication – many modern transport companies publish their delivery schedules on the internet. This increases the transparency of their operations and enables new level of communication with customers of transport costs if they use the already announced dates and routes of transportation.

It is evident that both in transport processes and in the entire logistic process the timely information are essential. The information systems which manage the transport must provide the following information to the user with perfect precision [7]:

- Information on type of transport (road, rail, sea or air);
- Information on the load (size, weight, type, amount, height);
- Information about the sender and receiver (name, name of the organization, address);
- Deadlines (date and time of sending and the date and time of receiving the load).

Lately, the transport systems are not required only to be faster, but rather also to meet the customers' quality expectations. The method of delivering the transport service has become equally important as well as its speed. The transport companies have responded to these needs by accepting the telematics technologies. This refers to the term that connects the concepts of telecommunications and information technology, and the task of this technology is to allow gathering and transfer of data needed by the system user. The installation of such systems in the transport company vehicles has become very popular. The system via computer built in a vehicle gathers information that enable the analysis of the consumption of vehicle, driving style, utilization level of vehicle torque and optimal speed.

Apart from systems based on telematics technology, there is a series of less advanced systems that are used in companies when organizing transport processes. For instance, the detectors and sensors enable monitoring of vehicle condition at a distance: systems of land and satellite communication enable the transmission of information at a distance; electronic and wireless communication allows communication between vehicles and communication between vehicles and the environment; databases and data warehouses allow storing and fast processing of large amounts of data; modern technology allows instant communication, etc.

V. CONCLUSION

Advanced information systems in the modern times are expected to provide more and more. The quality and speed of gathered information has become one of the main competitive advantages based on which modern managers establish the development of their companies. At a time of large amount of collected data, it is extremely important that the information systems have the capacities that can collect and process this amount of information, but also to be able to adequately present information derived from the collected data, so that managers could really use them in making business decisions. These trends are extremely emphasized when speaking about traffic companies, that aim to respond to the needs of their customers with fast and good service. At modern time, the task of transport companies is not reflected only in the transport of goods and persons, but rather a very important element of their business is precisely the timely and high-quality presentation of the gathered information. Not only is investing in the information technology affordable and desired, but rather necessary in the modern world. In some other industries it is mentioned that investments in the technology cannot always be measured by financial measures such as ROI, but the affordability is rather reflected in the survival of the company on a market, that might be endangered by the absence of such investments.

It is often necessary to learn from best practices and in this case the best example shows how sustainable development of logistic and transport companies is based on investments in

information technology. The truth is that every investment in new technologies brings with it some uncertainty, but this needs not discourage companies. Some technologies prove as successful, some less successful, but in the end the winners among the companies are those that invested in their development. Therefore, the investments in information technology need not be necessarily considered as investment that will be justified by the financial indicators of success, but rather as an investment into the survival of a company on the dynamic and rapidly changing market.

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Topo Memorization System

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Abstract—**There are lots of memorization techniques that could help students. There are also several studies that confirm the possibilities of applying such techniques when learning and studying. In this paper we describe several memorization techniques: the chain of association method, the file cabinets method and the topo memorization system. For the topo memorization system we developed a proper computer application, which helps the user to adopt the system. That way this technique may be used as an efficient memorization tool for studying, as well as for everyday life.**

Keywords- Chain of association method, File cabinets method, Topo memorization system, Computer application

I. INTRODUCTION

In almost everything we do there is a lot of data that should be memorized - phone numbers, credit cards, passwords, various codes. Even though there are lots of memory techniques which allow us to easily and efficiently memorize all types of data [1-7], the average person has almost no knowledge of their existence. This is particularly important for students. They have to memorize various types of data, and could really benefit from using proper memorization techniques. The effectiveness of these techniques has been researched by several authors in various fields [8-13]. This paper represents an attempt of the authors to contribute to the popularization of the memorization techniques, mainly those described in [1]. For one of the methods, called topo memorization system, we developed a computer application that helps the user to adopt the mentioned technique.

There is plenty of information about various memorization techniques. One comprehensive source of such techniques is [1]. Tony Buzan [2-4], founder of the World Memory Championships and the World Championships of the Brain, is an author of several books in this area. His books have been translated into 30 languages. Dominic O'Brien [5], eight times World Memory Champion, is also an author of a few books, in which he teaches common memorization techniques, as well as some techniques that he personally has developed. Ron White [6], an American Memory Champion, has developed several courses for memorization techniques.

Using various memorization techniques may transform a person with average or below average memorization capabilities into a person who seems to be supernatural. That is the reason why several studies have been done on the possibilities of applying memorization techniques in education. We will mention just a few of them. Roediger and Pyc [8] considered strategies, identified by cognitive and educational psychologists, which can improve learning and information retention. They identified three general principles that are inexpensive and have been shown to improve learning, both in laboratory and field experiments: distribution of practice in learning facts and skills, retrieval practice for durable learning, and explanatory questioning. Milikowski and Elshout [9] studied the difficulty of memorizing numbers between 1 and 100. Their conclusion was that various categories of numbers have different levels of memorizing difficulties. McCormick and Levin [10] have researched the use of the mnemonic keyword method in learning prose. In the experiment, the groups of students that were using the method showed significantly higher levels of recall than the control group. Krzywicka et al. [11] studied the use of IT tools in the laboratory classes to create Buzan's Mind Maps [4] among Material Science course students. Noonan [12] also studied the use of Buzan's Mind Maps, but in midwifery education. Gulanowski and Kozak [13] considered if memory training can contribute in learning a foreign language.

Similar to [11], we have also researched the possibilities of using IT tools as a means of learning, mainly for describing and/or practicing memorization techniques. The first author of this paper, in his previous work, has taken part in developing several computer applications that graphically describe the basic association technique, chain of association method and the file cabinets method (which will be described in Sections II, III and IV of this paper). To our knowledge there are no similar (computer or mobile) applications for these methods, as well as for the topo memorization system (described in Section V). Memorizing numbers is also a very interesting area. In [9] it is shown that students generally have problems with memorizing numbers. A proper technique for memorizing numbers, which is based on 'translating' numbers into words is described in [1, 2, 3, 6, 7]. Each digit may be presented with a consonant and then each 2-digit or 3-digit number may be translated into a single word by combining the proper consonants with vowels. We have found several computer/mobile applications that describe/use this technique. Among them, applications [14-17] give help in memorizing numbers – the user enters the number(s) that is(are) to be memorized, and the application shows appropriate words [14-16] or images [17] that may be used for memorizing the entered number(s). In [14] there is also a part in which the user may time oneself while memorizing a series of numbers. Applications [18-21] are developed mainly for practicing memorizing numbers - the user is given a task to memorize a group of numbers in some way. The application [18] also has a part in which text and/or an image may be associated with numbers from 0 to 999. This

part of the application may also be used for the file cabinets method.

The paper is organized as follows. In Section II we will get to know the basic association technique, which represents a basis for lots of other techniques and methods. Two such methods are the chain of association method and the file cabinets method, which are respectively described in Sections III and IV. Sections V and VI describe the topo memorization system and the developed application for its adopting. Section VII considers future work, and Section VIII is the conclusion.

II. Basic Association Technique

The *basic association technique* is a basis for many other techniques. It is based on making a connection, i.e. an association between two concepts that are not mutually connected in any way. The simplest way to explain this technique is to use an example. Let us assume we have the following four pairs of objects:

boat - giraffe

ball - cannon

cigarette - phone

skater – bottle

Our task is to memorize these pairs so that when someone mentions one of the words, we should tell the other word in the pair. The basic association technique is based on picturing an image in our heads in which the both objects appear, such that something illogical or impossible or comic is going on, i.e. the picture should contain something very unusual, since that is easily memorized. For example, for the first pair we can imagine a giant giraffe standing in a lake up to its knees in the water and a boat passing below it, like below a huge bridge. For the second pair we can imagine a cannon that is firing a ball instead of a grenade. For the third pair we could imagine a huge amount of cigarettes going out of a phone and filling up the whole room while we are making a call. Finally, for the last pair we could imagine a skater that has bottles instead of skates, making various pirouettes. Each person should imagine what suits them best, and for each person their own picture (movie) will be the best possible picture (movie). It is enough to imagine the scene we are visualizing for only a couple of seconds providing that we imagined something totally unusual.

III. Chain of Association Method

The basic association technique, explained in the previous section, represents a very powerful technique and lots of other techniques and methods are based on it. The *chain of association method* directly results from the basic association technique, if we make a chain from the things that are to be memorized. If we got back to the same example from the previous section, we could have the following queue of objects:

boat - giraffe - ball - cannon - cigarette - phone - skater - bottle

To memorize this queue, we should first use the basic association technique to make an association between the boat and the giraffe, then we should make an association between the giraffe and the ball, then an association between the ball and the cannon etc. until the end of the queue. For the last element in the queue, the bottle, we can do 2 things - make an association with the first element, the boat, or place it in some weird position. That way we will know that we have come to the end of the queue. A variant of the chain of association method is to make up a funny story in which the elements that are to be memorized are appearing in order in which they should be memorized. The chain of association method can be used for memorizing series of 10, 20, even 50 or more words, such that the whole queue may be reproduced in both directions, forward and backwards (unless the 'funny story' variant is used, in which case one might have difficulties in reproducing the elements backwards). This method is convenient for memorizing the sequence of main points for some lecture one has to give, sequence of chapters of a book, queue of themes when studying for an exam, etc. In [1] it is shown how this technique may be easily adapted for memorizing all sorts of data, not just objects.

The main advantage of the chain of association method is that there is no limit in the number of elements that can be memorized. We can actually memorize queues that are practically non limited in lengths. On the other hand, the main drawback of this method is that we cannot reproduce the elements out of order.

IV. Mnemonic Peg System and File Cabinets Method

The *mnemonic peg system* and the *file cabinets method* offer a memorizing capability that might appear supernatural to an average person. These two systems have different names, but are basically the same. They enable memorizing lists of elements in such a way that one can easily answer questions such as "Which element is the fifth?", "And which one is the eighth?", "What is the ordinal number of a particular element?" etc. If we used the same example of the queue that begins with the boat and terminates with the bottle, then when using the chain of association method, one has no problem to reproduce the whole queue in both directions, but cannot easily answer the question "Which element is number 5?". To answer that question one would have to go 'through' the first four elements until the fifth one 'comes across'.

The idea in the mnemonic peg system and the file cabinets method is to use vocal sound similarities, e.g. one -> sun/gun, two -> shoe, three -> tree, shape similarities, e.g. one -> candle/straw, two -> swan/duck, three -> heart, or any other type of similarities for numbers from *1* to *n*, where *n* is the capacity of the buffer one needs – it can be 10, 20, 50, 100, or even 1000. Different systems use different objects, but the idea is the same - using various types of similarities. For example, TV tower is the object for number 1 in [1] and pencil is the object for the same number in [6]. Obviously, both the TV tower and the pencil are similar to the shape of the number 1. The object for number 2 in [1] is swan and in [6] is sink. The swan looks like the number 2 when observed from the side and the sink has 2 knobs, it has 2 options - on and off, hot and cold, etc. The object used as number 3 in [1] is a triangle, for

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obvious reasons, etc. How is this used for memorizing the queue? First we make an association (using the basic association technique) between the TV tower (the object assigned to number 1) and the boat (the first element that is to be memorized), then we make an association between the swan (the object assigned to number 2) and the giraffe (the second element that one has to memorize), then an association between the triangle (the object for number 3) and the ball (the third element), etc. until the end of the queue. It is obvious that if we memorized all the elements this way, we would have no problems to tell the exact ordinal number for each of the elements, or to tell each element by its ordinal number, out of order. On the other hand, it is also obvious that we would not have limitless possibilities, like it was the case with the chain of association method - we can only have a buffer with capacity that is as large as the number of numbers we have pre-memorized, i.e. have 'translated' into proper objects. This means that the mnemonic peg system and the file cabinets method have the opposite merits/drawbacks compared to the chain of association method. These two methods allow out of order reproducing (or even memorizing) the elements, but need pre-memorizing the proper ordinal number elements to get a proper buffer, and the buffer obviously must have a limited size.

V. TOPO SYSTEM

The *topo memorization system* [1] is, in a way, a combination of the methods from previous two sections – the chain of association method and the file cabinets method, in the sense that it has the advantages of both methods. We can memorize lists in a way to be able to tell each element by its ordinal number, as well as tell the ordinal number for each of the elements out of order, and at the same time we can easily form a buffer with relatively large size.

