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It is with great pleasure that we present to you the jubilee issue of our and your Journal of Information Technology and Applications (JITA), published by Pan-European University APEIRON Banja Luka. We have now published the 20th issue of the journal, which completes 10 years of publishing.

The JITA journal publishes quality, original papers that contribute to the methodology of IT research as well as good examples of practical applications.

We can proudly point out that JITA started with the selection of quality articles and has continued as such to this day. Members of the review team come from all continents, as well as authors of papers. With two independent “blind” reviews, we manage to select the highest quality articles and then publish them.

Tremendous energy, knowledge and work in these 20 issues, besides the authors, were invested by the editors of the journal:

- Prof. dr. Gordana Radić (gordana.s.radic@apeiron-edu.eu)
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Our mission has been, and remains to promote and establish cooperation and dialogue between academic institutions and research institutes belonging to the field of information technology, which are the following:

- Promoting the best research output in the academic field.
- Support in the professional training of IT staff.
- Introducing computer scientists with advanced modern technological achievements.
- Announcement of novelties in the most advanced information technologies.

### Gratitude

On behalf of the Editorial Board, we would like to thank the authors for their high quality contributions, and also the reviewers for the effort and time invested into preparation of all these 20 issues so far of the Journal of Information Technology and Applications.

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### Conflicts of Interest

The authors declare no conflict of interest.

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# SCALING COMPLEXITY COMPARISON OF AN ACO-BASED ROUTING ALGORITHM USED AS AN IoT NETWORK CORE

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## Contribution to the State of the Art

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**Abstract:** This paper proposes a routing method that is based on an Ant Colony Algorithm (ACO) for minimizing energy consumption in Wireless Sensor Networks (WSNs). The routing method is used as the backbone of the Internet of Things (IoT) platform. It also considers the critical design issues of a WSN, such as the energy constraint of sensor nodes, network load balancing, and sensor density in the field. Special attention is paid to the impact of network scaling on the performance of the ACO-based routing algorithm.

**Keywords:** ant colony algorithm (ACO), energy consumption, internet of things (IoT), network lifetime, optimal path, wireless sensor network (WSN).

## INTRODUCTION

In the last decades, the development of wireless sensor networks (WSNs) has completely changed the way various data are collected from the field and sent to the appropriate destination where these are further processed. The flexibility, low cost, and efficiency of WSNs have contributed to their rapid expansion into many sectors. As a result, WSNs became integral parts of some information technologies, significantly improving their characteristics but also opened space for the development of hybrid new technologies. The application of WSNs in many sectors such as medicine, ecology, meteorology, agriculture, army, energy, etc. has eliminated a whole range of sensor cable networking problems, ranging from the high cost of cabling and network inflexibility to the inaccessibility of sensors in the field.

From another perspective, the Internet of Things (IoT) is a set of connected technologies that enable smart management of various devices over the Internet. IoT has found significant application in the

so-called 'smart home' area, where it is necessary to network smart devices in the household and make the data obtained from them to be available anywhere in the world. Figure 1 shows the functional architecture of the IoT platform. The core of the IoT is a wireless sensor network that consists of the required number of sensors that represent nodes in the wireless network. Each of the sensors captures (senses) a physical quantity, and then forwards the sensed data (information) using the WSN to the place where they are processed. Then, the data are passed on to the end-user where it is a human or a specific application. The sensors are powered autonomously via small built-in batteries whose replacement is not cost-effective or feasible. After a battery depletes, the sensor shuts down, and the data it needs to deliver becomes unavailable. In the case of IoT heterogeneous sensors, each sensor usually performs specific capturing so the other sensors (located in the immediate vicinity) can not take over this function of the switched-off sensor. Therefore,

it is necessary to organize the WSN in a way that will ensure minimum energy consumption and thus maximizing the network lifetime. To send data, the sensor consumes far more energy than it takes to just listen to the terrain and process the data inside the sensor. Energy consumption increases with the square distance of the path along which the communication takes place. Therefore, the choice of the optimal data transmission path is an extremely important factor in reducing the power consumption of nodes, and thus to extend the network lifetime. These are the aspects that have the greatest impact on the stability of the IoT system.

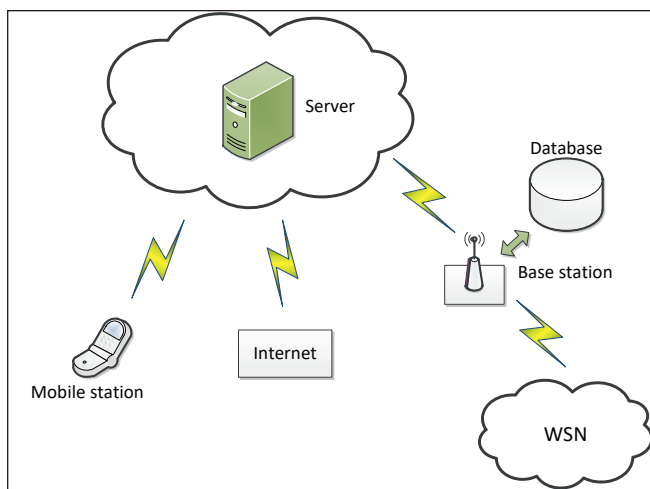


Figure 1. IoT system architecture

Depending on the type of networks and their application, different routing techniques (forwarding data from source to destination) are used [12-14]. The choice of routing technique depends on the goals set and expectations of the network behavior. Routing in wireless sensor networks differs greatly from the routing in traditional networks. AWSN has not a permanent infrastructure, links are not always available, and nodes in the network do lose energy over time. Also, the network can be organized in different ways: direct, hierarchical, and radio-relay. For a specific deployment, optimal routing can be realized based on various criteria such as minimum hop, residual node energy, minimum broadcast price, etc.

An Ant Colony Algorithm (ACO) is a nature-inspired algorithm based on the behavior of ants when finding food sources, in a way that represents a benefit to the whole community. This paper pro-

poses an ACO-based routing algorithm that is used as an IoT network core. In our framework, we consider the specificity of the application of WSN as the backbone of the network in the IoT infrastructure. ACO was originally proposed by Dorigo [4]. This algorithm belongs to the metaheuristic methods for solving combinatorial optimization problems [1]. Such algorithms generate partial searches to obtain a sufficiently good solution to the optimization problem in cases of insufficient or imperfect information or limited computing power. A globally optimal solution is not guaranteed as only a sample of all possible outcomes is taken.

Using the originally developed MATLAB simulation, we compared the complexity of the proposed algorithm for different network configurations. Therefore, we analyzed the possibilities of applying this ACO-based routing algorithm in different situations.

### RELATED WORKS

In previous years, extensive research has been conducted on variants of the application of the ACO algorithms in WSNs. Hereafter, we present those ACO realizations that aim to save energy in the network and thus extend the lifespan of WSN. We outline some important research works which inspired our ACO-based routing algorithm.

Ming-Hua et al. [9] proposed a variant of the ACO algorithm that is based on the fuzzy system FACOA (Fuzzing Ant Colony Optimization Algorithm). FACOA computes the pheromone and residual energy through three different steps: (1) fuzzing; (2) inference; and (3) de-fuzzing. The ants select the next hop according to the result of fuzzy selection.

Luo and Li proposed [8] a modification of the ACO algorithm in part of searching neighbor nodes. They proposed a search angle to limit the neighbor area during the node selection activities. By using the search angle approach, the nodes only broadcast their packets to their neighbor in this search angle area to reduce the energy consumption of the sensor node. This approach can also increase the search speed of ants and reduce the delay in packet transmission.

Sun et al. [15] introduced an improved heuristic function in ACO by considering the distances,

transmission direction, and residual energy of the nodes to find the optimal path from the source node to the destination node. Thus, the network energy consumption is reduced and the network lifetime is prolonged.

Okdem and Karaboga [11] presented an ACO-based algorithm for wireless sensor networks consisting of stationary nodes. It provides an effective multi-path data transmission method to achieve reliable communication in the case of node faults while considering the energy levels of the nodes.

Jiang and Zheng [6] proposed a hybrid routing algorithm that integrates ACO and a minimum hop count scheme. The proposed algorithm can find the optimal routing path with minimal total energy consumption and balanced energy consumption on each node.

Chiang SS et al. [3] proposed a routing protocol that chooses hop counts and battery power levels as metrics to conserve as much energy as possible in both computations and data communications. Besides, when some of the nodes fail or run out of battery, the routing protocol could effectively adapt the change and find an alternative path.

Djukanovic and Popovic [5] presented different methods for updating the amount of pheromones in the paths between sensor nodes in wireless sensor networks. The authors [5] concluded that the scaling of the network is one of the problems that emerge in the application of resource conservation algorithms in WSNs. The scaling of the network leads to an increase in the complexity of the proposed algorithms during the growth of the search space. In order to address this issue, we must perform measurements on small and large networks in the simulation. Then, we can compare the measurement results and determine whether the performance of the algorithm changes significantly or not. Although this is an important aspect, it is often neglected in many works. Simulation experiments performed would contribute to a more complete understanding of the real performance of the proposed algorithms.

### ACO ALGORITHM IN WIRELESS SENSOR NETWORKS

The data routing techniques in WSNs have two goals: (1) to find the optimal path between the

source and destination node; and then (2) to transmit data packets along the selected path. Routing techniques significantly affect the energy efficiency of the network. The energy of the sensor nodes is limited, while the longest possible network lifetime is desirable. Depending on the implementation of the IoT system, the number of sensor nodes (inside the network) can vary greatly, with nodes being distributed over different areas. In such conditions, each node has only information about the local topology of the network and knows nothing about the topology of the remote parts of the network except that it knows the exact location of the final destination of the message. Accordingly, routing is performed in steps, where only locally available information is taken into account.

The ACO algorithm mimics the exchange of pheromones between ants in search of food [2,7]. When applied to WSN, ants represent the data packets that are transmitted to a destination (base station) and a pheromone is the data packets that contain the necessary information to select the optimal path between nodes. According to the principle of positive feedback, through iterations in an unlimited number of cycles, the paths between nodes that have a higher pheromone density are more likely to be selected in each of the iterations.

Ants (i.e., data packets) are denoted by  $k$ . Each ant autonomously finds the optimal path to its destination. Data can be sent continuously, in response to an event, or at specific, predefined intervals, depending on the application. If the data are sent at regular intervals, the transmission is performed in iterations through the required number of cycles. The iteration begins when everyone (or a predetermined percentage of sensor nodes) starts sending messages at the same time and ends when the last ant returns to its original node. When moving from the source node to a common destination, each of the ants keeps its own list of visited  $M_k$  nodes, which ensures that in further routing it will not pass again through the sensor node that it has already visited in the current iteration. This list is carried by each ant and it is deleted at the end of each iteration.

When ant  $k$  is found in any node  $r$ , this node must perform the calculation of the next step, i.e., to determine the sensor node to which it will forward

this message. Only “adjacent nodes” come into consideration, where the term proximity can be defined using different criteria. The next step is determined according to the probability:

$$P_k(r, s) = \begin{cases} \frac{[T(r,s)]^\mu [\delta(s)]^\vartheta}{\sum_{s \in M_k} [T(r,s)]^\mu [\delta(s)]^\vartheta}, & s \notin M_k \\ 0, & \text{else} \end{cases} \quad (1)$$

where  $P_k(r, s)$  is the probability that the ant  $k$  will move from the node  $r$  to node  $s$  in the next step.  $T$  is a routing table in each node, which stores data on the amount of pheromones for each of the possible paths  $(r, s)$  from node  $r$  to the corresponding adjacent node  $s$ . Heuristic information, often called the visibility table, is denoted by  $\delta_{rs}$  and is obtained from expression (2):

$$\delta_{rs} = \frac{E_s}{\sum_{n \in N_i} E_n} \quad (2)$$

where  $E_s$  is the instantaneous residual energy of the node  $s$ , and is the total energy of the set of adjacent nodes. With the help of weight parameters  $\mu$  and  $\nu$ , the relative influence of pheromones in relation to visibility is adjusted, since the probability of path selection is a compromise between the amount of pheromones and the value of heuristic energy.