The ordinal numbers in this method are memorized as places in a room. In the basic version each room has 10 places and in the advanced version each room has 50 places. The basic version enumeration is given in Fig. 1. In [1] it is assumed that the entrance (door) of the room is always in the middle of the wall, like it is shown in Fig. 1a. In that case the position where ones enters the room is signed as number 1, and the rest of the numbers until 8 are positioned in a clock-wise direction – number 2 is the first corner on the left, the middle of the left wall is number 3, number 4 is the following corner, etc. until number 8, which is the last corner. The middle of the room is signed as number 9, and the middle of the ceiling (or the chandelier, if there is one) as number 10. We wondered what should one do in cases where the entrance of the room is at one of the corners, and concluded that the simplest way would be keep the 'positions' the same, and simply sign the first position that we enter as 2 or as 8, depending on whether the entrance is at the left or at the right corner. This is shown in Fig. 1b and Fig. 1c, respectively. This way the walls are always signed with odd numbers (1, 3, 5, 7) and the corners are always signed with even numbers (2, 4, 6, 8). In that case we are able to use this enumeration with literally any room we have ever seen or been into.

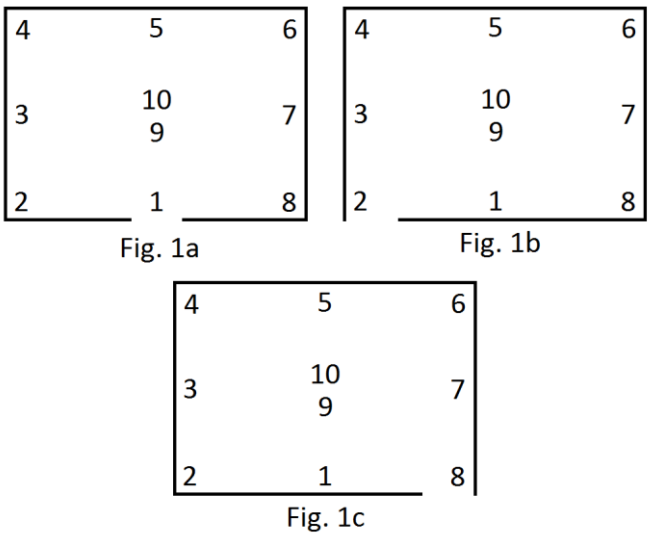

Figure 1. Basic version of the room numeration for the topo memorization system

If we need more than 10 places we can simply use another room or several rooms, if needed. For example, Fig. 2 shows a plan of a residence with 5 rooms. As each room has 10 places, we can use this for memorizing a list of 50 elements. This means that by just adopting the basic version of the topo system, we can get a buffer of 50 (or more) elements. And that is accomplished by using just one residence with 5 (or more) rooms. We can, of course, use as many apartments/residences as we need.

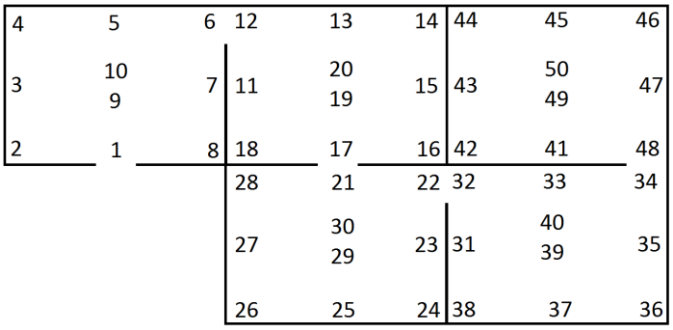

Figure 2. Using the basic version for a residence with 5 rooms

The full potential of the topo system is accomplished by using its advanced version, which can be seen in Fig. 3 (which was taken from [1]). Now each room has 50 positions. Each of the 4 walls and the floor has 9 positions, with values 2-10, 12-20, 22-30, 32-40, and 42-50, with a layout that suits the word 'Z' - the first three values (e.g. 2, 3, 4) are positioned 'at the top' from left to right, the next three values (e.g. 5, 6, 7) are 'in the middle' from right to left, and the last three values (e.g. 8, 9, 10) are 'at the bottom' from left to right. The ceiling has the values 1, 11, 21, 31, 41, which are 'joined' with the proper wall. Number 1 is in the middle of the ceiling, which means

that the rest of the numbers of the first decade (2-10) are on the floor. Number 11 is positioned near the wall that is in front of the observer (after entering the room), which means that the rest of the numbers of the second decade (12-20) are positioned on that wall. Number 21 is near the right wall, which means that the third decade is positioned on the right wall. The rest of the numbers are positioned in the same manner, and each subsequent decade is on the next wall, when we move clock-wise, observed from the ceiling. By using the advanced version of the topo system we can memorize a list of 250 elements, be able to tell the ordinal number for each element or tell each element by its ordinal number, in order or out of order, and all of this can be accomplished by using just one residence with 5 rooms.

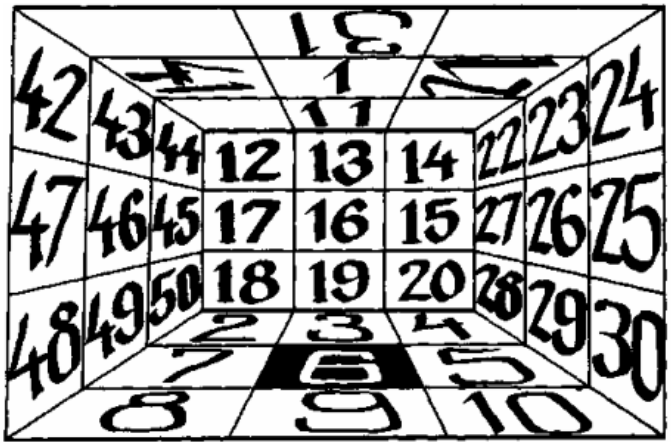

Figure 3. Advanced version of the room numeration for the topo system

VI. The Application

In this section we will describe the application we have developed for adopting the topo system. At the moment of writing this paper we have finished only the part for the basic version. The starting window of the application is given in Fig. 4. We are positioned at the place for number 1, and we can see the rest of the walls (signed as 3, 5, and 7), and the two corners between them (signed as 4 and 6). We can also see the middle of the floor (signed as 9) and the ceiling (signed as 10). The wall signed as number 1 is behind us, hence we cannot see that wall. We also cannot see the two corners signed as 2 and 8. To ease the process of pre-memorization, we use different colors for the walls and the corners, as can be seen.

By moving the mouse left or right the application will simulate that we are turning on our left or on our right. That way we can see the wall and the corners that are not visible at the start. We can also move the mouse forward or backwards, and the application will simulate that we are floating in the air

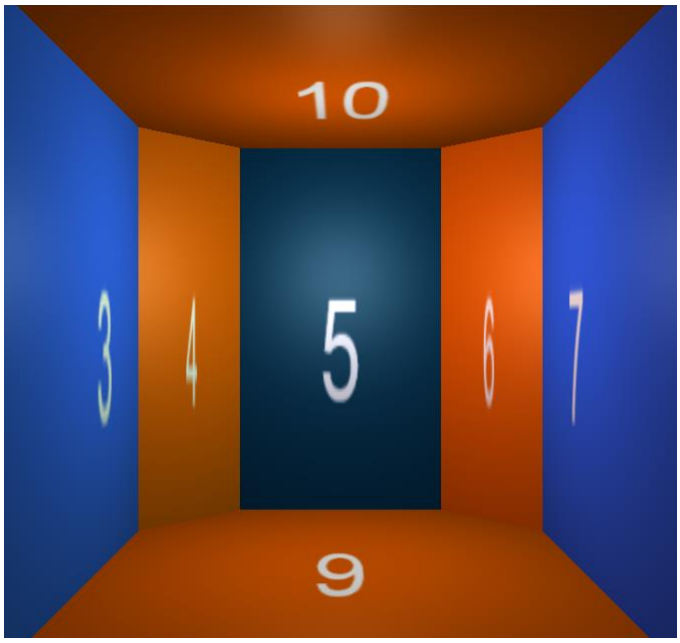

Figure 4. Starting window of the application

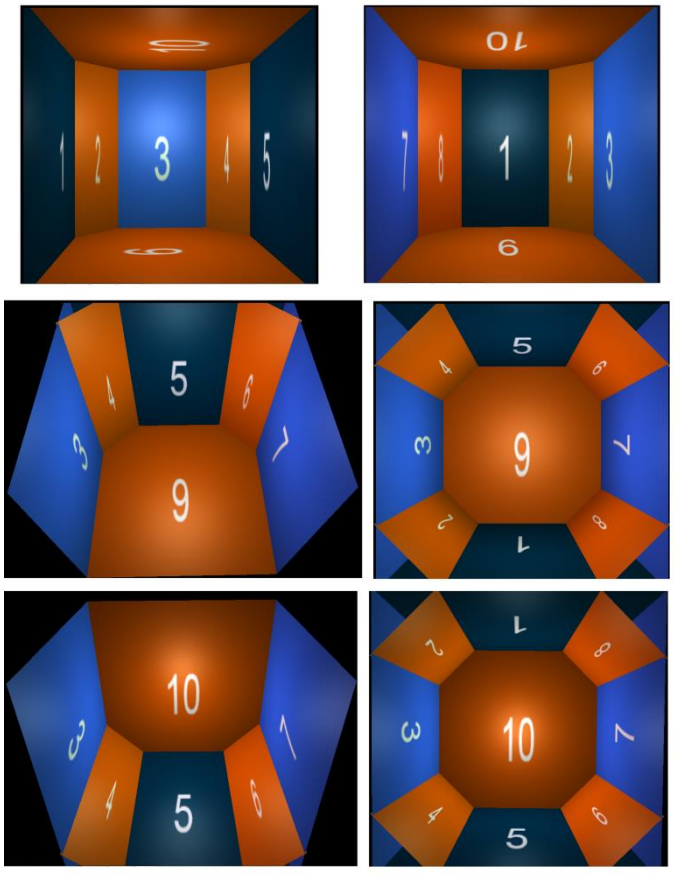

Figure 5. Several characteristic screen shots of the application

and looking down, or that we are lying down and looking up. By all these 'effects' the user gets the feeling that they are moving around the room, which helps them to more easily memorize the proper numeration. Fig. 5. shows several screen shots which partially demonstrate the completeness of the possible 'movements'.

VII. Future Work

In future work we plan to first develop the part for the advanced version of the room enumeration of the topo system. After that we will add parts for training. In these parts of the application the numbers will not be shown. The application will randomly select a number (from 1 to 10, or from 1 to 50, depending on whether we work with the basic or the advanced version), and then it will show the proper position of that number in the room. That way the application will be able to help the user to really master the topo system.

VIII. Conclusion

There are many memorization techniques that allow easy memorizing of all sorts of data. Students, no matter what type of faculty they are studying, have to memorize various types of data. Therefore, they could really benefit from using proper memorization techniques, especially regarding the fact that the effectiveness of these techniques has already been proven by several studies. Personal computers and mobile devices can be especially useful for learning the material, as well as for practicing memorization techniques. That way the process of learning may be significantly relieved.

In this paper we have described the basic association technique and its usage in the chain of association method and the mnemonic page system / file cabinets method. We have also described the topo memorization system. For the topo memorization system we have developed a proper computer application that shows the basic version. That way the user can more easily adopt this method. In the future work we plan to develop a part for the advanced version of the topo system, and also add parts for training. That way we will gain a useful application which helps the user to completely master the topo memorization system.

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Rapid Signal Processing Block Synthesis

Using the Cubed-C Design Environment

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Abstract—**Design environments and automated CAD systems are proliferated nowadays with various preferences and restrictions in their work environments. One serious problem of automated high-level synthesis tools is their inability of at least difficulty to use for low, bit level functions such as signal processing blocks. Here the Cubed-C environment is used for the rapid implementation of a number of low level functions and blocks such as UARTs without difficulty. Cubed-C is a full-strength high-level synthesis CAD system, nevertheless, its structure and properties make it particularly suitable for this type of applications. The experiments in this paper prove that the Cubed-C synthesis tools are particularly suitable for both complex and for low, bit level signal coding functions.**

Keywords- High-level Synthesis, Rapid Prototyping, Low level signal processing, Serial Communications

I. INTRODUCTION

The proliferation and complexity of current integrated circuits (ICs) both as FPGA and as Application-Specific Integrated Circuits (ASICs) and System-on-Chips (SoCs) determine that a high proportion of the custom, specialized logic on chip is designed and verified with High-level Synthesis/Verification techniques. However, for low-level functions such as bit-level processing or signal coding is done manually, damaging the advantage of having a unified design flow for all parts of the chip.