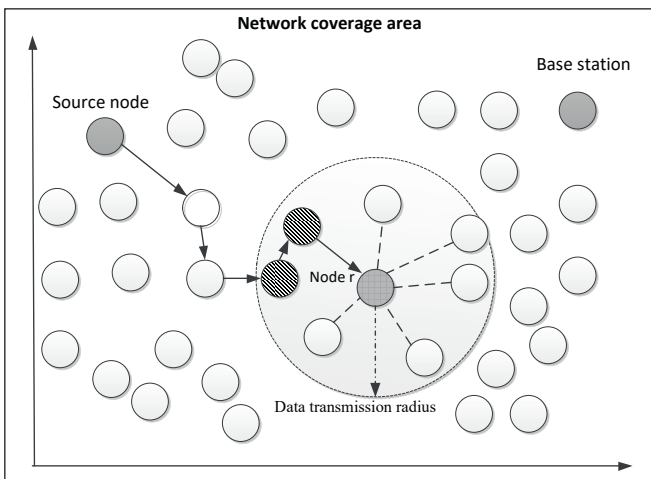


Figure 2. Area of adjacent nodes

Figure 2 illustrates the state of the network when selecting the next step for node  $r$  (calculating expression (1)). The area of adjacent nodes is marked

by a dashed circle. Only these nodes are considered for the selection of the next step. The shaded nodes are members of the  $M_k$  list, so they cannot be selected, regardless of the two located close within the area of adjacent nodes. During one iteration, each ant moves from node to node following expression (1) until it reaches its destination, i.e., the base station. The arrival of the ants to the destination corresponds to the delivery of the data packet to the base station. After the base station receives this data, it sends a return message to the sensor node that sent it. This message is considered as an ant  $k$  confirming, to the destination node, the receipt of the message in the base station, but its basic mission is related to the optimization of further routing in the network. In return, the ant  $k$  returns along the identical path along which it reached its destination following the entry in the list of  $M_k$ . However, on return, the ant secretes a pheromone on the traversed path by analogy with real ants. Of course, the pheromone in this case is not a chemical substance but an update of the members of Table T.

In nature, ants look for food in a group and not individually. In doing so, they use the pheromone as a medium for mutual communication. A pheromone is a chemical that ants release along the entire path they take in search of food. The amount of pheromone released depends on the length of the path. The longer the trajectory, the smaller the amount of pheromone secreted on it and vice versa. Ants are more likely to choose a path with a larger amount of pheromones for their movement. Over time, more and more ants cross the same path, releasing more and more pheromones on it until all the ants choose the same path as the optimal one [10].

In the application of the ACO algorithm to WSN in the first iteration, it is assumed that all elements of the table T are reciprocal values of the distance from node  $r$  to node  $s$ ,  $T_{rs} = Q/d_{rs}$ , ( $Q$  being a constant) so the shortest paths have the highest pheromone density. In all other iterations the table is updated according to expression (3):

$$T_k(r, s) = (1 - \rho)T_k(r, s) + \Delta T_k \quad (3)$$

where  $(1-\rho)$  is the coefficient representing the effect of pheromone evaporation in the previous iteration and is introduced into the formula to avoid



the unnecessary accumulation of pheromones on paths chosen with low probabilities, and  $\Delta T_k$  is the amount of pheromone that ant  $k$  secretes on the path between nodes  $r$  and  $s$ .

After the ant  $k$  (feedback from the base station) returns to the node in which it was created, its mission is completed as well as one cycle for this source node. When all the ants return to their destination, the network is ready for a new iteration.

After a few iterations, each of the nodes will find an adjacent node that is best for further sending a message, and over time, more and more ants will pass through the selected routes, secreting more and more pheromones. Since the choice of the shortest paths is desirable, the amount of secreted pheromone on longer paths will be significantly smaller, so the probability of their choice will be relatively small. The paths selected in this way are not globally optimal and over time the energy consumption of the sensor nodes located on these paths will increase unbalanced compared to the other nodes until these sensors are completely turned off. Therefore, it is necessary to carefully choose the way to update the pheromones in the paths and strive for the best possible compromise between energy consumption and the amount of pheromones.

The amount of pheromone secreted depends on the length of the path traveled by the ant during the direct path. In this way, ants search for possible solutions. The amount of pheromones is calculated according to the equation:

$$\Delta T_k = \frac{Q}{L} \tag{4}$$

where  $Q$  is a constant, and  $L$  is the length of the ant path in particular iteration.

Each time a returning ant arrives at a node  $r$ , the routing table is updated. During the return of ants, the amount of pheromones in the existing paths between the nodes evaporates, so each time the returning ant enters the node, it is necessary to update the condition, subtract the amount of pheromones that have evaporated in the meantime, and add a new amount of pheromones left by the returning ant.

### SIMULATION AND RESULTS

In this paper, we present the results of a simulation written and performed using MATLAB. The authors developed an original simulation that implements the idea of an ACO algorithm in a WSN network in the manner described in the previous Sections. Table 1 shows the network parameters used during the simulation.

**Table 1.** The network parameters used during the simulation

Parameters	Value
Node initial energy	0.2 J
Packet size	2000 bits
Coefficient $\mu$	1
Coefficient $\theta$	1
Pheromone evaporation (1-p)	0.8

In order to investigate the influence of the network scaling (i.e., how an increase of search space and an increase of the number of nodes in the network increase the complexity of the algorithm), we simulated three characteristic cases shown in Table 2.

**Table 2.** Parameter values for the three Cases

Parameters	Case 1	Case 2	Case 3
Number of sensor nodes	20	80	320
Number of ants	5	5	5
Network coverage area	100x100 m <sup>2</sup>	200x200 m <sup>2</sup>	400x400 m <sup>2</sup>
Data transmission radius	50 m	100 m	200 m

These Cases were chosen so that the number of nodes in the network and the network coverage area in each subsequent case increases 4 times. In this way, the density of nodes in the network remains the same, so comparing the complexity makes sense. The radius of adjacent nodes increases 2 times in each subsequent case. The number of ants in each case is the same, i.e., 5. These 5 ants are chosen randomly in each iteration.

After the simulation is finished, we obtained the following graphs (Figure 3, Figure 4, and Figure 5) showing how the total energy of the nodes in the network changes through iterations during the network lifetime.

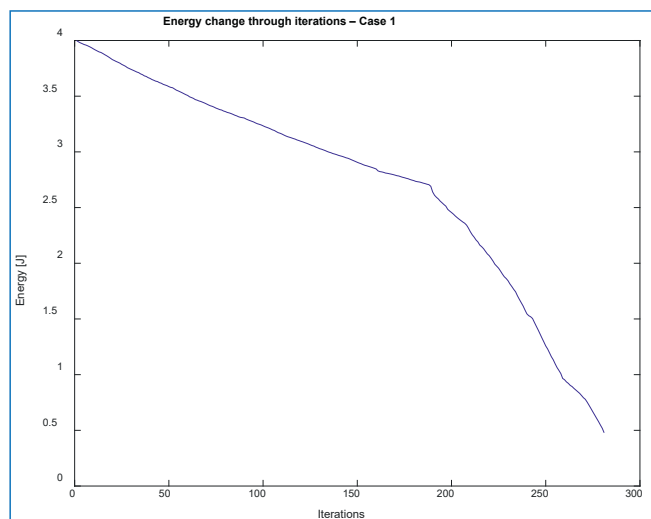


Figure 3. Energy change through iterations – Case 1

Figure 3 shows that initial network energy for Case 1 is 4 Joules (20 nodes with 0.2 Joules), and network lifetime is 280 iterations. Initial energy for Case 2 (Figure 2) is 16 Joules (for 80 nodes), and for Case 3 (Figure 3) it is 68 Joules, since 320 nodes with 0.2 Joules are set in field initially.

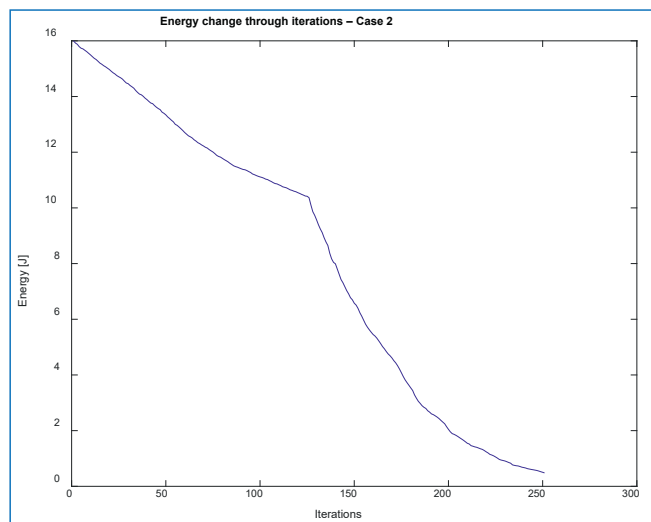


Figure 4. Energy change through iterations – Case 2

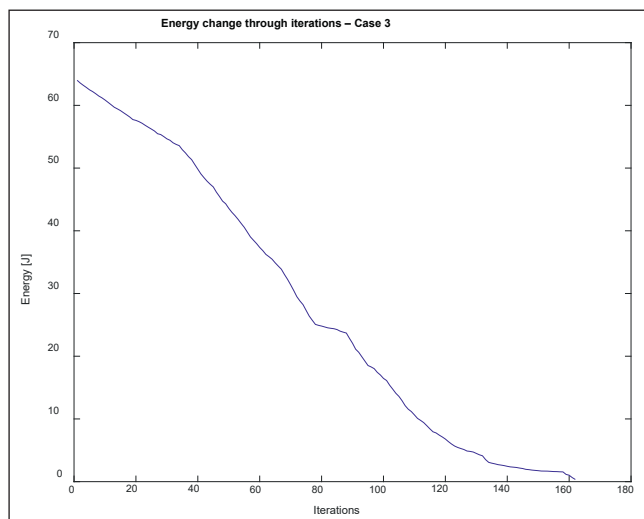


Figure 5. Energy change through iterations – Case 3

Table 3 summarizes the simulation results obtained. Every simulation stops when the total energy in the network reaches down to 0.5 J of the initial energy in nodes, or when the network is left with only one node. Both of these cases are considered as the end of the network lifetime.

Table 3. Results of simulation

Measured value	Case 1	Case 1	Case 3
Number of iterations	280	250	161
Simulation duration	11.159 s	41.618 s	292.916 s
Average iteration duration	0.0399 s	0.1665 s	1.819 s
Average number of steps per ant	2012	5242	23201

The number of iterations indicates the lifetime of the network. In this case, the data are not delivered in real-time but in stages. When all the ants return to the starting nodes, one can move on to the next cycle. Therefore, reports can be sent periodically according to a predefined rule. The obtained simulation results indicate that the lifespan decreases with the complexity of the network. This occurs although the number of ants in the network, as well as the average density of nodes in the network, are always the same. The duration of the simulation for complex networks increases significantly with increasing complexity. In the third case, the duration of the simulation gets a value that is disproportionately large concerning the scaling of the network. Most of the time is spent on calculating the next step in the network. In the third Case, this calculation becomes extremely complex due to the size of the cov-

erage and the number of nodes. During the lifetime of the network, the average number of steps per ant increases in proportion to the scaling, although the number of ants is always the same and the number of iterations is smaller.

## CONCLUSION

This paper evaluates the impact of the network scaling on the performance of an ACO-based routing algorithm. We implemented and simulated this routing algorithm using MATLAB. The ACO algorithm was deployed to the IoT core network in three Cases having different scales. Simulation results are focused on the scaling of the network while keeping the density of the nodes constant. Simulation results show that the simulation time increases significantly for complex networks having increasing complexity while keeping the density and the number of ants the same. The simulation time further increased, it even lasted for tens of minutes or hours. During the lifetime of the network, the average number of total steps per ant increases in proportion to the scaling, and the number of iterations decreases while network complexity increases. Soon, we aim to expand and develop further the developed simulation in MATLAB to investigate and test other cases in WSN network as an IoT network core.

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# USE OF ELECTRONIC MODULES ON DEVICE FOR TRIBOLOGICAL RESEARCH IN THE FIELD OF PLASTIC DEFORMATION OF SLIM METAL SHEETS

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Contribution to the State of the Art

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**Abstract:** Electronic modules are important components of manufacturing and research equipment in the field of plastic deformation of sheet metal fabrication, as well as in other processes. Depending on the type and complexity of the production or research process, different electronic modules are also used. The indispensable electronic modules in production as well as experimental (research) systems are: encoders, signal processing, A/D and D/A converters, required software of all levels, all the way to large packages for numerical process simulation. This scientific paper presents an original computerized device for testing tribological influences in plastic deformation of slim (thin) sheet metal forming (fabrication), whose control base consists of electronic modules. Some results are also shown as dependencies, obtained by testing on this developed device.

**Keywords:** slim (thin) metal sheet, tribology, plastic deformation, electronic modules.

## INTRODUCTION

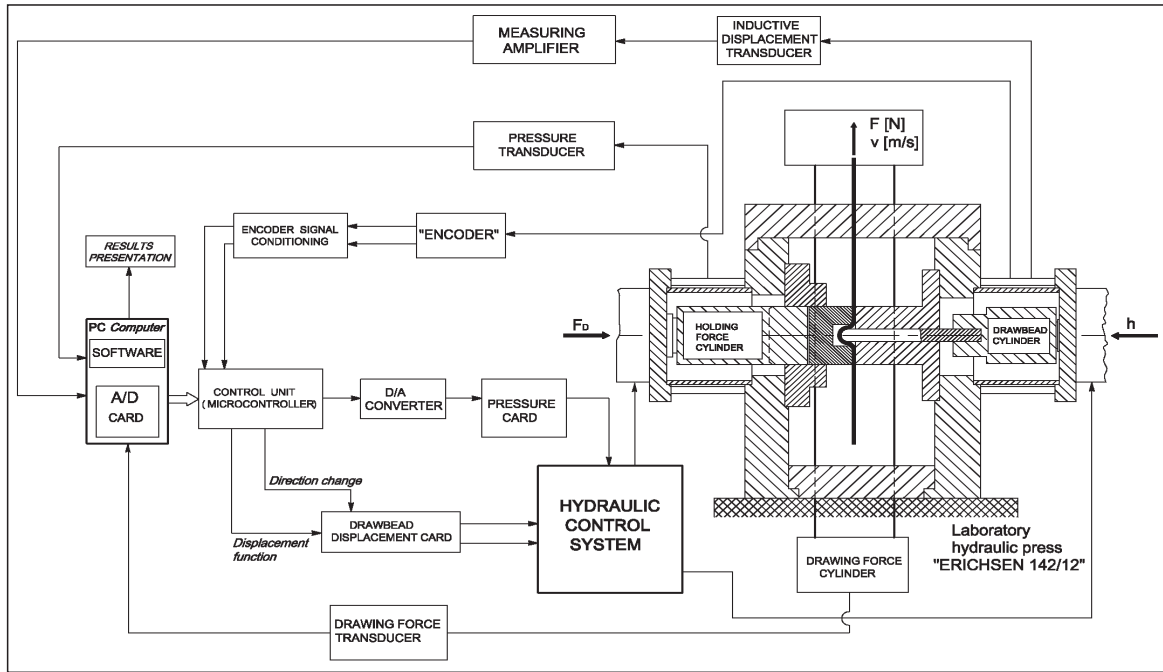
The technology of slim (thin) metal-sheet processing by plastic deformation in large-scale production has great advantages over other processing technologies. This is why slim (thin) metal sheets are a material of strategic importance in the metal world industry. The use of thin sheets as a deformation technology is most prevalent in the automotive industry.

The processing of slim (thin) sheets by plastic deformation is often the subject of study and specialization (production of sheets with better mechanical and tribological properties, development and production of new lubricants, development of numerical simulation techniques, development and used of control systems, etc.) in all well developed industrialized countries /1/. Computerized manufacturing and experimental slim (thin) sheet metal forming systems are a combination of mechanical,

hydraulic, pneumatic and electrical modules. Without the proper electronic modules, neither control nor regulation of production or systems is possible as device for experimental research /2/.

## DEVELOPED DEVICE

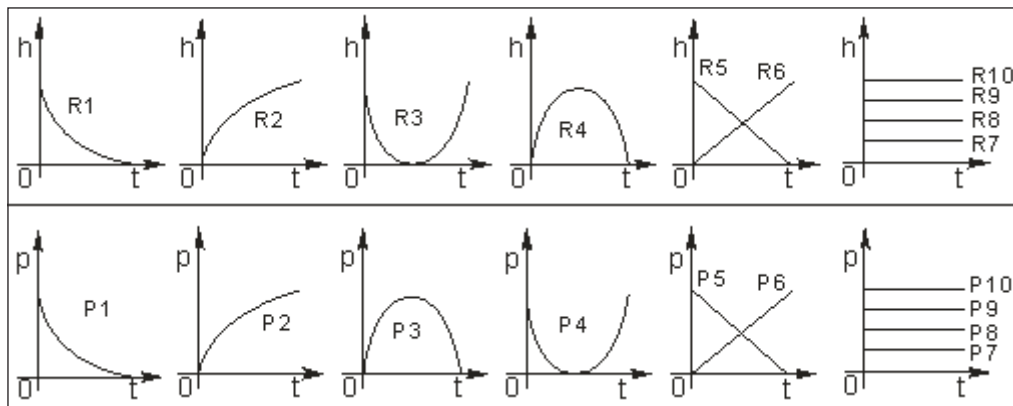
In this scientific work, a computerized device with programing control is implemented, which should provide appropriate tasks for changing the height of drawbead and metal-sheet holding force, as well as measuring the state of strees of traction /3/4/. The concept of the complete system is shown in the block diagram - Figure 1.



**Figure 1.** Scheme of a measuring and control system for testing the effect of the tensile curve and the holding force on the pulling force

The operation of the shown system consists of pulling the metal strips sheet over a tensile drawbead defined height ( $h$ ), as well as a given holding force ( $F_D$ ), determined by the pulling speed ( $v$ ) and the pulling force ( $F$ ). The actuators are double acting hydraulic cylinders. Cylinders, with the support of mechanically constructed elements and electrical modules, should provide the specified dependence of the holding force and the pressure (force) of the grip holder as well as the measurement of the pulling force (Figure 2). A laboratory hydraulic press, which has its own hydraulic module, was used to provide traction force.

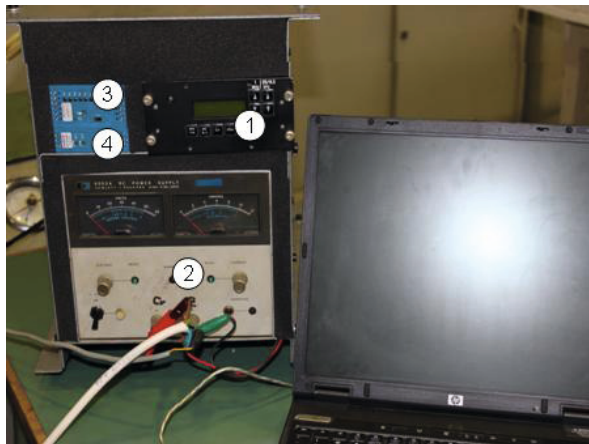
As the realization of the shown dependences of the pressure of the holder and the height of the drawbead, as well as the measurement of the pulling force, is ensured, it is shown in the measuring and control scheme (Figure 1). In the memory of the control unit, a program for all the curve of pressure and drawbead changes was recorded according to the experiment plan. The program is written in C-language. A LIMAS program is installed on the computer, which registers, processes and displays all values of the pulling force, the pressure of the grip holder and the displacement of the tension drawbead. The metal-sheet pull speed is adjusts using



**Figure 2.** Curve changes in drawbead height and grip holder pressure

potentiometer, which is in line with the 60mm pull length for three minutes.

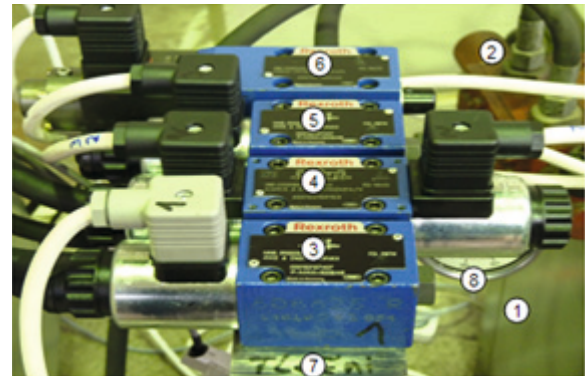
Functional dependencies of the height of tension drawbead (R) are achieved by sending information to the control unit for the selected dependency via PC. (Figure 3).



1-control unit; 2-power source; 3-drawbead control card; 4-pressure control card

Figure 3. Control unit with power supply

According to the program, the control unit sends control signals to the control card (Figure 4), which generates these signals as required by the electro-magnetic proportional valves that power the actuating hydraulic cylinder for the positioning of the drawbead (Figure 5). Then the LIMAS program is activated as well as the pulling metal sheet.



1. hydraulic power unit; 2. three-position manual distributor; 3. solenoid valve for change the direction of the drawbead cylinder; 4. proportional solenoid valve for drawbead cylinder for the holder; 5. solenoid valve for change the direction of the cylinder for the holder; 6. proportional electromagnetic manifold for cylinder holder; 7. junction plate

Figure 5. Hydraulic module

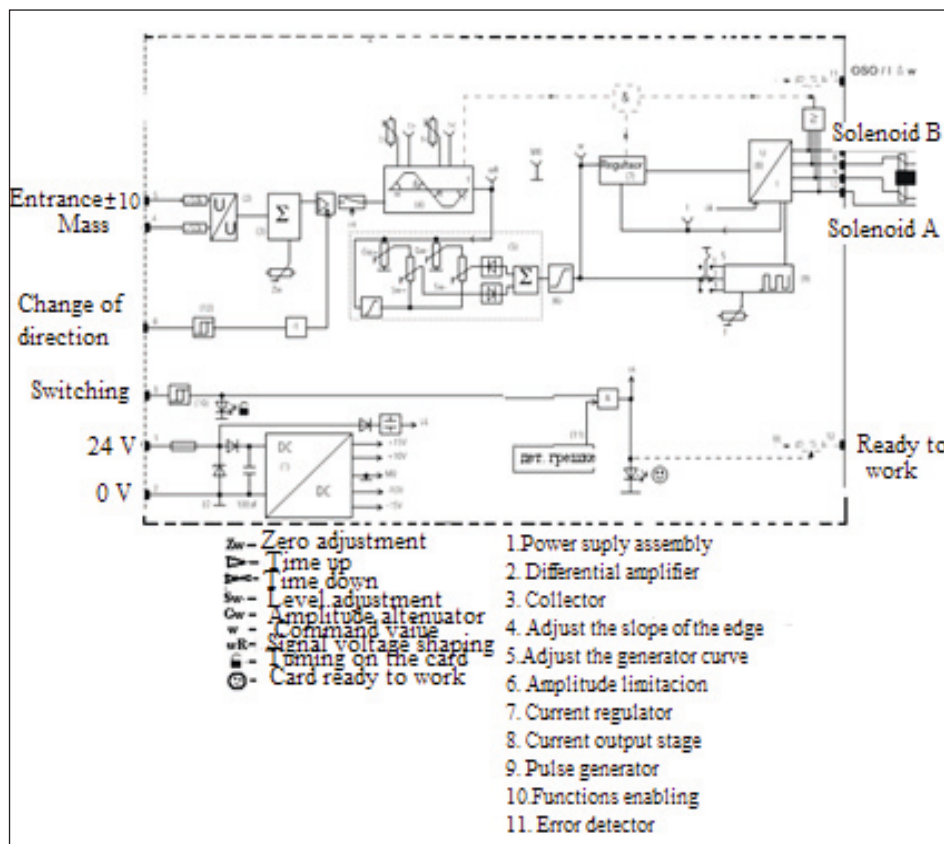
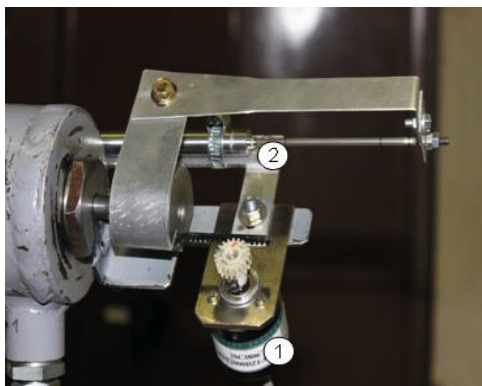


Figure 4. Proportional valve control valve for moving the drawbead

The process is flowing, the path encoders (Figure 6) register the position of the drawbead, measure and send signals to the computer, which through LIMAS processes displays them on the monitor. At the same time, the encoder (Figure 6 Pos. 1) registers the position of the drawbead at all times, and sends this information to the control unit that compares the measured and programmed setpoint (position) at that moment. If there is a difference, the control card sends correction pulses for the next step. Likewise, the inductive displacement encoder (Figure 1) registers the position of the drawbead during the process, and sends information via a measurement bridge (Figure 7) to a computer that draws the dependency achieved through the A/D converter and the LIMAS program.