In this work the Cubed-C High-level Synthesis (HLS) tool and method is discussed. The focus is particularly on its ability to manage both highly-hierarchical and complex as well as low, bit-level blocks with ease and integrate the verification of both parts in one formal step, such as the cycle-accurate simulators which are produced at the output of the tool. This is something that most of the HLS tools fail to address. Our tools are flexible and can be used to design loop-based signal coding response blocks for both NRZ and RTZ algorithms, as shown further down in this paper. All of the synthesis outputs are simulated to verify the correctness of the functionality. This is demonstrated both at the RTL and the cycle-accurate simulator levels.

II. RELATED WORK

Improved methodologies and tools started appearing from the late 90s and continue with enhanced input programming code sets as well as scheduling and other optimization algorithms. Furthermore, system level synthesis matured in the last decade by using more (application-wise) specialized and platform-oriented methodologies. The CoWare hardware-software co-design environment [1] employs a data model that allows the user to specify, simulate and produce heterogeneous implementations from heterogeneous specification source models. The specific synchronous dataflow (SDF) type of DSP applications, is implemented into hardware using languages such as SILAGE [2], DFL [3], and LUSTRE [4], [5]. The advantage of this type of designs is that they can be scheduled at compile time and the execution of the compiled code can be two orders of magnitude faster than event-driven VHDL (e.g. RTL) simulations. In contrast to this, dynamic dataflow (DDF) algorithms consume and produce tokens that are data-dependent, and thus they allow for complex if-then-else and while loop control constructs. This is the largest part of real applications and it is dealt with by the Cubed-C synthesizer. CAD systems that allow for specifying both SDF and DDF algorithms and perform as much as possible static scheduling are the DSP-station from Mentor Graphics [3], PTOLEMY [6], GRAPE-II [7], COSSAP from Synopsys and SPW from the Alta group [8].

C programs that include dynamic memory allocation, pointers and the functions malloc and free are mapped onto specific hardware in [9]. The SpC tool [9] takes a C function with complex data structures and generates a Verilog model. The different techniques and optimizations described above have been implemented using the SUIF compiler environment [10]. The memory model consists of distinct location sets, and it is used to map memory locations onto variables and arrays in Verilog.

A heuristic for scheduling behavioral code with complex conditional control flow, is discussed in [11]. This heuristic is based on a specific intermediate design representation which apart from established techniques such as chaining and multicycling, it enables more advanced techniques, such as conditional resource sharing and speculative execution, which are suitable for scheduling conditional behaviors. The developed tool can generate VHDL or C code from "Hierarchical Control and Data Flow Graphs", but no reports about translating a standard programming language into HCDG are known so far.

The synthesis approach in [12] utilizes a coordinated set of coarse-grain and fine-grain parallelizing transformations on the input design model. These transformations are executed in order to deliver synthesis results that don't suffer from the negative effects of complex control constructs in the specification code. The synthesis techniques were implemented

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in the SPARK HLS tool, which transforms specifications in a small subset of C into RTL VHDL hardware models. A resource-constrained scheduler is used in SPARK and it is essentially a priority-based global list scheduling heuristic. Nevertheless, there are serious restrictions on the subset of the C language that SPARK accepts as input, and limitations such as inability to accept design hierarchy modules (e.g. subprograms) and of "while" type of loops.

Typical HLS tasks such as scheduling, resource allocation, module binding, module selection, register binding and clock selection are executed simultaneously in [13] so as to achieve better optimization in design energy, power and area. The scheduling algorithm utilized in [13] applies concurrent loop optimization and multicycling and it is driven by resource constraints. The tool generates RTL Verilog implementations. The developed HLS system is targeted at control-intensive applications but it is also applicable to dataflow dominated designs.

An incremental floorplanner is discussed in [14] which combines an incremental behavioral and physical optimization into HLS. These techniques were integrated into an existing interconnect-aware HLS tool called ISCALP [14]. The average improvements of IFP-HLS over ISCALP, for implementations with unity aspect ratio functional units, are 12% in area, 7% in power consumption, 100% in reduction in the number of merge operations, and for some benchmarks the IFP-HLS CPU run time was 6 times less than that of the ISCALP method.

[15] and [16] introduces a synthesis methodology which is suitable for the design of distributed logic and memory architectures. Beginning with a behavioral description of the system in C, the methodology starts with behavioral profiling in order to extract simulation statistics of computations and references of array data. This allows the generation of footprints which contain the accessed array locations and the frequency of their occurrence. This synthesis approach is implemented into an industrial tool called Cyber [17].

Communicating processes which are part of a system specification are implemented in [18]. In contrast to the conventional HLS approach which synthesizes each concurrent process of the system individually, the impact of the operation scheduling is considered globally in [18], in the system critical path (as opposed to the individual process critical path). The authors in [18] claim that their methodology allocates the resources where they are mostly needed in the system, which is in the critical paths, and in this way it improves the overall multi-process designed system performance.

In [19] memory access management is integrated within a HLS design flow. It mainly targets digital signal processing (DSP) applications but also more general streaming systems can be included along with specific performance constraints. Mutually exclusive scheduling methods [19], [20], [21] are implemented with the "Extended Data-flow Graph". This is achieved because EDFG allows for data and conditional semantics to be handled in the same way, and thus the exploitation of potential design parallelism can be maximized. The processed graph is then given to the GAUT HLS tool [22] to perform operator selection and allocation, scheduling and binding. This methodology is rather more suitable for dataflow dominated systems such as video streaming and linear DSP algorithms.

A combined execution of decomposition and pattern-matching techniques is applied on HLS problems, in order to reduce the total circuit area in [23]. The datapath area is reduced by decomposing multicycle operations, so that they are executed on monocycle functional units (FUs that take one clock cycle to execute and deliver their results). A simple formal model that relies on a FSM-based formalism for describing and synthesizing on-chip communication protocols and protocol converters between different bus-based protocols is discussed in [24]. The work in [24] contributes towards three aspects of protocol converter synthesis: a formal, FSM-based model for protocol definition, a precise definition of protocol compatibility and a definition of converters and converter correctness (for a given pair of existing and known protocols). Protocol converter testcases that were used to evaluate the work in [24] incluced an ASB to APB converter and a set of converters between the Open Core Protocol (OCP) and the AMBA family of bus protocols. The existing synthesis framework is limited to protocols that can be defined by a single FSM, and for more than one FSM per protocol description capabilities, future work on this is envisaged by the authors.

The methodology of SystemCoDesigner [25] uses an actor-oriented approach so as to integrate HLS into electronic system level (ESL) design space exploration tools. Its main aim is to automate the design and building of correct-by-construction System on a chip (SoC) implementations from a behavioral model. The design starts with an executable SystemC system model. Then, commercial synthesizers such as Forte's Cynthesizer are used in order to generate hardware implementations of actors from the behavioral model. Modules or processes are modeled in [25] as an actors which communicate with other actors via a number of communication channels. This is the starting point for modeling a system in [25]. The specification language of an actor is a subset of SystemC which is defined in SysteMoC library [25]. The final FPGA bitstream is generated in [25] using the Xilinx EDK (Embedded Development Kit) tools. A motion-JPEG test application was used to validate the proposed methodology in [25].

A formal approach is followed in [26] so as to prove that every HLS translation of a source code model produces a RTL model that is functionally-equivalent to the one in the behavioral input to the HLS tools. The validating system in [26] is called SURYA and it is using the Symplify theorem prover to implement the validation algorithms. SURYA was used to validate the SPARK HLS tool [11], and SURYA managed to find two bugs in the SPARK compilations, which were unknown before.

An assumption is made by the formal model of refinement in [27], that the specification and the implementation are single entry and single exit programs. A transition diagram represents every process in these programs. This diagram uses generalized program locations and program transitions. A program location represents a point in the control flow of the program and it is

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either a node identifier, or a pair of two locations which refer to the state of two processes that are running in parallel.

The replacement of flip-flop registers with latches is proposed in [28] in order to yield better timing in the implemented designs. The justification for this is that latches are inherently more tolerant to process variations than flip-flops. The latch replacement in [28] is executed not only during the register allocation task, but in all steps of HLS, including scheduling, allocation and control synthesis. This method assumes that the delay of the controller is negligible, as compared to the transparent and non-transparent phase times. Nevertheless, implementing registers with latches instead of edge-triggered flip-flops is generally considered to be cumbersome due to the complicated timing behavior of latches.

III. The Cubed-C Design Environment

The Cubed-C HLS design environment consists of the frontend and the backend compilers. The frontend compilers process programs in ADA and C and produce an intermediate format named ITF. More on the description of this format can be found in [29]. The frontend compilers extract all the information from the source code which is required to transform the input subprograms into functionally-equivalent RTL modules in hardware.

The backend compiler is built with Prolog predicates and therefore its HLS transformations are formal and the produced hardware implementations are provably-correct. Most of these transformations and optimizations are captured in an aggressive scheduler called PARCS. PARCS will always try to bring the best result (most compressed schedule) however obeying to the data and control dependencies as well as any existing module-locked or global resource constraints.

Fig. 1 depicts the design and verification flow within the Cubed-C environment. The internal structure of the Cubed-C hardware compilation system is obscured in this figure. However, the importance of unified synthesis/verification strategy is obvious in Fig. 1.

PARCS is based on formal techniques and it is a resource-constrained scheduler. It can be driven with local (module-wise) or global resource constraints. The backend compiler can be driven by options about the architectural template, the HDL language, the location of large multi-dimensional data objects, the use of custom blocks, etc.

Apart from the RTL code, the backend compiler uses the same internal formal model for the hardware FSMs to extract one cycle-accurate simulator in ANSI-C for each module in the input code hierarchy. By compiling and executing this simulators, the user can go through the FSM states and observe the changes in various storage elements inputs and outputs of the design. Thus, this verification is based on formal means of verifying the same model used by synthesis, and in all of our testcases the functionality of the generated hardware structure coincided with that of the input code, which was expected due to the formal nature of the hardware synthesis transformations.

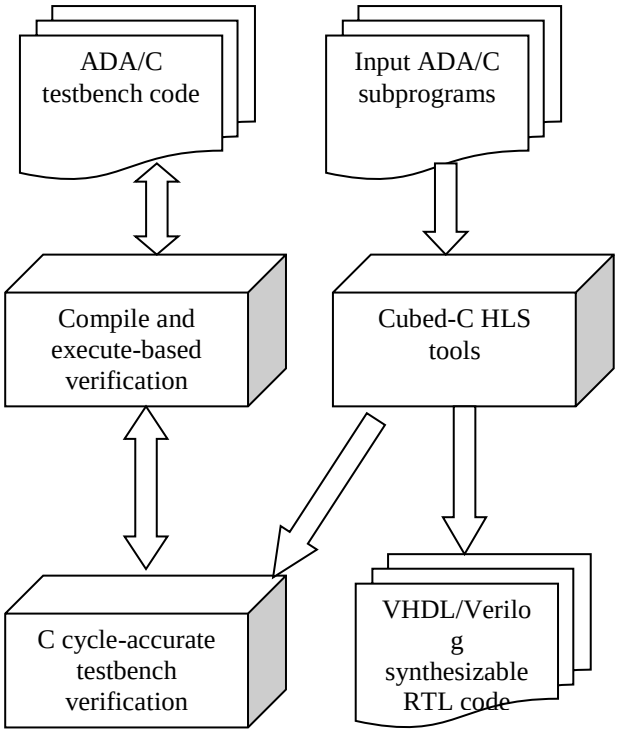

Figure 1. The Cubed-C synthesis/verification flow

IV. Signal Coding Algorithms

The 0 and 1 value of digital signals are sometimes transmitted as are with low and high voltage corresponding values. Often, and in order to enable clock recovery from the signal waveform, as well as information compression, they are modulated or mapped onto signal voltage level change or stable value as well. In general there are four categories of signals:

1. Non-return to zero (NRZ) signals.
2. Return to zero (RZ) signals.
3. Phase Encoded (PE) or phase split signals.
4. Multiple level signals – Multi-level binary (MLB) signals.