Figure 7. Measuring bridge

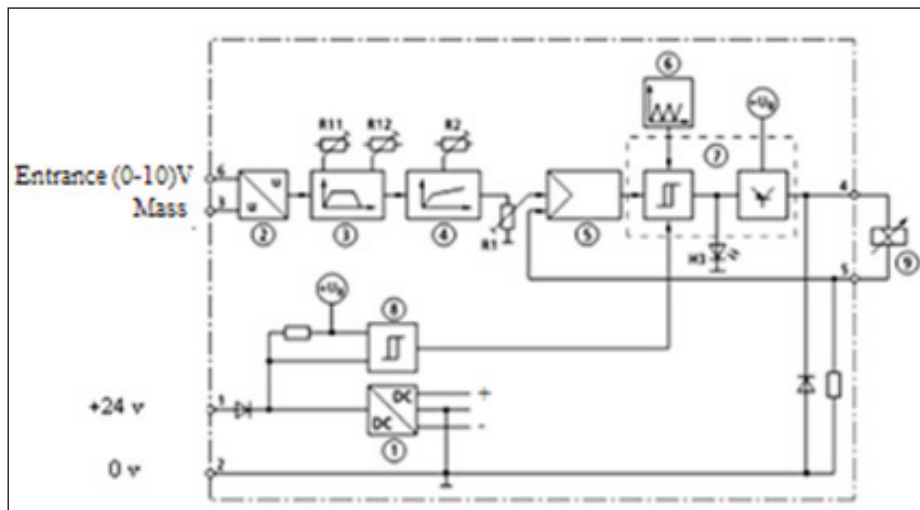


1-optical encoder; 2-inductive path encoder

Figure 6. Encoders for drawbead position measurement

The functional dependencies of the pressure of the holder are provided and realized in the same way as with the drawbead so that the selected dependence is sent via PC to the control unit (Figure 3). According to the program, the control unit sends control signals to a control card (Figure 8), which generates these signals as required by the electromagnetic proportional valves that power the actuating hydraulic cylinder to exert a holding force. Then the LIMAS program is activated as well as the lane drag. During the process, the pressure transmitter measures the pressure and sends values to a computer that graphically displays the A/D (Figure 1) of the converter and the LIMAS program draws the realized dependency.

The basic results of testing the process of pulling the ribbon over the tensile drawbead essentially boil down to examining the nature of the relationship between the tractive force and the



1. Charging; 2. Diffenential amplifier; 3. Edge slope adjustment; 4. Function generator; 5. Curent regulator; 6. Pulse generator; 7. Output stage; 8. Commutation degree; 9. Proportional solenoid

Figure 8. Schematic of the proportional valve control card for changing the pressure of the holder



THE PROCES OF PULLING A SHEET OF METAL OVER A TENSION DRAWBEAD							
TRACTION SPEED	V = 20 mm/min						
THE SHAPE OF A SHEET OF METAL DIMENSION							
MATERIAL	STEEL DC04 (Č0148)				ALUMINUM ALLOY AlMg4,5Mn0,7		
CONTACT CONDITIONS	DRY SURFACES (S)		OIL (M)		DRY SURFACES (S)		OIL (M)
RADIUS OF CURVATURE	r = 2 mm	r = 5 mm	r = 2 mm	r = 5 mm	r = 2 mm	r = 5 mm	r = 2 mm

Figure 9. Conditions for the experiment

combination of various influences including: friction conditions (dry and lubricant used), drawbead geometry (two radius of curvature) and material type (Č0148 and AlMg4,5Mn0,7) which are shown

in Figure 9. with flexible pressure functions and tension drawbead.

The results of these studies are given in the form of diagrams. As this developed device enabled the

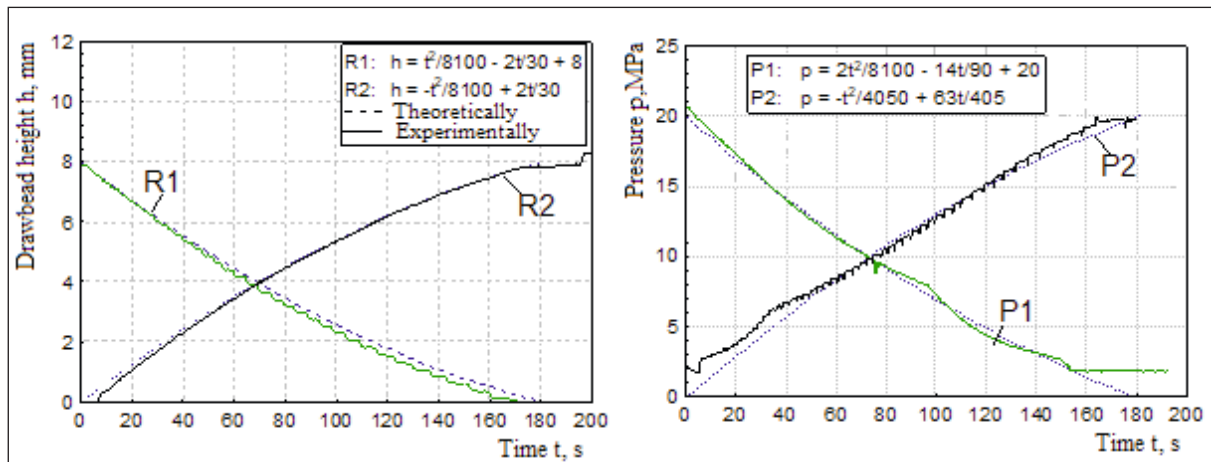


Figure 10. Theoretical and realized dependencies

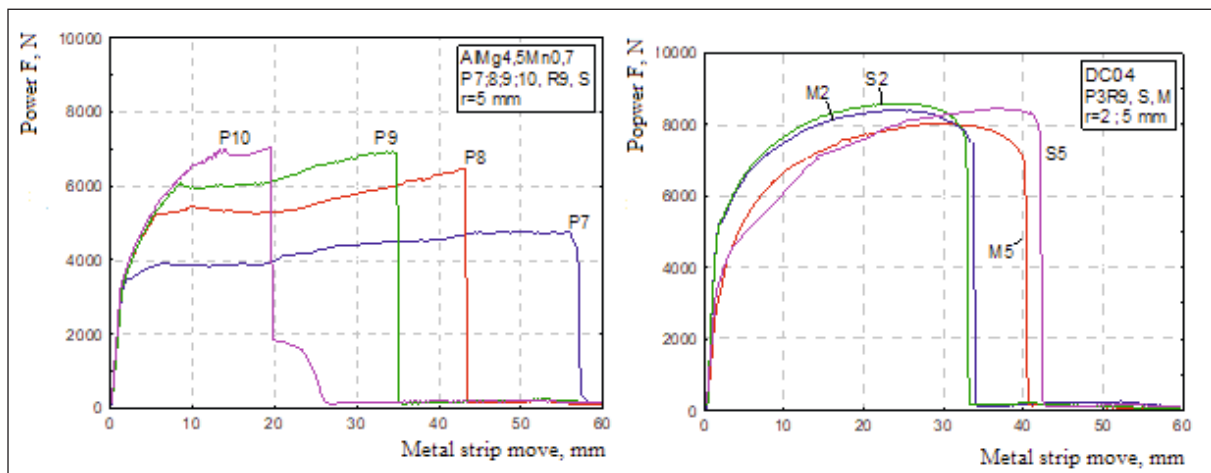


Figure 11. Combinations of realized drag force dependencies

foreseen tests (investigations) which consisted in performing, measuring and recording is best shown in the results. Only a few of these results in this scientific paper will be shown in the theoretical and realized dependencies of pressure and drawbead (Fig. 10), as well as realized dependencies of pulling force under different conditions (Figures 11 and 12).

## CONCLUSION

The obtained results show that the developed device with sufficient accuracy achieves the required dependencies. With a combination of used electrical modules, which are neither complex nor expensive, a fairly simple device was developed on which complex tribological research in the field of thin sheet metal processing can be performed. In addition to the electro module, a proportional technique was used in the structure of the device to support the executive hydraulic cylinders, which is much simpler and less expensive than the servo technique.

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**Dragan Mihić** born on November 29, 1959 in Jagodina. He finished primary and secondary school in Derventa in 1978. He enrolled at the Faculty of Mechanical Engineering in Banjaluka in 1978, where he graduated in 1982. At the Faculty of Mechanical Engineering in Mostar, he enrolled in postgraduate studies in 1988. In 1994, he enrolled at the University of Westminster in London. Since 1990, He have mostly worked in the UK as a consultant in the field of Informatics. As a software analyst and developer, he used a number of current IT technologies.



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# DEVELOPMENT OF AWARENESS AND COMPETENCES OF EMPLOYEES IN THE PROCESSES OF INFORMATION SECURITY MANAGEMENT SYSTEM

- guidelines for practical application -

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A General Survey

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**Abstract:** Based on author's experience, in this we will analyze some issues of awareness and competence development of all employees in the organization in the processes of information security management system (ISMS), in accordance with the requirements of the International Standard SRPS ISO/IEC 27001 Information Technology — Security Techniques — Information Security Management Systems — Requirements.

**Keywords:** data, Security, information, awareness, competence.

## INTRODUCTION

One of the most important characteristics of the modern age is the *collection, storage, preservation, transmission and use of large number of data and information* of all types and significance degrees for the owner of that data, i.e. the individual or legal person to whom the data relate. The significance of these data and information for their owner derives from the type and intensity of the consequences of their unauthorized and/or malicious use by, both entities to which access to this data and information is allowed, and those to which that is not allowed. In this regard, there is a legal, but also, above all, ethical obligation of the subjects (users of data and information) to whom, for any reason, the data of another party (individual or legal person) are available, to handle this data and information in such a way as *to preserve their confidentiality*, i.e. to treat them in such a way that they are not available to (unauthorized) third party without the prior consent of the owner of that data.

Along with the development of information technologies and their increasing availability, a trend of

collecting and storing a huge amount of diverse data and information in almost all areas of life and work of modern man emerged. Besides, very often, to put it mildly, the need to collect certain data is debatable, but also problematic, i.e. the purpose of collecting certain data and information in relation to a particular subject or entity (individual or legal person) is often not clear and understandable. At the same time, there is a very pronounced trend of increasing threat to the confidentiality of collected data and information with the aim of their unauthorized and illegal use and misuse for the purpose of obtaining certain, tangible or intangible, benefits. As a result, *damages* (tangible and intangible) to the owner and user of the data can be large, *often immeasurable*. In particular, the impact of these procedures on the viability of the organization's operations, as well as its reputation, should be borne in mind.

One of the key factors influencing the degree of protection of data and information available to the organization, but also the factors of their endangerment is *a man* - a member of the organization (employee) in any position in it. By his *conscious* (inten-

tional) and/or *unconscious* (unintentional) actions, he creates conditions for achieving a certain degree of security of data and information, i.e. the degree of their endangerment by unwanted actions of certain subjects. The outcomes of the actions of employees at all levels in the organization depend, primarily, on:

- **the degree of their awareness** of the importance of the data and information available to the organization for:
  - the organization itself,
  - other organizations and individuals in the organization's environment;
- **the competence of employees** who, within their responsibilities and authorities, have access to certain data and information and use them in their activities.

Understanding the importance of awareness of all employees in the organization about the need to create and maintain a high level of data and information security, as well as their **competencies** in this area, are key factors for effective and efficient implementation of all activities in the organization aimed at achieving and maintaining adequate protection from unwanted effects of data and information that the organization disposes.

An organization that wants to achieve a high level of data and information security that it disposes and uses in its business must develop and maintain an effective and efficient data and information security management system. *Guidance on the establishment and maintenance of such a system is provided by the International Standard SRPS ISO/IEC 27001:2014 Information Technology - Security Techniques - Information Security Management Systems - Requirements.* [3] The requirements related to the establishment and maintenance of the process of developing and maintaining the awareness and competencies of employees in the organization on issues related to data and information security are defined in paragraphs 7.2 and 7.3 of this standard.

*How is it possible to meet these requirements of the SRPS ISO/IEC 27001 standard and what can be the benefits of that, that is, what can be the consequences of inadequate level of awareness and competencies of employees regarding data and information security?*

One of the possible answers to these questions will be given later in this paper by interpreting the

content of the requirements, ways of their application in practice and possible effects, based on the author's experience gained through practical application of International Standards for management systems [1], [2], [3], [4] and others in production and service organizations of the Republic of Serbia and the Republic of Srpska, as well as teaching work in higher education.