NRZ-level signals map the 1 value to high voltage and 0 to low, or the other way round. It is the simplest type of NRZ signal. NRZ-mark signals map the change in voltage to level 1 and the absence of change to level 0. NRZ-space coding is the opposite of NRZ-mark. These types of signal codings don't offer error correction or clock recovery and they have a constant component which makes it impossible to transmit it with capacitive or inductive links.

Unipolar RZ is the simplest coding of including the clock information. Unipolar RZ is the logical AND between the signal and the clock, therefore when value 1 then there is a 1 pulse for the first half of the period, and 0 otherwise. In Unipolar PPM coding value 0 is coded as a short pulse (1) at the beginning of the clock period, and value 1 is coded as a

short pulse (1) somewhere at the middle of the clock cycle. In Unipolar PDM value 0 is coded as a short pulse (1) at the beginning of the clock cycle and value 1 as a long pulse (1) at the beginning of the clock cycle. In this way this group of coding schemes carries in its data the clock information, which can be recovered at the receiver.

Another group of signal codings is the Phase coding group. The first coding is called the Polar Biphase level, and it is otherwise known as Manchester code. In Manchester code value 0 is coded as 0-to-1 transition at the middle of the cycle and value 1 is coded as a 1-to-0 transition at the middle of the clock cycle. Polar Biphase Mark and Polar Biphase Space are essentially Frequency Key Shifting. In Biphase M. value 0 is coded with stable and alternating (with continuous 0) levels, and value 1 is coded with double frequency clock. Polar Biphase S. is the opposite coding of Biphase M. In delay modulation which is also known as Miller code value 0 is coded with alternating level (at the end of the cycle) if it is followed by 0, or same level if it is followed by 1. In Miller code, value 1 is represented by a change of the level in the middle of the clock cycle.

An interesting group of signal coding is referred to as multi-level coding. This type of coding avoids the constant component and offers excellent synchronization of the receiver. The Polar RZ represents values 1 and 0 with positive and negative pulse of duration half of the cycle, respectively. Bipolar or alternate mark inversion features half-duration alternating positive/negative pulse for value 1 and level 0 for value 0. Dicode coding represents 0-to-1 change with a positive pulse and 1-to-0 change with a negative pulse, and stable level otherwise. In pair selected ternary pairs of bits are encoded depending on an encoding table. In Duobinary coding, when value changes there is a change in level but only to half height, e.g. from 1 to 0, from 0 to -1, from -1 to 0 and from 0 to 1, and no change when values remain the same. For this group of codings it is necessary to encode at least 3 levels of signal, e.g. 1, 0 and -1. For this we have selected encoding with two bits, that will drive a DAC at the output (not shown in our experiments).

V. Design Experiments

Although most of the signal coding algorithms that were reported above, were coded in high-level ADA and implemented in the Cubed-C framework, for the sake of economy here we describe two representative ones the Manchester code and the Polar RZ.

The algorithms were coded and debugged in executable ADA programs according to the verification scheme of Fig. 1. Then the code was ported to the input of the Cubed-C compiler that synthesized the RTL VHDL code. The RTL models of the code/decode processors were simulated and verified in a RTL simulator. Then the results were compared to the input ADA code and in all cases the behavior matched that of the source code programs. Fig. 2 and Fig. 3 depict snapshots of the RTL simulations for the Manchester modulator/demodulator.

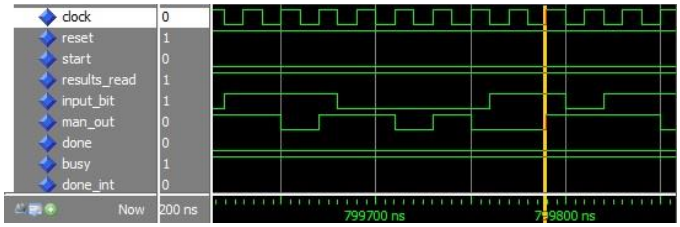

Figure 2. RTL simulation of the Manchester encoder

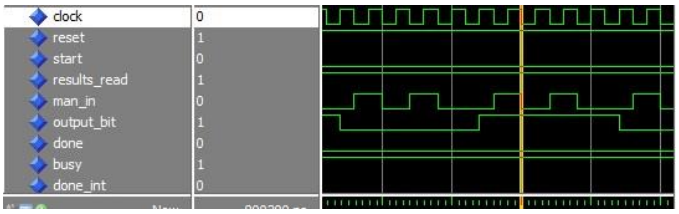

Figure 3. RTL simulation of the Manchester decoder

Moreover, the RTZ Polar RZ algorithm was implemented with the same flow and the automatically generated RTL code of the Polar RZ processors was simulated to verify the expected correctness of the synthesis process. Fig. 4 and Fig. 5 contain snapshots of the Polar RZ modulator/demodulator respectively.

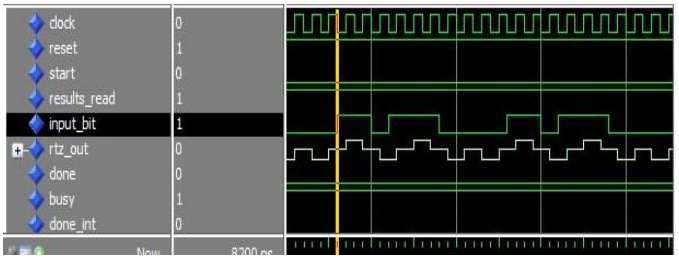

Figure 4. RTL simulation of the Polar RZ encoder

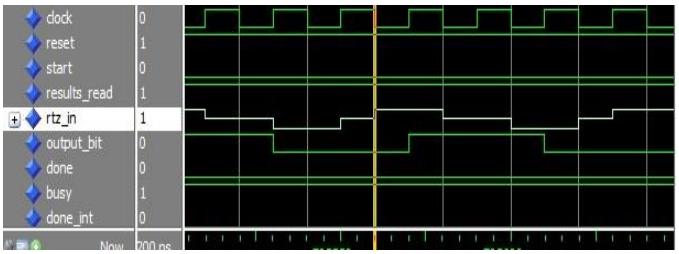

Figure 5. RTL simulator of the Polar RZ decoder

As shown in the above figures, in all synthesis experiments with Cubed-C the behavior of the synthesized code matches the intended one of the ADA source code. This is actually expected due to the formal nature of our tools' synthesis transformations.

It is worthy to mention that most of the experiments took less than an hour each, which reinforces our contribution towards a sizable increase of the designer's productivity. The Polar RZ experiments utilized the custom blocks option of the Cubed-C compiler to design the custom Boolean functions required for the signal value translations.

A. A small UART serial communications processor

A UART design was verified and synthesized using the Cubed-C synthesizer. Table I shows the Xilinx Spartan 3 FPGA statistics of its implementation.

TABLE I. UART DESIGN IMPLEMENTATION STATISTICS

Object	SPARTAN-3 XILINX FPGA stats		
	Used	*Total*	*Utilization*
Slice Flip Flops	84	7168	1%
4 input LUTs	122	7168	1%
occupied Slices	93	3584	2%
bonded IOBs	27	173	15%
BUFGMUXs	2	8	255

The worse-case delay was around 8 ns, allowing an implementation speed of clock up to 100 Mhz.

The UART was verified at the ADA level, at the cycle-accurate simulator level (produced by Cubed-C) and at the RTL VHDL simulation. The latter is showed in a snapshot in Fig. 6.

The experiment took less than an hour to complete. This is due to the rapid nature of our modeling and synthesis flow.

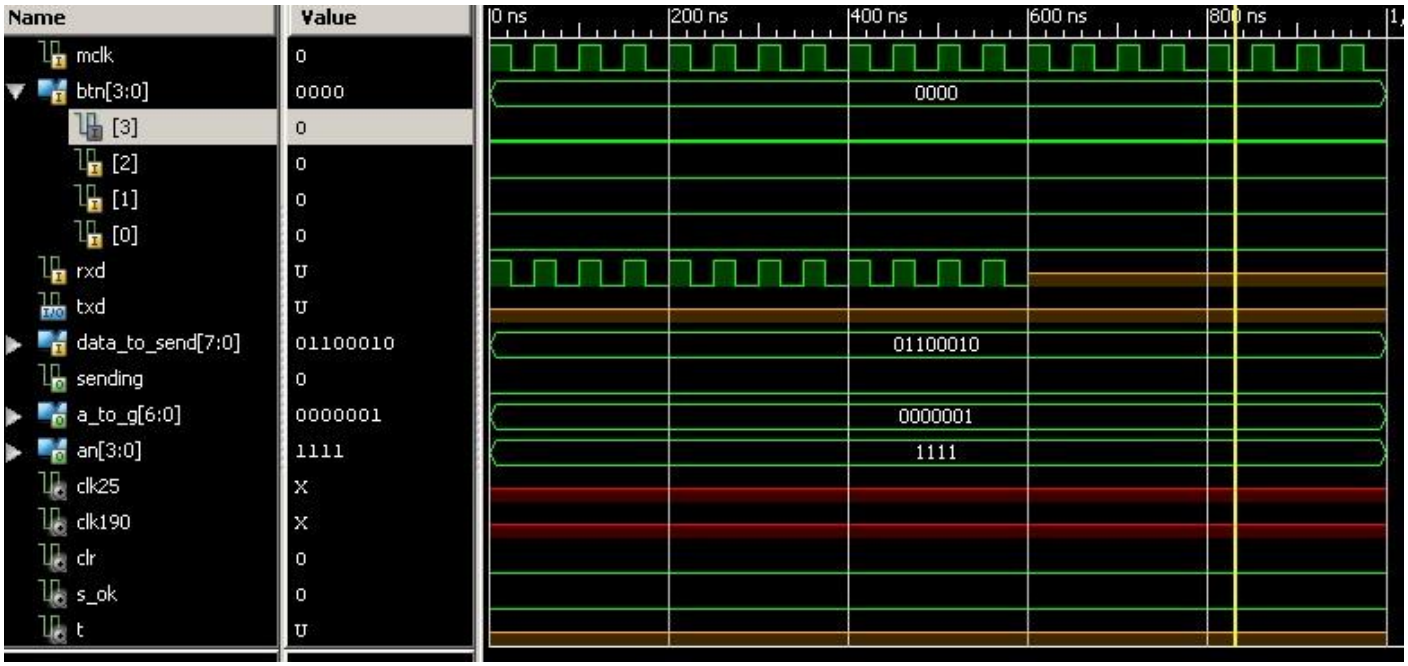

Figure 6. RTL VHDL simulation snapshot of the UART design

VI. CONCLUSSION AND FUTURE WORK

Formal and rapid automated synthesis and automated formal verification methods flows are used in the Cubed-C tools. The major contribution of this work is that low level, bit-wise, detailed hardware signal coding algorithms are rapidly and formally implemented with the Cubed-C framework, although Cubed-C is a full-blown HLS system.

In all cases, RTL/gate level verification showed that the behavior of the generated hardware processors matches the behavior of the input specification code and model.

Future work includes more low level modulation algorithm implementation, more experiments with Cubed-C and the embedded Cycle-accurate simulator. This reinforces the value of the seamless synthesis and verification aspects of our flow.

ACKNOWLEDGMENT

Grateful acknowledgements to the informatics teacher and post-graduate student Nick Dollas, for providing the experimental results of the UART design.

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EFFICIENT METHOD OF CALCULATING ELECTRIC LIGHTING

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Abstract—**Purpose: The purpose of this study is to present the calculation method efficient electric lighting. Knowing the latest news related to this field, the advantages that brings technology to improve the saving of electricity when is known that lighting nets are one of the consumers of electricity. As an important part in the study and issues related to the maintenance and management of public lighting networks.**

Materials and methods: To realize a comprehensive survey regarding efficient methods used for calculating the electric lighting is important that the right recognized and valued as the basic concepts of lighting flux, intensity, Illumination, yield etc. Among the methods that were highlighted in this study are those for calculation of indoor lighting and public lighting as method IEC, with the rate of yield methods, methods of specific power, etc. drip method. An important element is the recognition and the types of lamps used in those incandescent lighting to the latest LED technology. In addition to these techniques use STABILUKS for electricity saving is a further major advantage.

Results: Through the replacement of traditional incandescent lamps and downloads them in the gas lamps led durability and efficiency increases in the cost of electricity. Likewise STABILUKS use regulator which makes it possible to reduce the working voltage of the lights in times when the flow of light should be lower also affects the life of lamps.

Conclusions: An important aspect is the fact that the use of efficient techniques to calculate and control the electric lighting networks bring advantages in saving electricity and minimize the problems for maintenance and services that are related to the normal work of lighting networks.

Keywords- lighting rate, coefficient of lighting, photometric curves

I. ENTRY

In modern times, they have received tremendous value to create a complex details and at the same time make the subject treated unique. After structural architecture are primaries in the shaping of an object is the proper task of lighting specialists to fill it with details that identify and enhance the architectural values. The design in this field has a tendency fact that the majority of spectacles, social activities and social or business presentations in art centers or be under the influence of light. All this due to the fact that the technology of lighting has made the quality before the completion of landscape art facility, that lighting is not only used for the primary purpose of it, to illuminate the object to be seen by the lack of natural light, but "the painted with light." It is understood that the achievement of this goal is not a simple thing as required to carry out several essential conditions:

Be available a technical staff capable of carrying out high level tasks in the design phase as well as in the implementation phase.

Financial opportunities are to meet the costs of projects that are relatively high

External lighting is a very important part of the lighting in general. He treats roads, squares, residential areas, parks, bridges, etc. From year to year, external lighting is given more and more importance, due to the fact that recognition of the positive value it provides in terms of social society is making it an indispensable factor of the highly demanded by the population. On the other hand it is becoming common for facilities like parks, bridges, roads and green with special architecture, facade, etc., are also required special lighting. These kinds of lighting, through the placement of the light source, even if minimal in terms of power, in the right place under the right corner, with light shades create a real painting with light. These kind of plant, mainly use indirect lighting, where the light body is hidden inside the building and the effect is seen only gives light. Today's technologies have made it possible to advance the imagination, creating effects-not only light but also with shadows colors. Technology production of lamps produced lamps of very high qualities with light in white, yellow, red, green, blue, etc.

In conclusion we can say that is advanced lighting technology without limits. Restrictions remain only on the personal skills of enforcement designers to use these degrees of freedom that technology offers us. Technology again through computer developments, enabling us to use the data, achievements and latest news to provide lighting in the vanguard of Europe and the world. These new sites are updated in their published and are a great help for designers.

II. WAYS OF ACHIEVING THE INTERNAL FOR LIGHTING CALCULATION OF THE COEFFICIENT OF UTILIZATION METHOD AND THE SPECIFIC POWER

A. Calculation of lighting installation with the method of utilization coefficient

Lighting coefficient method to calculate the power of the lamps to be installed, can be applied in those cases when lights are placed symmetrically, the distance between them is close and convenient distance to the work surface is horizontal.

$$u = \frac{F_p}{nF_1}$$

n - number of lamps , each light flux F1.

The total flow of all the luminaries F1 Fb only part falls on the horizontal work surface, while the rest is absorbed by couplings illuminated the walls and ceiling, therefore, u <1. The size of the coefficient of utilization light depends on the yield of light, photometric his curve, color of the walls and ceiling and bar form.

$$\varphi = \frac{a \cdot b}{h'(a+b)}$$

The impact of bar forms that expressed by the bar indicators φ which is as follows, direct lighting systems, and mixed formula applies.

$$\varphi = \frac{3}{2}\frac{a \cdot b}{H(a+b)}$$

φ - indicator of the bar,

b - width of the bar,

h '- the distance illuminating the work surface,

H - Height from floor

Index premise calculate φ through two formulas above by the lighting system to take practical .We consider, for simplicity of the premise φ indicator does not count, but based on the size of the facility and find as given through the table.

B. Calculation of installing lighting with lighting coefficient method.

The coefficient of utilization of the lighting installation, F1 flow of each lamp light and n the total number of luminaries

The flow of light that falls on the surface that is calculated is:

$$FP = u \cdot n \cdot F1 \qquad (1.1)$$

This influx work falls on the surface of S = ab (a and b are the width and height of the bar).

$$Emes = \frac{F_p}{S} \text{ ose } E_{mes} = \frac{U \cdot n \cdot f}{S} \qquad (1.2)$$

To ensure the conditions of exploitation degree of Minimum illumination Emin selected according to the rules, we must have in mind the coefficient reservation known as the difference between the minimum level of illumination Emin and the average Emes, change that is characterized by the coefficient black minimum level of lighting given as follows

$$z = \frac{E_{mes}}{E_{min}} \qquad (1.3)$$

Based on this equation (1.2) can be written.

$$E_{min}kz = \frac{u \cdot n \cdot F_1}{S} \text{ ose } E_{min} = \frac{U \cdot n \cdot F_1}{S \cdot k \cdot z} \qquad (1.3)$$

To determine the flow of light of each lamp lights during installation calculations equation takes the form

$$F_{II} = \frac{E_{min}S \cdot k \cdot z}{u \cdot n} \qquad (1.4)$$

Emin - minimal lighting level chosen according rates and reserve k-coefficient,

z - scale coefficient of minimum illumination.

C. Calculation of lighting installation with specific method of power.

Let be a (m) width of the facility, b (m) of its length, n the number of lamps installed and P1 [W] power of each lamp. The total installed power of government is:

$$P = N\,PL \quad [W]$$

The surface of the bar is: S = ab [m2].

Specific power of lighting installation is:

$$P = \frac{P}{S} = \frac{n \cdot P_1}{a \cdot b}\left[\frac{W}{m^2}\right] \qquad (1.5)$$

The greater the degree of illumination, the greater will be the specific power. Specific power depends on the type of light, illuminating the placement of the power and type of lamp and environmental features that will be illuminated (height, surface, reflection coefficients of the walls and ceiling, etc.)

Calculation of lighting installation with specific method of power becomes this order:

1. Determine the number of luminaries

2. Light type based on the characteristics of the specific power facility located in special tables.

3. $Pl = \frac{p \cdot S}{n}$ [W] power lamp is calculated by formula

4. The lamp table with the selected type of standard power

5. The power of standard lamp n multiplied by the number of lamps to be used and thus found the installed.

III. STABILUKS TECHNIQUES

Energy saving and reduction of maintenance costs are two of the current arguments seeking solutions from the field of lighting staff.

To achieve the goals fixed should be done with technologically advanced equipment. For this propose of the light flow regulator which allows the reduction of maintenance costs, reduce energy consumption and limit the flow of distributed skyward in accordance with preset schedules at specific programmable way.

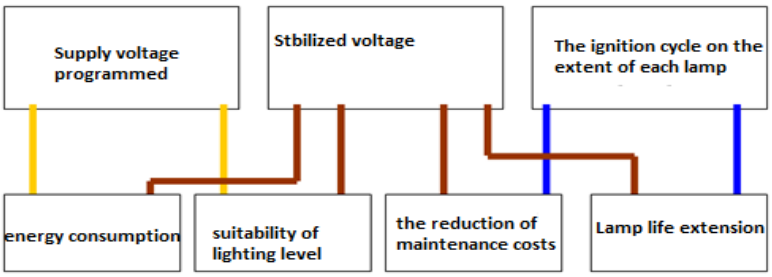


Figure 1.

STABILUX provides an energy saving of 50%, thanks to the stabilization function of voltage and food bulbs programmed schedule function burner. In graphical form, as follows:

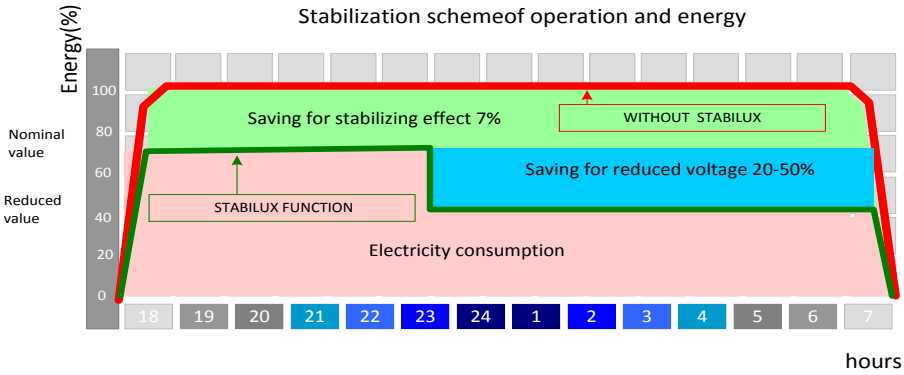


Figure 2. Stabilization scheme of operation and energy

Advantages

Food energy. Food correct sodium vapor lamps, mercury, fluorescent and metal iodide, bearing the characteristics of the supply network parameters unchanged at all times. From studies carried out, the flow of lighting maintained at very high levels even after 20,000 hours of real use.

Lamps- life expectancy due to the operation of the ignition regulator and lower in value than nominal, but never higher. With the use of STABILUX's, double lamp life bearing high levels of light emission standard.

Reduced cost of the plant management guaranteed a return of investment in a very short time.

It contributes to prolonging life light.Experience sources shows that increases lamp life of 50% -300% depending on the voltage and the type of lamp used. Graphically it is expressed in this form.

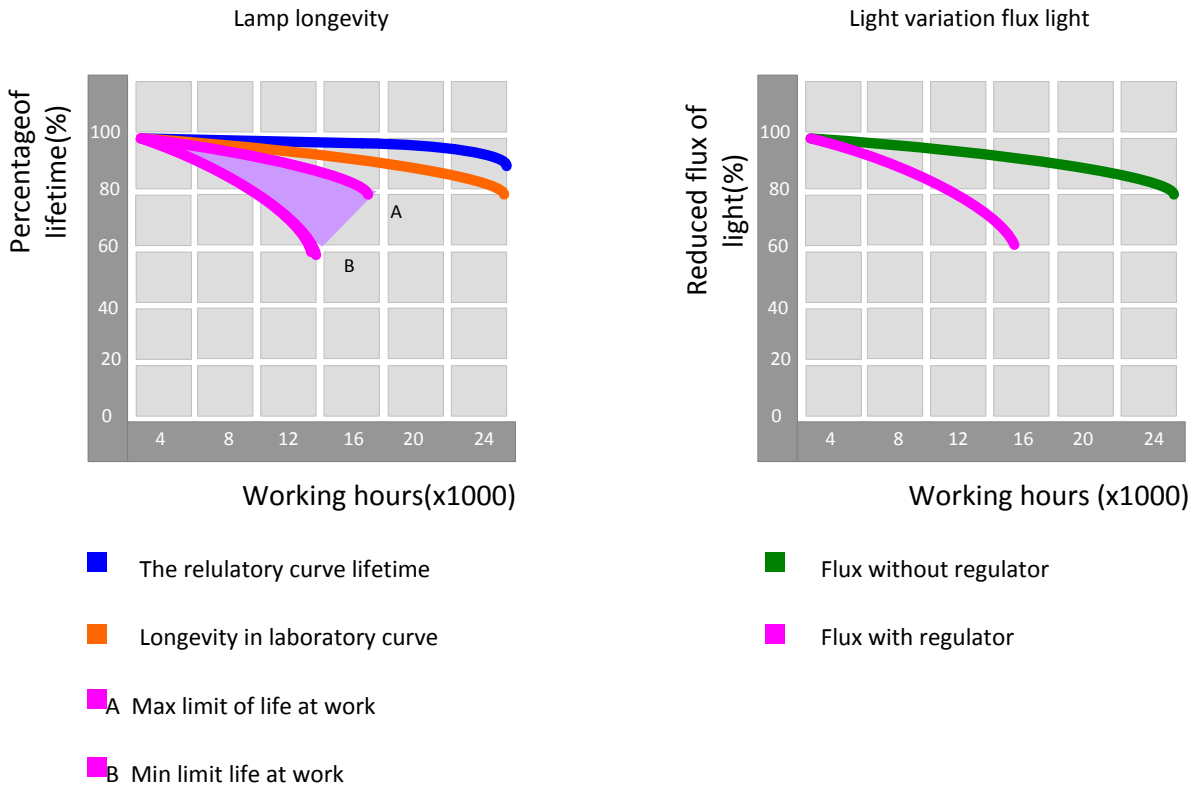


Figure 3. Lamp longevity and Light variation flux light

Stabiluks method also provides a road in applications with greater certainty by creating a constant and uniform lighting level by eliminating the risks of shadows created around conical lamps.