## INTERPRETATION OF STANDARD REQUIREMENTS SRPS ISO/IEC 27001

### Terms and definitions

In this paper, we have used the terms defined in the International Standard *SRPS ISO/IEC 27000:2018 Information Technology - Security Techniques - Information Security Management Systems - Overview and Vocabulary* [2], as well as *SRPS ISO/IEC Guideline 73:2002 Risk Management - Vocabulary - Guidelines for Use in Standards* [4], and *SRPS ISO 9000:2015 Quality Management Systems - Fundamentals and Vocabulary* [1].

### Competences of employees

The requirements of the SRPS ISO/IEC 27001 standard regarding the **competences** of employees in the areas of data and information security are defined in paragraph 7.2, and regarding **awareness** in paragraph 7.3 of the standard.

The term *competence*, according to the definition given in the International Standard SRPS ISO 9000:2015 Quality Management Systems - Basics and Vocabulary [1] implies "ability to apply knowledge and skills to achieve intended results". In other words, this term implies *a set of characteristics of the employee from which his ability and convenience to be assigned responsibilities and authorities to perform certain tasks are derived*. These are:

- knowledge acquired through formal education (education),
- knowledge acquired by acquiring knowledge other forms (courses, trainings...),
- skills necessary to perform certain tasks (e.g. driving a motor vehicle, handling certain types of tools and machines...),
- experience gained by performing the same and/or similar tasks,
- ability to follow, understand and accept

changes and innovations in the field they deal with and in relation to it,

- psychophysical abilities in accordance with the requirements of the workplace,
- other, in accordance with the requirements of a particular job.

From the aspect of data and information security, the necessary competencies of employees can be divided into two groups:

- competencies that must be possessed by employees who are professionally engaged in data and information security, and
- competencies that must be possessed by all other employees in the field of data and information security, depending on their status in the organization and the assigned powers and responsibilities.

What does the standard [3] require of the organization and what is required for the requirements to be met?

1. The organization must *determine the types and degree of necessary competencies* of all persons performing tasks that, within its activities, are managed by the organization, and which affect the security of data and information.

Satisfaction of this requirement is the basis for satisfying all other requirements related to the competence of employees, but also for satisfying some other requirements of the standards related to information security. Why?

The first question that arises when considering this request is: To which employees does this request apply? Here, the organization can make a mistake if this requirement is understood as referring **only** to those employees *who have defined direct responsibilities and authorities for the implementation of certain tasks related to the functioning of the data and information security management system*. The right answer to this question is that **all employees**, *in accordance with their powers and responsibilities, in some way affect or can affect the security of data and information*. In this case, the term **all employees** means *permanent or temporary employees in the organization* (members of the organization) and members of other organizations who, on any basis, perform tasks for which the organization is responsible.

From this follows a conclusion that the organization must define the competencies of all its employ-

ees necessary for proper action regarding data and information security, in accordance with their status in the organization. In practice, this fact is often overlooked, which results in **"holes"** in the information security management system.

By defining and providing appropriate competencies of all employees, the organization creates the necessary preconditions for proper and timely actions of employees in relation to data and information security. This is especially important in situations where there is a certain level of risk in terms of data and information security (*information security risk*) and when it is necessary the employees effectively respond in the event of certain *events or incidents related to information security* that affect or may affect *information security*.

To meet this requirement of the standard [3], it is necessary for the organization to identify *all information security risks*, i.e. the possibility of occurrence of *events or incidents related to information security* that affect or may affect *the security of information*, as well as their possible consequences and the intensity of those consequences. This includes a detailed analysis of all processes and activities in the organization from the aspect of endangering the security of data and information during their implementation. One of the results of that analysis must be the definition of the necessary competencies of employees related to the considered problem.

Deviation from the satisfaction of this requirement of the standard [3] will not lay a solid foundation for the development and operation of data and information security management systems. If the competencies of employees related to data and information security are not defined in accordance with the real *risks of information security* and other influencing factors, adverse events can be expected with high probability as a result of insufficient or inappropriate competencies of employees, with all the consequences can be produced.

The competencies of employees, according to the considered requirement of the standard [3], must be **the result of appropriate education, training or experience**.

The manner of satisfying this requirement arises from the type of activity of the organization and the qualification structure of the employees in the organization. Accordingly, the organization must define:

- jobs that require a certain type and level of education,
- jobs for which adequate training is required and sufficient, and
- jobs for which, in addition to education and/or training, appropriate experience is required.

The manner and scope of meeting this requirement is directly related to the satisfaction of the previous: Depending on the status of the employee in the organization, primarily in terms of their powers and responsibilities arising from their impact on data and information security, the organization should, in determining the necessary competencies **at the same time determine the manner and forms of acquiring these competencies**. The next step is for the organization to ensure *that the competencies of the employees are acquired in an appropriate (determined) way*. This means that organizations will entrust the performance of key professional tasks related to information security **only to persons who possess competencies acquired in a certain type and level of education**. Possession of appropriate skills and relevant experience will also be mandatory elements of the competence of these employees. For other employees, in accordance with their powers and responsibilities, the organization will require competencies acquired in another, appropriate, way that ensures sufficiently reliable and quality execution of certain activities related to data and information security.

The main consequence of not meeting this requirement is the following: Key professional tasks in the field of data and information security **are not performed by competent professionals** and, therefore, the achievement of full effectiveness, efficiency and reliability of data and information security management systems is questioned. Such personnel are a weakness of the organization and, therefore, *the risk of information security is increased, with all the consequences that arise from it*.

2. If the employees do not possess the appropriate competencies or those competencies have not been acquired in an appropriate manner, the organization must *take appropriate measures for the acquisition of competencies*. It can be, e.g. employment of competent persons, organization and implementation of appropriate forms of acquiring the necessary competencies (education, training, trainings,

etc.). In doing so, the organization must *evaluate the effectiveness and efficiency* of these measures and, based on the results of that evaluation, define, plan and take appropriate measures in order to achieve the necessary competencies of employees.

To meet this requirement, it is necessary to establish *a process of continuous monitoring, measurement and improvement of competencies of employees in the field of data and information security*. This stems from the fact that procedures and resources related to data and information management are constantly changing, along with the constant changes in the manner and intensity of endangering the security of data and information. The result of all this must be the appropriate *ability of the organization* to respond effectively to all forms of threats to data security and information at its disposal. This ability of the organization primarily depends on *the competence* of its employees to implement all activities related to data and information security.

The process of monitoring and measuring employee competencies must be based on the development and application of appropriate **indicators** of the degree of satisfaction of requirements related to employee competencies (policy implementation, achievement of goals, etc.), as well as **criteria** for drawing conclusions in this regard. These indicators and criteria must be harmonized with the real situation, needs and capabilities of the organization, in order to enable obtaining the results applicable in the processes of improving the data and information security management system.

3. If it does not meet this requirement of the standard, the organization will not have insight into the actual competencies of its employees, and the existing competencies will be far below the required ones. Therefore, the level of data and information security will be insufficient, with real possibilities of endangerment and harmful consequences that may result from it.

The organization must keep evidence of the competencies of its employees. These are appropriate documents that confirm and prove that a certain person is competent to perform certain tasks on the basis of knowledge and skills acquired in an appropriate manner. This requirement is realised as part of the implementation of *the human resources management process* and no special explanations are required.

It is noticeable that in order to meet the requirements related to the competence of employees, it is necessary to establish and implement the process of providing the necessary competencies of employees for the proper and timely implementation of all activities in the field of data and information security. This process should be part (subprocess) of the process of human resources management of the organization, i.e., the process of ensuring the competencies of employees, with specifics arising from the importance and specificity of the process of data and information security management. This process is shown in Figure 1.

4. The process of providing the necessary competencies of employees in terms of data and information security is based on the need to meet the needs of the organization in this area as a result of the situation and changes in the environment, primarily in terms of types and degrees of data and information. Data on the state and changes in the environment and the needs of the organization are the basic input elements of this process.

Based on its needs and the situation in the environment, the organization determines the necessary competencies of employees in relation to data and information security. The next step is to provide the necessary competencies. By monitoring and measuring the existing competencies, the organization determines the needs and undertakes the necessary activities in order to improve the competencies of its employees. This process is continuous, given that changes in the environment (internal and external) are continuous, which directly affects the changes in the needs of the organization in the field of data and information security that it has and uses them in its business.

It is noticeable that the structure of this process follows the Deming PDCA cycle.

Establishing and implementation of this process requires *the engagement of appropriate resources* - human and material, which depends on the structure of the organization, its activities, types and characteristics of data and information at its disposal, dangers and risks to data and information security and other factors. However, one should keep in mind the *potential benefits* arising from the results of this process, which, except in material terms, can be very important for maintaining *stakeholders confidence* in the organization's capabilities, as well as its image and overall position in the environment.

### Awareness

A very important factor for the effective and efficient functioning of the management system and its subsystems is *the awareness of employees about the facts and phenomena that affect or may affect the achievement of expected results in a particular area, as well as their participation and contribution*. The requirement to develop and maintain the awareness of employees in certain areas is a mandatory prerequisite of all standards for management systems related to that area.

In the field of data and information security, the issue of developing and maintaining employee awareness requires a systematic approach, given the importance of data and information for the functioning of the organization. International Standard *SRPS ISO/IEC 27001*, clause 7.3, defines the requirements that an organization must meet in terms of awareness of its employees on data and information security issues.

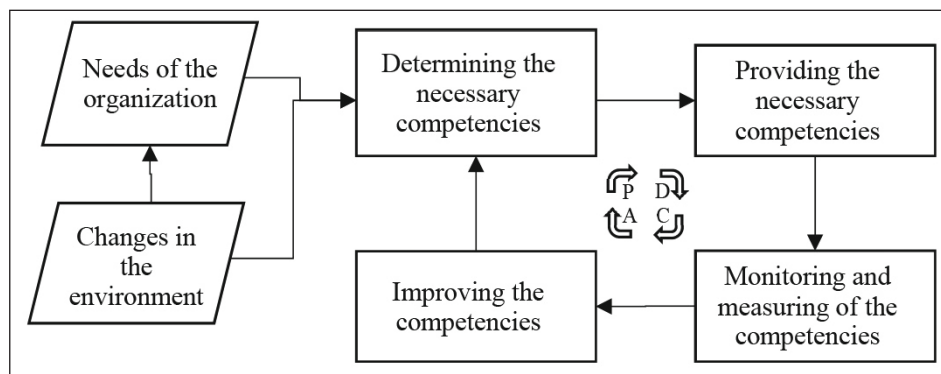


Figure 1: The process of providing the necessary competencies

1. The first requirement of clause 7.3 of the standard is that ***all employees who perform tasks managed by the organization are aware of the quality policy.***

Here, as in the case of requests related to employee competencies, the request applies to *all employees in the organization* as well as *other persons* (individuals or members of other organizations) who, on any basis, perform tasks for which the organization is responsible. The essence of the request is that all employees:

- *are acquainted with the existence, content and essence of data and information security policy,*
- *understand and accept the importance of that policy,*
- *recognize their place and role in the implementation of that policy and actively participate in it.*

To meet this requirement, it is necessary that the data and information security policy is defined clearly, unambiguously and understandably for all employees, regardless of their status in the organization. It is also necessary for the management of the organization at all levels, by a detailed interpretation of this policy, to ensure that all employees take *the same, positive* attitude towards it and accept it as a solid and stable framework for their actions in the organization. In addition, the ongoing obligation of management is to monitor the level of awareness of employees about data and information security policies and take appropriate measures to improve them. In this regard, management should establish a process for monitoring and measuring the degree of understanding, acceptance and implementation of data and information security policies and, based on the results of those monitoring, take appropriate action.

2. Employees must ***be aware of their contribution to the effectiveness and efficiency of the data and information security management system.***

The contribution of the employee in the realization of the goals of the data and information security management system can be different in types and intensity. It can be positive or negative, small or large, ***but it cannot be neutral!*** Employees must be aware of the fact that *each of their activities*, regardless of its characteristics, in some way *affects the*

*level of data and information security.* In doing so, they must *be aware of the type and intensity of their influence* and, on that basis, *aware of the necessary way of their action* in order for their contribution to be within the expected limits. In doing so, they must be aware of the type and intensity of their influence and, on that basis, aware of the necessary way of their action in order for their contribution to be within the expected limits. In other words, employees must be in a proper way *informed of the possible consequences of their activities*, as well as the way in which *they must act so that those consequences are not be negative but, where possible, positive.* This approach enables ***proactive action*** of all employees in accordance with their status in the organization and ***continuous improvement*** of the level of data and information security in the organization and the performance of its information security management system.