Calculation of saving

To assess analytically derived advantages from the application of lighting flow regulator STABILUX should verify the maturity of the investment. It is advisable to assess each project individually.

The Power absorbed by the active total plant count:

$$P = NxW + (1 + P / 100) \times (1 + L / 100) \cos\varphi \quad (1.1)$$

N- Number of lamps

W- Power lamp

P- Losses in equipment

L - Losses in lines

The total energy absorbed by the network shall be:

$$E=P \times hc \times Ce \quad (1.2)$$

P - active power active absorbed by the plantHc- work hours reduced voltage

Ce - Costs per 1 kWh

Energy saved

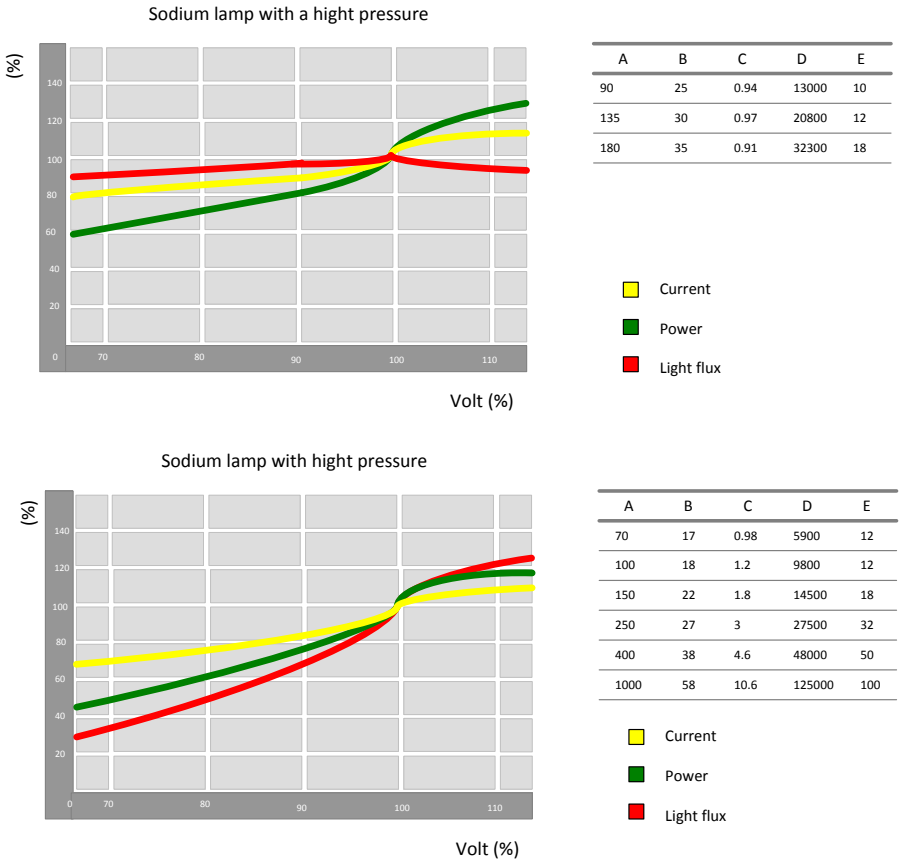
The calculation of energy savings is made of the formula:

$$Ret = P \times \cos\varphi \times r / hr \times Ce \times 100 \quad (1.3)$$

Energy holding back r- accessible through supply voltage Ce- cost electricity for 1kWh

The hours Hr- reduced voltage (estimated 2850 hours per year)

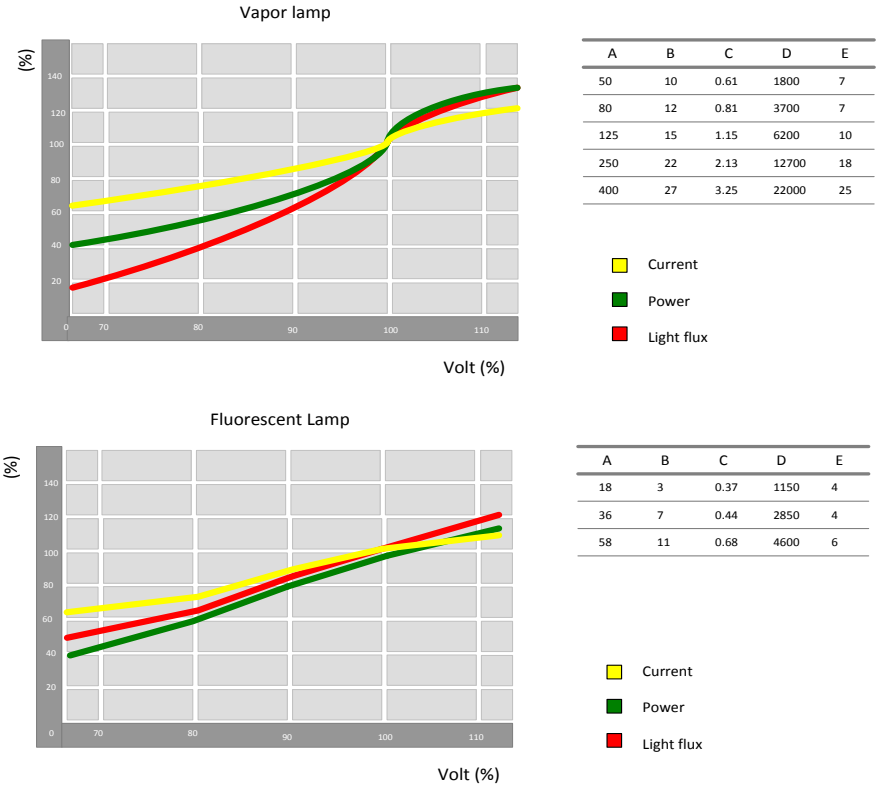
We graphs, curves typical for any given lamp where dependence on energy saving against different food values below the nominal value and the effect of saving in each case is as follows



A	B	C	D	E
90	25	0.94	13000	10
135	30	0.97	20800	12
180	35	0.91	32300	18

A	B	C	D	E
70	17	0.98	5900	12
100	18	1.2	9800	12
150	22	1.8	14500	18
250	27	3	27500	32
400	38	4.6	48000	50
1000	58	10.6	125000	100

Figure 4. Sodium lamp with a high pressure



A	B	C	D	E
50	10	0.61	1800	7
80	12	0.81	3700	7
125	15	1.15	6200	10
250	22	2.13	12700	18
400	27	3.25	22000	25

A	B	C	D	E
18	3	0.37	1150	4
36	7	0.44	2850	4
58	11	0.68	4600	6

Figure 5.

IV. DISCUSSION

Lighting Management Network membership in an external looks like a relatively simple premise problem. But in his simplicity how problematic it is complex, and keeping its optimum operating parameters requires technical personnel commitment from previous experience. The main directions where today more work in this area are:

- Calculating how much more fair and magnitude of lighting, with intending to be complied with European norms as of the quantity as well as for the quality of lighting, with intending to handle the scale of needed lighting with uniformity requested and without creating effects blinding of transitional or for executives vehicle. Also the degree of lighting Chat facility conform hand relevance, magnitude of mobility, speed of movement, density of movement for residents etc.
- Use of equipment with sufficient quality European standard, would bring not only guarantee parameters of technical means, but also life time lighting installations under construction depreciation on familiar terms. In addition to these, even during the period of Maintenance work not anomalies membership would bring unpredicted.
- In response to the solutions required in reality presents of the different energy saving, it is essential that savings of electricity consumed by lighting networks. This time becomes considerably by today's trends of urban expansion, the formation of an infrastructure construction of decent working area it's where is undisputed aspect of external lighting, public lighting or as it is called.

V. CONCLUSIONS

1. Determinationof the power of the lamps. On several occasions, noted that illumination of specific areas or roads and lighting has a higher than norms that corresponds to that type of object.

2. Adoption of measures for the reduction of reactive power grid lighting that takes the source of electricity. Most of the lamps that are used are lamps with downloads in gases (in the vapor of sodium, Mercury iodide metals, etc.) is his presence, a large number of elements inductive (drossel) that the worsen hand multiplier power control who can be up tocos φ =0.5. These membership value becomes unacceptable because of its impact is far too great in aggravation of most energy sources, in that circulate growth trends in the network, in increasing losses and the need for growth in hand sections of the wiring lighting networks. In order to avoid further construction important problem as in technical terms, but that there are also economic costs, measures that offset this power and reactive power control that membership improve coefficient up to 0.9 to 0.95.

3. Commision of a prophylactic in nature maintenance services, in order that the lighting equipment much more efficiently have membership in the work who perform (cleaning of luminaires from dust, contacts control, control sharing of lines that demand control by much more symmetric load, etc.)

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The impact of using mobile devices on road traffic safety

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Abstract—**Using a cell phone is one of the most distracting activities while driving. Answering text messages is the most dangerous since the driver spends more time focusing on the phone screen which increase the chance for an accident. Drivers involved in cell phone use accidents are generally 29 or younger. For research a study was conducted consisting questions about using cell phone during driving. The study was done both online and face to face. The given results are similar to those of previously conducted studies. There is a need to educate drivers and the general public of the risks of cell phone usage while driving.**

Keywords- Cell phone, Driving, Traffic accident, Distraction

I. INTRODUCTION

The use of cell phones while driving is getting more common in everyday road traffic what makes the use of cell phones increasingly important cause of traffic accidents. Drivers often focus on having a conversation or writing text messages and ignore the situation and road conditions, what can lead to severe consequences.

Using a mobile device while driving represents a risky behavior that endangers the driver, co-driver, passengers and other road users and leads to visual, physical and cognitive distraction because the driver cannot keep attention on the road and objects, and timely and properly react and adapt his driving.

Driver distraction is a serious threat to traffic safety. One of many definition of distraction is: any activity that could distract the driver its attention from driving, which is its primary task. The emergence of distraction is real problem and one of the key factors that have a negative impact on road safety [8]. Depending on the use of mobile phones while driving, distractions appear in a different intensity or a combination. Visual distraction occurs when visual signals in or out of the vehicle divert attention from the main task – safe driving. Physical distraction occurs when driver move his hand off the wheel in order to hold cell phone while operating a vehicle. Even when the phone is used with "hands-free" device, the driver must press at least one key. Cognitive distraction occurs when the mental (cognitive) tasks are being simultaneously executed, and the execution of both tasks is often much more difficult than if they had been performed separately. This is because the focus has been divided or transferred between tasks, and because there is a competition in the cognitive processes. In simple terms this means that the request for a telephone conversation can somehow compete with the demands of driving and vehicle safety. These distractions may occur alone, but they usually occur in combination with greater or lesser influence of one of them.

Certainly, a distraction is most intense when it occurs on visual, physical and cognitive level at a same time, which evidently most often occurs while exchanging data, taking picture and recording with mobile device.

Given that the Republic of Croatia has not yet sufficiently explored the impact of mobile phones on the safety of driving, the survey within this article will try to show how much the use of phones while driving affects the safety and how much does it affects the drivers themselves.

II. FACTORS OF THE ROAD TRAFFIC SAFETY

Traffic is a very complex system, which in itself homogenizes a number of factors affecting its implementation. In order to increase traffic safety, it is necessary to implement a number of measures, whose task is to reduce the risk and to increase traffic safety. Factors that appear in traffic can conflict which can potentially lead to traffic accidents. Road transport can therefore be seen through three sub systems [4]:

- Man
- Vehicle
- Road

Considering that the three main components are human-vehicle-road, in order to affect the very safety of transport one of these elements must be improved. The most difficult task is to change the human consciousness of the hazards associated with negligence in traffic. Precisely for this reason, some countries, such as Sweden, started a program called "Vision Zero" which focuses on the prevention of the consequences of traffic accidents it they do occur. "Vision Zero" does not exclude human error and is not trying to influence the man, but is improving the infrastructure (e.g., fencing trees beside the road with barriers) in order to reduce the consequences of accidents if they do occur.

Factors man-vehicle-road does not include all the elements that can affect the state of the traffic system, for example, the proper movement of traffic on the roads, traffic management

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and control, etc., And therefore it is necessary to introduce the fourth factor, which is called "traffic on the road."