### **What should the organization do?**

Starting from the fact that a man is the most important element of any management system, its strongest but often the weakest element, the management of the organization must *recognize the strengths and weaknesses* of its employees regarding information security. Management should, in an appropriate manner, *inform employees* of this and take measures to *use existing forces and increase them*, as well as *eliminate or reduce to an acceptable level* the characteristics of their employees that may adversely affect the level of data and information security. It should be borne in mind that the identified strengths and weaknesses do not arise solely from the characteristics of the employee (education, experience, culture, habits...) but also from factors arising from the characteristics of the organization: type of activity, context of the organization, organizational structure, personnel structure, organizational culture, etc.

The constant task and continuous activity of the organization's management should be to *develop, monitor and evaluate* the level of awareness of employees about *their* (potential and actual) contribution to data and information security. At the same time, it is necessary to ensure that employees *realistically see their (actual and potential) influence and contribution* in this area, because any unrealistic as-



assessment of their own influence and contribution (increase or decrease) can lead to undesirable consequences. One of the most effective ways to achieve the expected results in this area is the *active involvement of all employees* in addressing issues in the field of data and information security, in accordance with their status in the organization through:

- *timely and complete two-way informing (both management by employees, as well as employees by management)* about the occurred and possible (“near miss”) cases of endangering the security of data and information, with emphasis on events that occurred as a result of poor professional practice and due to non-application of defined preventive measures,
- *informing about new sources and methods of endangering* the security of data and information, as well as ways of protection from them,
- *collecting opinions and suggestions from employees* regarding data and information security,
- *application of appropriate forms of motivating and stimulating* employees for an active approach to solving problems related to data and information security,
- *developing and implementing an approach to reporting* on data and information security events aimed at increasing *the efficiency of the system, rather than identifying shortcomings and taking repressive measures.*

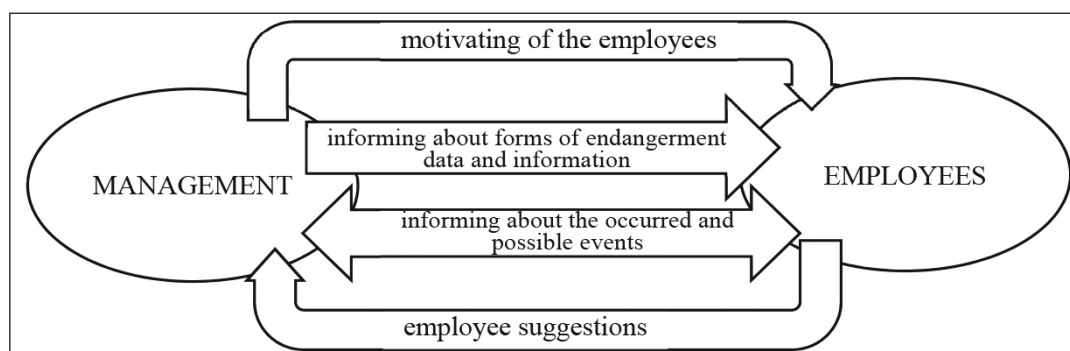
This procedure is shown in Figure 2. It is noticeable that the essence of the process is *the continuous flow of information and efficient communication between the management of the organization and employees* on data security and information issues.

In that way, the employee will become a conscious, active and useful subject of the data and information security management system.

The process of monitoring and measuring employee awareness of their impact on data and information security, as well as in the case of monitoring and measuring their competencies, must be based on the development and application of appropriate *indicators* of compliance with employee awareness requirements (policy implementation, achievement of goals, etc.), as well as *the criteria* for drawing conclusions in this regard. These indicators and criteria must also be harmonized with the real situation, needs and capabilities of the organization, in order to enable obtaining the results applicable in the processes of improving the data and information security management system. Given the connection between the impact of competence and employee awareness on data and information security, it is recommended that, when developing indicators and criteria, these two parameters be considered simultaneously, taking into account their mutual influences.

3. A particularly important requirement, which is directly related to the previous one, is that employees must *be aware of the consequences of non-compliance with the requirements of the data and information security management system.*

Requirements for the effectiveness and efficiency of the data and information security management system are defined by the organization’s management with appropriate documents that are binding for all members of the organization and, in certain cases, for members of other organizations and individuals who perform certain tasks related to the organization. These requirements, primarily, include the requirements of binding documents (laws, bylaws, regulations...). Also, if management decides, the requirements of appropriate, non-binding, external documents (standards, guidelines, rules of



**Figure 2:** Active involvement of employees in the data and information security management process

practice, etc.) may be included. *Any deviation from the observance and application* of these documents and full or partial deviation from the satisfaction of their requirements - *non-compliance* - can have different, often unforeseeable, consequences for the security of data and information that organization disposes. This can also jeopardize the survival of the organization.

The organization must, based on the analysis of the information security risks of the process and the requirements related to the key elements of the process, identify possible non-compliances, their causes and consequences. The organization must then evaluate the consequences of non-compliance and determine their possible impact on the effectiveness and efficiency of the data and information security management system. The results of these analyzes must be, to the extent necessary, available to all employees so that they can, within their powers and responsibilities, apply them in the implementation of their activities.

## CONCLUSION

The security of data and information is one of the key factors for the sustainable success of the organization, given the importance of data and information for the business of the organization, as well as the possibility of incalculable harmful consequences through unauthorized and malicious use. The development and functioning of an effective and efficient data and information security management system is one of the most important preconditions for reducing *the information security risk* and the possibility of *adverse events* related to data and information security.

According to the International Standards of the *SRPS ISO/IEC 27000* series, the issue of the functioning of the data and information security management system is considered from several aspects. The most important aspect is defining the *requirements* that this system should meet in order to be able to provide effective data and information security management in the organization. Requirements for *competence* and *awareness* of employees in the field of data and information security are, although this, at first glance, is not noticeable at first glance, two very important requirements for the effective and efficient functioning of this system.

The importance of employee *competencies* and their *awareness* in terms of achieving, maintaining and improving the effectiveness and efficiency of data and information security management systems stems from their status in the organization, ie. from the functions they perform and the responsibilities and powers that arise from it.

What is most important regarding the implementation of the requirements of the International Standard *SRPS ISO/IEC 27001*, related to the competencies and awareness of employees, is the following:

- The organization must *pay special attention* to ensuring the necessary competencies of employees, as well as developing and maintaining their awareness regarding data and information security issues.
- The organization must *establish processes to monitor and measure* compliance with both requirements.
- For monitoring and measuring the satisfaction of the considered requirements, the organization must *define indicators and criteria* on the basis of which it will monitor and measure the degree of satisfaction of the requirements and, based on the obtained results, make appropriate decisions.
- The consequences of not meeting the requirements considered can be very detrimental to the organization, including its success, image and survival in the market.
- To meet the considered requirements, the organization must plan to engage appropriate resources (human and material), as well as all other investments in achieving and maintaining the effectiveness and efficiency of data and information security management systems, which will result in multiple, tangible and intangible benefits for the organization.

Due to all the above, the top management of each organization must, as its priority tasks, define:

- Publication and consistent application of data and information security policy and, accordingly, policy of development and maintenance of necessary competencies of employees in relation to data and information security issues.
- Development and maintenance of awareness of employees at all levels in the organization about the importance of data and informa-

tion security for the organization's business, as well as their importance for achieving and maintaining the required level of data and information security.

With this approach, the organization gains another solid support that enables its sustainable success and continuous business in a modern, very demanding business environment.

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# MULTI-CRITERIA ANALYSIS OF WWW DOMAIN EFFICIENCY ON SOCIAL BEHAVIOR IN CYBER SPACE

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**Abstract:** The level of technological development, as well as technology, allows a contemporary individual to put any possible files, photos or multimedia contents on his internet-connected computer. As a result, nowadays we practically have an enormous amount of data, available to almost any possible individual worldwide. People make connections over Web service throughout internet as visible communication. World Wide Web represents the most prominent internet field thus partly influencing internet users in contemporary world. Defining efficiency of World Wide Web domain within cyber space means a lot to social behavior.

This paper deals with estimating efficiency of World Wide Web domain on social affairs in cyber space with the use of multi-criteria analysis. Based on the criteria chosen, World Wide Web domain efficiency assessment in cyber space has been conducted, with the emphasis on the influences towards efficiency in the domain of fulfilled influences on social affairs. Identification of such World Wide Web fields facilitates the process of technological progress on one hand or facilitates recognition, prevention and protection of human and material resources on the other hand. World Wide Web domain efficiency in cyber space analysis has been performed through the method of Analytic Hierarchy Process (AHP method), while the efficiency expertise of World Wide Web domain on social behavior in cyber space has been performed within a software tool "Super Decision 2.6.0 - RC1". For the sake of the comparative data analysis, an "on-line" survey has been made on a representative sample of 148 individuals, applying a five-degree Likert Scale of attitudes as well as the analysis of obtained data within a software tool used for statistical data processing "Statistical Package for the Social Sciences".

Upon a completion of performed analysis based on an influence significance, the following World Wide Web domains were singled out: Facebook, Youtube, Wikipedia and Twitter.

**Keywords:** World Wide Web domain, cyber space, multi-criteria analysis, AHP method.

## INTRODUCTION

### Basics of Web service

Modern technology allows every single individual to put lines, photos, multimedia contents interconnected as well as self-designed on his internet-connected computer. Internet represents a resource within a visible communication field allowing communication worldwide. Internet communication is performed through Web service whereby most people do not make either conceptual or categorical difference between the Internet and World Wide Web.

World Wide Web cannot be interpreted as a synonym for the internet. However, it does represent the most prominent part of the internet which can be defined as a techno-social system based on tech-

nological networks where people interact. Techno-social term refers to a system that improves human cognition as well as communication and cooperation. In other words, "Cooperation goes arm in arm with communication while communication requires previous knowledge" (Christian Fuchs, 2010).

Due to these facts, Web domains become a field significant for the shaping of social behavior as well as for the influence within cyber space, therefore they must be analyzed and explored as an occurrence.

### The history of Web service

Historically speaking, Web technology has evolved as of 1980s when Web 1.0 technology was

first presented all through the conceptual consideration of symbiotic networks also known as Web 4.0.

#### *Web 1.0*

The main feature of Web 1.0 technology suggests one-way communication where Web is considered to be a source of information. Web 1.0 represents the first generation of Web which is interpreted by Tim Berners-Lee as “a network system with its basic purpose to observe and read documents and to gain knowledge based upon documents observed and read” (Brian Getting, 2007). The basic purpose of Web 1.0 establishing is to create informative sites where companies can place and convey information towards wide auditorium. Thus formed network system provides a limited interaction between a user and contents placed on Web sites, allowing only browsing and reading information.

#### *Web 2.0*

Web 2.0 architecture is designed to let and support users, while accessing and using applications, create contents thus giving their contribution to a Web content or application. Such interactive relation allows a user to participate in creating Web content continuously collecting data on interaction performed. The data is turned into new forms, visualized and used in innovative ways. Web 2.0 term was officially defined in 2004 by Dale Dougherty, vice president of O'Reilly Media, during O'Reilly Media and MediaLive International conference (Tim Berners-Lee, 1998). Tim O'Reilly defines Web 2.0

on his Web page as: “Web 2.0 represents a revolution in computer industry caused by choosing internet as an interactive platform with a clearly defined goal. The goal is: Creating applications which use network effects in order to enable interactive use of contents for as many possible users.”

Web 2.0 is not just a technology that is used, but a change in a manner of contemplating as well as a focus change towards a social segment Web. Basic differences between Web 1.0 and Web 2.0 have been listed in the Table 1.

#### *Web 3.0*

John Markoff suggests Web 3.0 as a third Web generation (Spivack Nova, 2011). The main idea of Web 3.0 is to define and connect structural data for the sake of more effective detection, automation, integration and re-use of various information (Ossi, Nykänen, 2003). Web 3.0 aims to connect, integrate and analyze data from various data sets in order to achieve a new flow of information that is to convey information out of a domain of comprehending into a domain of knowledge.

#### *Web 4.0*

Web 4.0 is still just an idea, without any clear definition Web 4.0 is also known as a symbiotic network. This network is defined by the interaction between people and machines within symbiosis. The idea for functioning Web 4.0 service is based on communication through powerful interface such as mind-controlled interface (Hemnath, 2010).

**Table 1.** Basic differences between Web 1.0 u Web 2.0

Number.	Comparative criterion	Web 1.0	Web 2.0
1.	Way of using	Reading	Writing
2.	Users	Companies and Corporation	Users themselves
3.	Communication architecture	Client-server	Peer-to-Peer
4.	Most important standard	HTML	XHTML, XML, CSS
5.	Pages	Private	Blogs
6.	Way of providing information	Portals	RSS (different sources)
7.	Data organization	Taxonomy (making category groups)	Tags (users choose themselves a key word for categorization)
8.	Data transfer technology	Wire	Wireless
9.	Ownership	Personal ownership	Sharing
10.	Company – technology leader	Netscape	Google
11.	Way of interacting	Web forms	Web applications
12.	Downloading contents from various sites	Screen scraping	API (Application Programming Interface), RSS, XML
13.	Internet connection	Slow analog modem connection „dial-up“	Broadband online - fast
14.	Costs	Hardware price	Data permeability cost

### AHP method of World Wide Web domain efficiency on social behavior within cyber space

Multi-criteria analysis of AHP method implemented in this paper aims to determine efficiency of World Wide Web domain within cyber space of utmost significance on social behavior. One of the advantages of AHP method is a possibility to convert nonmaterial factors into numerical values as well as systematic value assessment of chosen factors in pairs through a number of sets comparison series (Saaty, T. 2008). Comparisons can be defined by algebraic expression through the assessment matrix that is through paired comparisons (Seungbum L., 2011).

Algebraic expression of assessment matrix that is paired comparisons is defined by the following:

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{12} & a_{22} & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{nm} \end{bmatrix} \quad (1)$$

When completing the assessment, that is paired comparison matrix, it is required to fill in upper (or lower) triangle part of the matrix only. Value 1 lies on the main diagonal (a decision maker is always indifferent while comparing alternative with oneself). The rest of the matrix is completed with reciprocal values (reciprocity rule,  $a_{ij} a_{ji} = \frac{1}{a_{ij} a_{ij}}$ ). Grade consistency is secured that way ( $a_{ij} * a_{ji} = 1$ ). Whereby  $a_{ij} a_{ij}$  stands for relative significance  $i$  out of  $j$ ,

$a_{ij} = \frac{1}{a_{ij} a_{ij}} = \frac{1}{a_{ij}}$  and  $a_{ij} a_{ij} = 1$  when  $i = j$ . Then the value of the vector  $\widehat{W} \widehat{W}$  significance is calculated by the following formula:

$$\widehat{A} * \widehat{W} = \lambda_{max} * \widehat{W} \quad (2)$$

Whereby  $\lambda_{max} \lambda_{max}$  represents the greatest inherent value for  $\widehat{A} \widehat{A}$  (each of the parameter value sets for which differential equation has no zero solution (own function) under circumstances provided).

World Wide Web method analysis of domain efficiency on social behavior

Rapid development of modern technology, computer technologies as well as internet technologies made “the whole world a global village” according

to Marshall McLuhan in his work. Web domains can and do accomplish a great significance on all social structures as well as any social classes in a country worldwide. At the beginning of a massive use of internet, people were limited to sending “e-mail” messages, while today, with the use of social networks they are practically exposed to a 24-hour-a-day influence. Such exposure to World Wide Web contents leads to a change in social behavior which can be aimed and pointed to a desired direction, which is why it is a necessity to analyze influences on social behavior achieved through Web domains as well as to realize social changes due to these uses.

This paper deals with efficiency in terms of accomplished results or the effect of World Wide Web domain on social behavior in cyber space realizing listed influences through five different phases of research:

- **Research phase 1** deals with social behavior for the sake of determining the most important factors which affect social behavior in a society.
- **Research phase 2** deals with a statistical analysis on attendance as well as ranking some Web domains in cyber space. The analysis in Phase 2 aims to analyze criterion of “availability” which is to be compared in Phases 3 and 4 with the results of *online* survey, processed by a software tool used for statistical data processing “Statistical Package for the Social Sciences” as well as with the survey results of prominent and professional experts in the domain field within a software tool „Super Decision 2.6.0 – RC1“.
- **Research phase 3** deals with an “on-line” questionnaire on a representative citizen sample as well as a statistical data process within a software tool “Statistical Package for the Social Sciences”, in order to determine media with a significant influence on efficiency of World Wide Web domain on social behavior in cyber space.
- **Research phase 4** deals with the survey of prominent and professional experts in the domain field. The survey results have been processed by the software tool “Super Decision 2.6.0 – RC1”. The aim of this phase is a comparative analysis of different Web domains as

well as a determined efficiency level of Web domain due to elaborated criteria.

- **Research phase 5** deals with summing up obtained results for the sake of determining the significance of some Web domains on social behavior in cyber space.

**Research phase number one**

Different attitudes find roots in every basic social behavior. Allport believes that “attitude represents neutral and mental competence based on experience thus directly or dynamically influencing individual’s behavior towards objects and situations he comes across” (Allport, G.W., 1935). This definition emphasizes attainment of attitudes, denies inherence and again emphasizes dynamical influence “our actions depend on our attitude”.

Social attitudes cover three different factors: cognitive, emotional and conative.

**Cognitive factor** covers beliefs as well as knowledge on objects towards which an attitude exists. That knowledge can be really narrow but it can also be an entirely developed system of knowledge.

**Emotional factor** implies that attitudes always include emotions towards an object we form our attitude on. It is also possible to appear as a complete line of emotions.

**Conative factor** implies there is always a tendency of doing something. Willful doing towards computer technics “an object we have attitude about, there can be just willingness to act yet can also manifest as a sequel of actions” (Greenwald, A. G., 1995).

All three factors of social attitudes are here considered as a whole within a context of efficiency World Wide Web domain has on social behavior in cyber space. Availability realization as well as Web domain ranking have been made in order to identify quantitative domain properties within which efficient influence on social behavior can be possibly performed.

**Research phase number two- Web domain ranking with the use of developed “on-line” tools**

Availability realization as well as Web domain ranking have been conducted with the help of tools developed on the site “Alexa” ranking. “Alexa” ranking is a worked out ranking system, defined by “Alexa”, a

branch company of Californian Amazon, specialized to offer commercial Web traffic information. Besides “Alexa”, as a source of information for similar researches, sites like SimilarWeb and Ranking can also be used since they deal with similar issues.

Web domain ranking is calculated this way: the average number of daily visitors combined with average pages displayed on a site during three-months’ time. Web domain with the greatest number of mentioned metrics combinations is ranked as number 1.

All data is obtained of the internet users’ subset using one of 25.000 browser extensions for Google Chrome, Firefox, Internet explorer etc. Apart from the above mentioned, “Alexa analytics” also lets the overview of Web domain ranking in certain countries as well as certain browsing categories such as: health-care, science, the military, academic society etc.

**Research phase number three - “on-line” survey by a sample of a population interviewed**

Towards this paper’s purposes, an “on-line” survey has been performed by a sample of a population. „On-line” survey covered 148 people from August to December of 2017, in order to view attitudes according to the similarity of comprehending defined terms. The questionnaire used in a survey has been created according to Likert Scale of attitudes (Vasilijevic D., 2016), handed out to various examinees who needed to express their level of agreeing/disagreeing on a five-degree scale where: “1-I completely disagree”, “2-I disagree”, “3-I have no opinion”, “4-I agree” and “5-I completely agree”. Upon the completion of “on-line” survey, a statistical data processing has been performed within a software tool “Statistical Package for the Social Sciences”.

Table 2 deals with a structure of respondents by their gender. Table 3 deals with a structure of respondents by their qualifications. Table 4 deals with a structure of respondents by their place of residing.

*Table 2. Structure of respondents by their gender*

Gender	Frequency	Percent	Valid percent	Cumulative percent
Male	89	60.1	60.1	60.1
Female	59	39.9	39.9	100.0
Total	148	100.0	100.0	

*Source: The author*

**Table 3.** Structure of respondents by the level of education

	Frequency	Percent	Valid percent	Cumulative percent
High school	28	18.9	18.9	18.9
Vocational school	15	10.1	10.1	29.1
College	30	20.3	20.3	49.3
Master's degree	60	40.5	40.5	89.9
PhD	15	10.1	10.1	100.0
Total	148	100.0	100.0	

Source: The author

**Table 4.** Structure of respondents by their place of residing

	Frequency	Percent	Valid percent	Cumulative percent
Netherlands	15	10.1	10.1	10.1
Croatia	29	19.6	19.6	29.7
Macedonia	15	10.1	10.1	39.9
Slovenia	29	19.6	19.6	59.5
Serbia	45	30.4	30.4	89.9
USA	15	10.1	10.1	100.0
Total	148	100.0	100.0	

Source: The author

Research phase number four –The application of AHP research method of World Wide Web domain efficiency on social behavior in cyber space

The ultimate purpose of AHP multi-criteria analysis is to determine the efficiency of World Wide Web domain on social behavior in cyber space.

This paper explains AHP method as a tool used to process the data obtained through the survey of prominent and professional experts in the domain fields while the interviewing results are processed by a software tool “Super Decision 2.6.0 – RC1”. This phase’s goal reflects in the comparative analysis of different Web domains as well as a determined level

of Web domain efficiency due to worked out criterion.

Diagram 1 depicts a graphic model of AHP method used in this paper.

For the sake of identifying criterion of deciding while making a multi-criteria analysis by AHP method, respondents have been asked to express their attitude according to the following: cost, infrastructure, procedures, knowledge and a dialogue according to obtained results given in Table 5.

In order to simplify the application of the method, “Super Decision 2.6.0 – RC1” software that supports decisions has been used. AHP method has been implied in this paper through five phases:

1. Structuring the problem;
2. Social behavior phenomenon examining;
3. Data collecting;
4. Relative level of difficulty assessment;
5. Problem solving;

**Structuring the problem**

This issue is consisted of decomposition of a certain complex decision matter into a series of hierarchy (Fallahpour, A., 2017), where each level represents a small number of managed attributes (Bimal N., 2010).

**Social behavior phenomenon examining**

The above mentioned phenomenon has been performed through the grading of a larger number of alternatives on a scale what makes an accurate assessment more difficult. Consequently, a paired comparison has been conducted. It has also been noticed that the most convenient scale for a research is the one from 1 to 9 (Likert or Saaty scale).

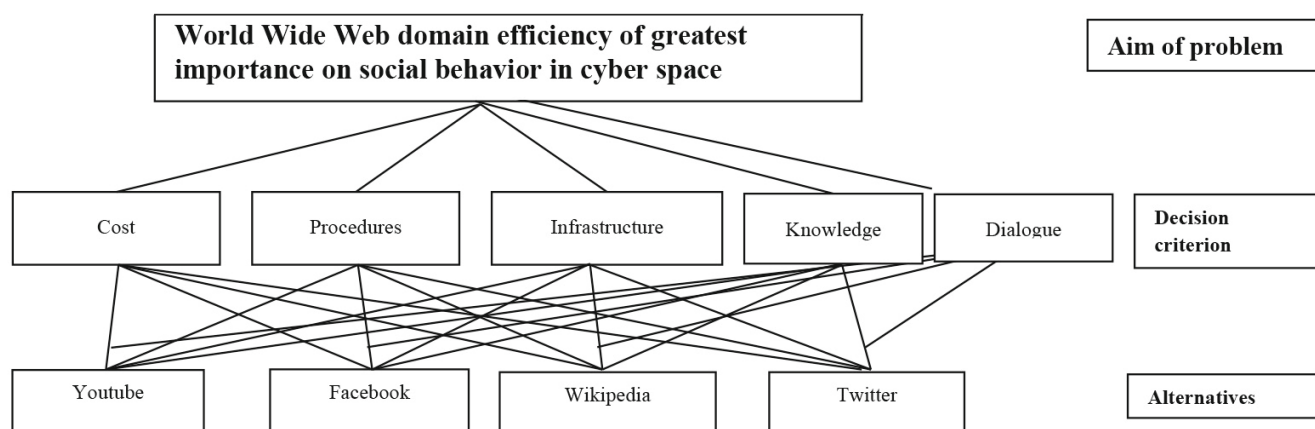


Diagram 1. A graphic model of AHP method



**Table 5.** Results of interviewing on the significance of the criteria

	Cost	Infrastructure	Procedures	Availability	Knowledge	Entertainment	Dialogue
N	Valid	148	148	148	148	148	148
	Missing	0	0	0	0	0	0
Mean	3.9392	3.8851	4.8851	4.0068	4.8851	1.9932	3.3514
Std. error of mean	.01971	.02630	.02630	.04011	.02630	.02795	.06277
Median	4.0000	4.0000	5.0000	4.0000	5.0000	2.0000	3.0000
Mode	4.00	4.00	5.00	4.00	5.00	2.00	3.00
Std. deviation	.23979	.31994	.31994	.48790	.31994	.34000	.76367
Variance	.058	.102	.102	.238	.102	.116	.583
Range	1.00	1.00	1.00	2.00	1.00	2.00	2.00
Minimum	3.00	3.00	4.00	3.00	4.00	1.00	3.00
Maximum	4.00	4.00	5.00	5.00	5.00	3.00	5.00

Source: The authors

The smaller scale cannot properly differentiate alternatives while the larger scale aggravates showing differences.