Factors of road safety: man, road, vehicle and traffic on the road appear are always sustained within the system if there is a traffic of vehicles and pedestrians on the roads. A behavior of these factors is subjective to some regulations, but it cannot include other elements appearing suddenly and unregularly and are also affecting the current state of traffic system, such as weather conditions or other elements, for example, the stones on the road, oil and mud on the road surface and similar. Therefore, it is necessary to introduce one more factor in which are contained all of the elements. This factor can be called "incidental factor" in order to emphasize its unregulated and unexpected occurrence [4].

Based on the analysis of statistical data on traffic accidents in the Republic of Croatia, it is evident that the three most common causes of road accidents are: a driver (80%), a vehicle (3-4%) and a road (7-9%) [4]. According to many authors, the road is the cause of traffic accidents in a wide range from 0.5 to 37 percent. In many European countries it is considered that the road causes traffic accidents in the 20 to 30 percent of cases [4]. Given that the European traffic network is better than ours, according to the same criteria it should be expected that the road causes traffic accidents in a significant higher percentage in Croatia. This difference is most likely due to the different treatment in the investigation report.

A. A man as a traffic safety factor

When a man is in a role of driver and as such participates in traffic, he receives real time road information, and considering his vehicle and existing traffic regulations, makes decisions about his movement on the road. Of all the factors that affect traffic safety, the influence of the human factor is most important. When considering the behavior of man (driver) in road transport, it must be assumed that the driver is a part of the system that makes decision on the basis of information received. There are major differences in the human behavior in a different situation. These differences in behavior depend on the level of education, on health status, age, temperament, morality, emotion, intelligence and so on.

Personality is made of features, characteristics and behavior which makes every human individual to stands out from all other individuals in that society. Mentally stable and harmoniously developed persons is a precondition for a successful and safe flow of traffic. In what level will person adapt to the ongoing conditions of traffic depends on whether there is a harmony between its capabilities and its characteristics. The concept of people in the narrow sense can include these psychological features [4]:

- Ability
- Viewpoints
- Temperament
- Personality
- Character

B. The vehicle as a traffic safety factor

The vehicle is a mean of transport designed to transport people and goods while moving in a straight line or in a curve line with a constant speed, fast or slow. Due to its construction and exploitation features it affects largely on traffic safety. According to data from the project "Check of the technical condition of vehicles involved in traffic accidents with fatalities" it is confirmed that out of 166 inspected vehicles 85 (51.20%) were technically correct, 11 (6.63%) were unknown and 70 (42,17 %) were incorrect [5]. However, this percentage is much higher because within the investigation report after a traffic accident certain vehicle parameters cannot be determined as cause of accident. Only clearly expressed malfunction can be taken into account, such as breakage of a part, complete cancelation of the braking device and the like. [4]. Malfunction, such as low efficiency of the brake system, the instability of the vehicle during braking, etc., have a great effect on traffic safety. Elements of the vehicle that affect the safety of traffic can be divided into active (brakes, steering, tires, etc.) and passive components (airbags, seat belt, body, etc.).

C. The road as a traffic safety factor

In order to ensure a safe traffic among other factors it is necessary that the road is safe for use. Technical deficiencies of the road are often the cause of accidents, and can appear as the result of design of the roads or while constructing the roads. The impact of the road structural elements on the traffic safety is visible through the design and by determining dimensions and structural characteristics of the road. Road as a traffic safety factor contains following elements [4]:

- The route of the road
- Technical elements of the road
- Road surface state
- Road equipment
- Road lightning
- Crossings
- The impact of side barrier
- Maintenance of the road

D. The "traffic on the road" as a traffic safety factor

The factor "traffic on the road" includes sub factors: organization, management and traffic control. Organization of traffic includes traffic regulations and technical resources for the organization of traffic. Traffic management includes the method and technique of road transport management. Traffic control includes the way of the traffic control as well as the testing and statistics of traffic accidents. Traffic signs use their symbols, signals and additional boards to warn motorists about traffic conditions and of their obligations under these conditions. Plan of the technical regulation of traffic should solve all the problems related to the development and reconstruction of traffic signals, including the road equipment, protective fencing, fenders over the railway lines, connecting secondary roads, parking spaces and stops, bus stops, positions

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of pumping stations, hotels, restaurants, etc. Traffic control is performed on the basis of the Law on road traffic safety. Traffic Safety Act and various regulations must be regularly updated and adjusted to the rapid development of traffic. The law and regulations must be unique, clear and equally interpreted in the entire area for which are valid [4].

E. The Incidental factor

Factors man, vehicle, road and traffic on the road are subject to certain regularities that can be predicted. However, these factors are not covered by atmospheric conditions or other elements, for example, an oil slick on the surface of the road, dirt, wild animals and the like, which are obstacles to safe traffic. Therefore, it is required to introduce one more factor, the so-called. accidental factor, whose action occurs in an unexpected and unsystematic way. The negative effect of weather conditions on traffic safety is reflected in the reduction of visibility and less grip between the tires and the road surface. Weather conditions affecting the safety of traffic may include: rain, ice, snow, fog, wind, atmospheric pressure, high temperature, effects of the sun and similar.

All those incident factors could cause uncertainty for the driver and can be the cause of an accident, but the factor of rain has the most negative effect on the safety of traffic. The most dangerous is the first rain since it mixes with dust and mud and creates a thin slippery layer between the wheels and the road surface, which reduces the coefficient of adhesion between tire and road surface. Drivers are in great danger if their vehicle has worn tires because when it rains they will achieve the ‘’ski effect’’ at much lower speeds.

III. THE IMPACT OF THE USE OF MOBILE DEVICE ON DRIVERS REACTION TIME

The reaction rate is extremely important in driving, especially in city traffic, where it is crucial to have the maximum concentration at all times. The use of mobile devices reduces the driver's attention, and thus prolongs the reaction speed of drivers, which results in a longer time to react, braking etc.

The US 'National Center for Statistics and Analysis of the National Highway Traffic Safety Administration "(NHTSA), in its annual survey from 2008 [2] on the use of mobile devices announced that at any time on American roads 812 000 vehicles were driven by driver using a mobile device. Furthermore, this study shows that out of the 34,017 fatal accidents in 2008, 37,261 people were killed, while 5,870 people were killed caused by some distraction while driving. This number accounts for 16% of all accidents in 2008. 21% of the 1.63 million people was injured in accidents caused by some distraction while driving. NHTSA conducted this research based on data obtained from the police, but it should be brought to mind that it is very difficult to prove is the use of mobile phone or some other distraction the real cause of accident, so that the number is very likely much higher than specified.

In Croatia, a money fine for talking on a mobile device while driving amounts 500 kn, while in the United States where this research was done, using mobile phones while driving is prohibited for all motorists in only 6 countries. 21 countries prohibit the use of phones while driving for the young drivers, while 17 states prohibit the use of mobile phones for drivers of school buses [2]. Studies have shown that not only the use of mobile devices by hand, but also other ways of using, equally distract driver’s attention on road performance. Studies have shown that the use of mobile devices while driving slows reaction of drivers equally as the 0.8 blood alcohol level. [2]

University of Utah [2] revealed that the drivers using text messaging while driving, are eight times as likely to participate in a road accident than those who do not use. While the University of Virginia conducted several research [2] and shown that drivers who use text messaging while driving, have a 23 times greater chance of being involved in a car accident. Their research has shown that the younger drivers are the population using the most text messaging while driving. Pew Research Center in 2009 [2] published a study on the use of messaging service of the young drivers while driving. The results showed that 26% of drivers from 16 to 17 in the year (in the US driver's license can be obtained at 16 years) have written a message while driving, and 48% of children from 12 to 17 years said they were riding with a driver who was texting while driving. The NHTSA study from 2012 [3] about making and answering calls from mobile devices (Figure 1), showed that more calls were received while driving than were dialed by driver. Categorically, it can be observed that men more often use a mobile device for receiving and making calls. Also, one can see that the most calls are received by people age 21-24

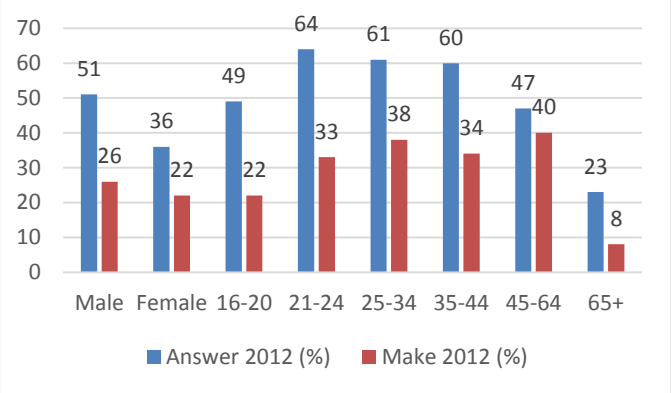

Figure 1. The use of mobile devices by age and gender [4]

years while the least calls are received by people 65+ years. Most calls are made by people 25-34 years old (38%), while at least calls are made by people 65+ years old (6%).

In another large NHTSA study from 2012 [2] conducted on 6016 samples, drivers were divided into two main categories; drivers having a distraction tendency while driving, and drivers that do not have distraction tendency while driving. In the sample, 33% of drivers were in the first category and 67 in the second. Drivers in the first category (prone to distraction), were of wealthier social status, typically younger and better educated than drivers from second category (not prone to distraction). More than half of drivers under 35 were classified as drivers tend to distraction, while only 5% of drivers over 65 were

classified into the same group. Also more than half of the respondents with a distraction tendency have an income of $ 100,000 a year, while 26% have lower incomes than $ 15,000 a year. From this it can be seen that drivers with higher incomes are more likely to use mobile devices while driving. Drivers with only a high school education are less likely to use mobile phones while driving, only 1/3 of them, compared with drivers of university education from which half of them uses mobile devices while driving. This finding makes sense, because people with a university degree have higher salaries than those with only a high school education.

In this study [2] frequency of travel is more than four of five drivers who drive every day or almost every day, 13% of people said they drive only a few days a week, while less than 4% of drivers drive a couple of times a month. Most drivers who use mobile devices while driving belong to the group of people that drive every or nearly every day while very small number of them are people who drive a car a couple of times a week [4]. Also nearly half of drivers (48%) are answering calls while driving, while 2 out of 5 drivers never answer a call while driving. More than half of drivers who answered the call continued talking while 17% of them warn the they're driving and will call later, 14% of them passes the mobile device to a companion in the car, and about 11% of them stops by the road in order to have a conversation.

About 24% of drivers makes a call while driving, what is even worse option then receiving a call, because to make the call driver must find a person in phonebook and dial, what distracts driver's attention from the road.

Sending messages while driving is most dangerous activity, because in addition to reducing the very concentration on driving, driver must also look away from the road, what is the worst combination of distraction while driving. Interestingly, the vast majority of people support severe punishment of people who use mobile phone while driving, but also use their own mobile device while driving. In a study [2], it was shown that drivers under 29 years most frequently use mobile device while driving. In analysis [6], it was concluded that sending messages during driving have affects on drivers actions needed to successuffly operate the vehicle [6.]In Croatia, the campaign against the use of mobile devices on the road is very poor and should be improved to arise the awareness of the dangers of using mobile phones while driving. But this should be done in a good way and carefully, not through advertisements by the road that are also distracting the driver.

Within the study of Vladimir Obradovic and Radmila Magušić in Slovenia [1], significant differences are visible in the amount of fines provided for the offense of use of mobile devices while driving (Figure 2.)

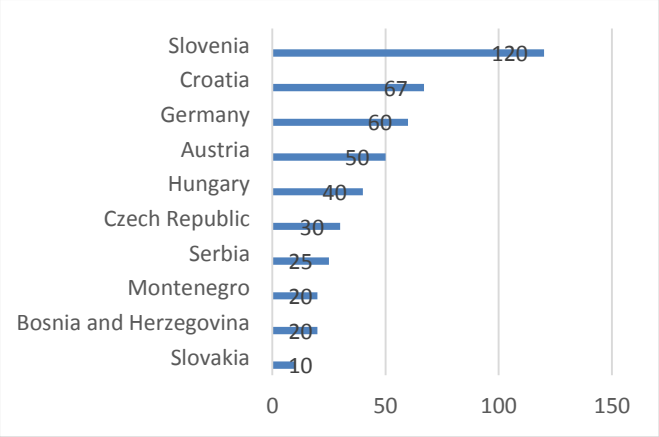

Figure 2. Fines in euros for using mobile phones while driving [1]

Important differences are visible in the amount of the fine provided for the offense of using mobile devices while driving. Money fines in the Republic of Croatia are 2 times lower than in Slovenia. Approximately 30.9% of respondents believe that the fine is not high enough, it is considered appropriate by 57.3%, while it is considered too strict by 15.4% of respondents. According to the survey, over 70% of people is phoning while driving, of which over 25% do it frequently. Every other driver reads received messages, and over 40% of drivers write messages while driving. These numbers are higher than those from studies in the United States, because there is a much larger campaign against the use of mobile devices while driving, so drivers are aware of the dangers that can be caused by this type of distraction while driving.

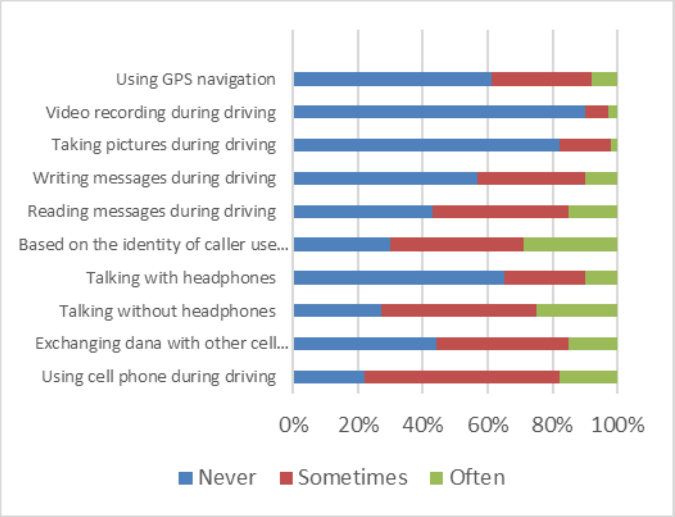

Figure 3. Modes of using mobile phone while driving [1]

In the Slovenian research, when taking into account all ways of using mobile devices while driving, almost all respondents use a mobile device while driving.

IV. THE SURVEY ON THE USE OF MOBILE DEVICES WHILE DRIVING

Based on previous, in the preceding chapters analyzed research, a survey was conducted on 309 respondents. The survey asked questions to achieve comparison with the survey

described in the previous chapter. Age groups are divided on 18-29, 30-49 and 50+ years. The first group is determined 18-29 to cover all young drivers and drivers under 29 years, because it was in previous studies proved to be a critical age for the use of mobile devices while driving. The survey is divided according to gender to determine how many men and how many women use mobile devices while driving, and in what way.

One of the most important issues is the way of the use of mobile device while driving, because all ways of use are not equally dangerous, for example, writing messages is much more dangerous than just talking on the mobile phone. Questions like 'How often do you receive calls?' and 'How often do you make calls?' are essential for the very safety of traffic, because the fewer the mobile device is used the likelihood of an accident is less. The question about writing text messages while driving is extremely important, because it has already been mentioned that this is the most dangerous way of using mobile phones while driving, in addition to reducing the concentration of road performance, the driver is moving eyes of the road and hands off the wheel. If the driver is using messaging it is also important how.

Survey is mostly based on the younger drivers, from 18 to 29 years of age. As previously noticed this 240 test subjects are the group with the highest chance of driving distraction. In the second group 48 people was interviewed from 30 to 49 years of age, while the last group included 21 people in the age of 50+ (Figure 4). Most respondents are 18 to 29 years old due to reason that the greater part of the survey was conducted online.

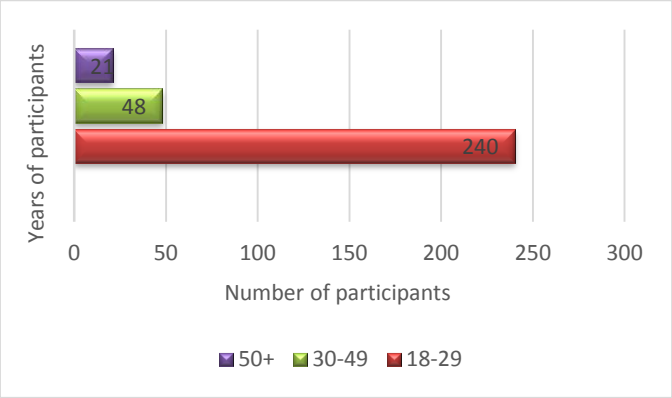

Figure 4. Survey participants by age

According to the gender of respondents, the results are equal, the survey includes 165 men participants, which make 54.1% of subjects, and 142 women, making 46.6% of total test subjects (Figure 5).

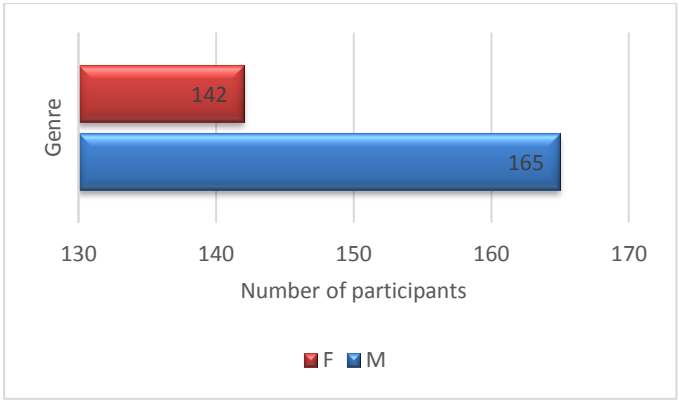

Figure 5. Gender of the survey participants

The way of using mobile devices is one of the most important items for traffic safety. All ways of using mobile devices are dangerous while driving, but as described in the previous paragraphs, text messages while driving are most dangerous. Figure 6 shows that 65 participants, or 21.3%, responded that their most common way of using mobile device is to write messages. Most participants said that they use a mobile device to receive calls, 166 of them, or 54.4% (Figure 6). Other ways of cell phone using came with the new technology and the use of smart phones, what is proved by 18 participants who use their phones for reading online content, photography, filming and social networks which couldn't be possible without smart phones.

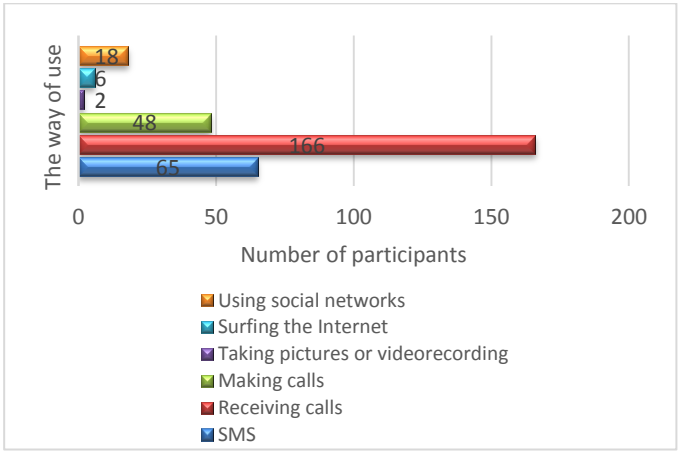

Figure 6. Ways of using mobile devices

When asked 'How often do you answer to an incoming call while driving?' 101 participants, or 33.1% answered with almost always. When taken into account that 83 people, or 27.2% always answers the call, it is clear that over 50% of people almost always answers the call, which badly affects the traffic safety (Figure 7).

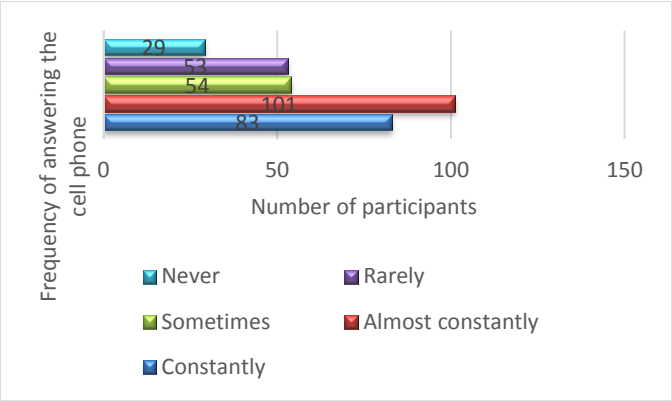

Figure 7. Frequency of answering to an incoming call

The frequency of making a call while driving is more dangerous category than answering the call, because driver has to find the person he wants to contact, and that action is taking some time in which the driver is less concentrated on road performance, and moves his eyes of the road.

From the Figure 8 it is evident that 112 people or 36.7% sometimes establishes a call while driving. It is also evident that the use of mobile devices in order to make calls is fewer in relation to receive calls, as expected, because it is more dangerous action than receiving calls.

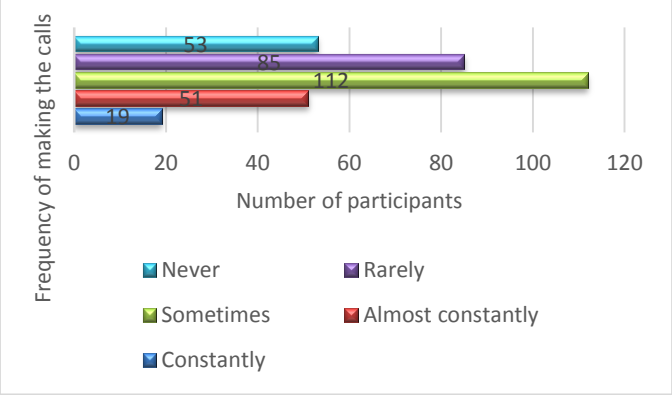

Figure 8. Frequeny of making the calls

The most dangerous action, as previously noted, is the use of mobile phone for writing text messages because the driver is moving his sight of the road, and is using his hand for writing a message. When asked about the use of text messages while driving, 82 drivers or 27% have responded positively. (Figure 9).

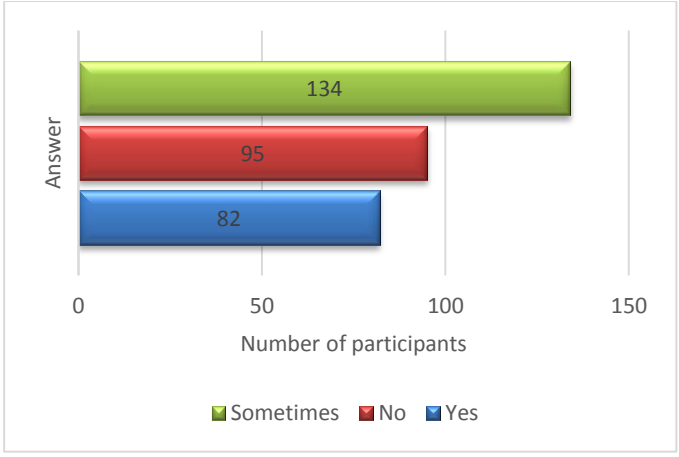

Figure 9. Participants answers on the using of mobile devices for texting while driving

95 of them responded negatively, and 134 respondents said they sometimes use text messages while driving.

V. CONCLUSION

The rapid development of technology and the production of smart phones, have also increased the risk of traffic accidents. The vast majority of drivers use smartphones, having a greater possibility of distraction than the "regular" phones, because they have a lot more options to use. According to tests conducted by NHTSA in the United States, and the results of the survey, it can be noted that the results are about the same, but the United States trend of using mobile phones while driving is on the decline, while there is no data from previous years to compare Croatian area to United States. The fall in the trend of using mobile devices in the United States came after a strong propaganda against the use of mobile devices while driving, which included education of the population. Now fewer states allow the use of mobile devices while driving, but drivers are more aware of the dangers of using mobile phones while driving.

Based on the conducted survey it can be noted that the most critical group of drivers are from 18 to 29 years old, as it was found in NHTSA research. The given results show that females are more responsible than males, and use mobile devices less while driving. Text messaging while driving is also most common among younger drivers, to 29 years, but this group of drivers uses mobile phone while driving the most, in general. The results show that the mobile phone while driving is most often used for receiving calls, and at least used for the additional services (photography, shooting, reading online content).

Taken everything into consideration, all the possibilities for distraction, the most important factor is a man who decides whether to use a mobile device while driving or not. Therefore, it is necessary to invest in the education of drivers, and aware the population of the dangers that can happen if using mobile device while driving.

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