Comparison of paired alternatives according to a defined criteria is performed in assessment matrices. This paper defines following criteria for the need of research: cost, infrastructure, procedures, availability, knowledge and a dialogue.

Results of interviewing on the significance of the criteria are listed below in Table 5.

According to the fact that criteria “entertainment” values 1.9932, significantly less than values of other criterion, it is not specified as a criteria to be analyzed.

**Table 6:** Saaty scale of nine points [11]

Scale	Explanation/Ranking
9	Absolutely the most significant/desirable
8	Very strong towards absolutely the most significant/desirable
7	Very strong towards very significant/desirable
6	Strong towards very strong
5	Stronger towards more significant/desirable
4	Weaker towards stronger
3	Weaker towards more significant/desirable
2	Equal towards weaker
1	Equally significant/desirable
0,50	Equal towards smaller, weaker
0,33	Weaker, less significant/desirable
0,25	Weaker to smaller stronger
0,20	Strong, less significant/desirable
0,17	Strong towards very strong/smaller
0,14	Very strong, less significant/ desirable
0,13	Very strong towards absolutely smaller
0,11	Absolutely the least significant/desirable

### Data collecting

Data collecting is conducted through “on-line” internet survey where examinees have been asked to fill in Saaty nine-point-Scale of attitudes in order to rank the significance of criterion within comparison pairs.

The third phase of AHP method starts with data collection as well as their assessment. A decision maker assigns relative grades to pairs of attributes regarding one hierarchy level which is for all the levels of entire hierarchy [11].

For the sake of the comparative analysis of results obtained within a software package “Super Decision 2.6.0 - RC1” this paper displays results obtained by an „online“ survey on a sample of 215 people different gender, education and age. The survey aims to realize attitudes towards similarity of comprehending defined issues. The questionnaire has been created according to Likert Scale of attitudes (Vasilijevic D., 2010), thus forwarded to respondents who have been asked to express their level of agreeing or disagreeing for each statement on a five-degree scale such as:

- “I completely disagree”,
- “I disagree”,
- “I have no opinion”,
- “I agree” and
- “I completely agree”.

Data obtained upon the survey have been processed by the software tool “Statistical Package for the Social Sciences“. Obtained data have been compared with processed data within a software package “Super Decision 2.6.0 - RC1” through interview-

ing experts in a domain field. Chapter 3 in this paper displays results of data processed in a software package “Statistical Package for the Social Sciences“.

**Analysis of the relative level of difficulty**

This analysis is made by the completion of an assessment matrix. This matrix completion is performed in the way where “the estimator“, by providing values from 1 to 9, actually compares alternatives. Value 1 stands for the equal preference among compared alternatives while value 9 stands for the extreme alternative preference in comparison with another alternative (Triantaphyllou, E. ,2000).

**Problem solving determination**

This is the final phase of AHP method. It implies finding a composite normalized vector. Upon the determination of the criteria activities order within a model, next level demands determining an alternative significance order within an each criteria analyzed in a model. Finally, the overall analysis of the problem is performed like this: each alternative involvement is multiplied with the level of difficulty criteria analyzed. Upon this all the values sum up for each alternative separately. Obtained result represents the analyzed alternative difficulty level within a model. The level of difficulty is in the same manner determined for all other alternatives in a model.

Significance ranking towards finding a solution to the problem solving with the use of AHP method is applicable in many systems which require the

choice of the best possible solution or alternative. Such systems are for example: healthcare system-while choosing the best possible treatment for instance, or a military system-while selecting armament etc. [15].

AHP method belongs to a group of popular methods since it provides the possibility of identification and analysis of decision maker’s consistency within a process the comparison of elements in hierarchy. Since the alternative comparison is based on personal assessment by a decision maker, its constant monitoring is needed for the sake of achieving a necessary accuracy.

This method provides the monitoring of assessment consistency in any moment while comparing alternative pairs with the use of a consistency index:

$$CI = (\lambda_{max} - n) / (n - 1) \tag{3}$$

consistency relation is calculated:

$$CR = CI / RI \tag{4}$$

where RI stands for random index (matrix consistency index of value *n* randomly generated compared pairs).

The final solution to the problem is determined through an expertise of World Wide Web domain efficiency of greatest significance on social behavior in cyber space. This expertise is performed by the application of AHP method in a software tool “Su-

*Table 7. Web domain global rank on 5<sup>th</sup> January 2018*

Rank	Domain	Purpose	Time spent on a site-daily (min:sec)	Daily browsing time per visitor	Percentage of traffic achieved while using a browser	The total of all sites linking
1	Google.com	Allows a global search of information including Web domains, photos and videos.	7:38	8.69	4.80%	4,114,642
2	Youtube.com	Allows videos to be put on with the possibility to give a mark of a content as well as to give a comment.	8:19	4.81	15.90%	3,106,319
3	Facebook.com	Social service that connects people, keeps friendship connections, loads photos, shares.	10:17	4.03	8.70%	8,251,598
4	Baidu.com	Leading Chinese browser allows a simple and reliable browsing in Chinese language as well as putting multimedia contents.	7:33	5.92	8.30%	194,758
5	Wikipedia.org	Free encyclopedia written by common users participation with the use of wiki software.	4:15	3.29	66.80%	2,200,261

per Decision 2.6.0 – RC1“ through an interviewing five prominent experts in a domain field which is the subject of analysis.

**Results of the World Wide Web domain efficiency on social behavior within a cyber space**

Results obtained upon examining a global rank of Web domain on “Alexa” site are displayed in Table 7.

The research conducted indicates that due to the significance of daily average of unique visitors as well as of average display of site pages Youtube.com and Facebook.com stand out as two leading domains. Observation of Wikipedia.org as well as Twitter, Inc. is also of great importance since they represent domains within which there is a possibility to influence social behavior in cyber space.

**Data analysis obtained by interviewing prominent experts**

The first step in data analysis is the environment structuring as well as the preparation of data input.

Data obtained by interviewing prominent experts in a domain field which is the subject of research are displayed in tables 8,9,10,11 and 12.

*Table 8. Field expertise 1*

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Facebook	0.5257	0.5257	1.0000	1
	Twitter	0.0726	0.0726	0.1381	4
	Wikipedia	0.1828	0.1828	0.3477	3
	Youtube	0.2189	0.2189	0.4163	2

*Table 9. Field expertise 2*

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Facebook	0.6437	0.6437	1.0000	1
	Twitter	0.0545	0.0545	0.0847	4
	Wikipedia	0.1492	0.1492	0.2317	3
	Youtube	0.1526	0.1526	0.2370	2

*Table 10. Field expertise 3*

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Facebook	0.6793	0.6793	1.0000	1
	Twitter	0.0531	0.0531	0.0782	4
	Wikipedia	0.1109	0.1109	0.1632	3
	Youtube	0.1567	0.1567	0.2307	2

*Table 11. Field expertise 4*

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Facebook	0.7288	0.7288	1.0000	1
	Twitter	0.0622	0.0622	0.0854	4
	Wikipedia	0.1212	0.1212	0.1663	2
	Youtube	0.0878	0.0878	0.1205	3

*Table 12. Field expertise 5*

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Facebook	0.7033	0.7033	1.0000	1
	Twitter	0.0635	0.0635	0.0903	4
	Wikipedia	0.1403	0.1403	0.1994	2
	Youtube	0.0930	0.0930	0.1322	3

Summing up results obtained by the application of AHP method points out that the expertise of World Wide Web domain efficiency of utmost significance on social behavior in cyber space ranks World Wide Web domains according to the following:

1. Facebook (100% of interviewed experts agreed);
2. Youtube (60% of interviewed experts agreed);
3. Wikipedia (60% of interviewed experts agreed);
4. Twitter (100% of interviewed experts agreed).

**The analysis of data obtained by “on-line” interviewing**

The results of “on-line” survey according to the similarity of comprehending World Wide Web domain efficiency on social behavior in cyber space are displayed in Table 12.

*Table 12. The results of respondents’ attitudes due to the similarity of comprehending*

	Youtube	Facebook	Wikipedia	Twitter
N	Valid	148	148	148
	Missing	0	0	0
Mean	4.0000	4.6959	2.9122	3.6892
Std. error of mean	.03713	.05309	.05747	.06421
Median	4.0000	5.0000	3.0000	4.0000
Mode	4.00	5.00	3.00	4.00
Std. deviation	.45175	.64585	.69916	.78117
Variance	.204	.417	.489	.610
Range	2.00	2.00	2.00	3.00
Minimum	3.00	3.00	2.00	2.00
Maximum	5.00	5.00	4.00	5.00
Sum	592.00	695.00	431.00	546.00

Source: The authors

The result of the “on-line” survey indicates that respondents are ranked according to the significance of World Wide Web domain efficiency on social behavior in cyber space in the following manner:

1. Facebook;
2. Youtube;
3. Twitter;
4. Wikipedia.

### DISCUSSION ON RESULTS AND CONCLUSION

Upon the comparative analysis of results obtained in AHP method as well as according to prominent experts' data of a domain field, plus due to “on-line” survey results by a representative sample of a respondent, we can conclude that the aiming alternatives regarding “World Wide Web domain efficiency of utmost significance on social behavior in cyber space” the following are leveled by their significance: rank one - “Facebook”, rank two - “Youtube”, rank three - “Wikipedia” and rank four - “Twitter”.

The difference has been identified while ranking alternatives “Youtube” and “Wikipedia”. According to the aim set in this paper, World Wide Web domain efficiency is of utmost significance on social behavior in cyber space, while taking into consideration the definition of cyber space “Cyber space as an environment within which a cognitive world (sensory world) is created through intellectual acting with the help of information and communication systems” (Vasiljevic, D. 2018). Moreover, cyber space division as well as the fact that prominent Serbian experts have been interviewed, what's more the respondents come from various surrounding countries, all of the mentioned before helps to achieve one of the conclusions: “Twitter” is more significant than “Wikipedia” for Micro and Meso cyber space as an alternative for the influence transfer in cyber space. On the other hand, “Wikipedia” is more significant than “Twitter” in Macro cyber space as an alternative for the influence transfer in cyber space.

“Alexa analytics” site also displays results obtained by multi-criteria analysis with the use of AHP method.

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# NONLINEAR PREDICTION MODELS IN DATA ANALYSIS

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**Abstract:** The modern entrepreneurial sensibility of the company's business implies directing the right information to the appropriate parts of the company at the right time. That is why it is necessary to digitalize processes as much as possible and make the organization "intelligent", and its human resources, to the greatest extent, the knowledge workers. The application of neural networks, i.e. nonlinear prediction models, enables systematic analysis of data in the function of evaluating the behavior of the system. Neural networks are a powerful tool, especially for forecasting trends and forecasting based on historical data. The grouping method, i.e., the k-mean value algorithm, is used as a precursor to neural networks.

**Keywords:** neural networks, Back-propagation neural network, grouping methods, k-mean algorithm.

## INTRODUCTION

In the last fifty years, technology has changed the world. Science has advanced more than in the entire history of mankind, while the total human knowledge, compared to the previous period, has increased several times, and the time required to increase knowledge is getting shorter. Information technology and its use are the most frequently mentioned topics in the business world. The reason for the great interest is its accelerated development and opening of great opportunities for business applications. Information and communication technology is changing the ways people work and live, and is changing the organization and way of doing business in modern companies. Those who do not adapt to these changes - either individuals or companies, will bring into question their existence and successful functioning in the newly created business and technological environment. Knowing some models and methods can fill a glass of prejudice, it can keep us in one place without allowing us to look at the problem from another angle. John Maynard Keynes defined it in 1936 with the saying: The difficulty lies not so much in developing new ideas as in escaping from old ones [5]!

Today we are witnessing that, even in the time of the pandemic, we must adapt the company's busi-

ness only to electronic forms of business. Those companies that have been trained for this type of business, work smoothly and fulfill the set goals. That is why it is necessary to know the possibilities provided by modern information technologies, and the context and business environment in which they operate in today's companies. This primarily refers to the ever-present gap between technology and business-oriented people, who so often have completely different visions of what information technology is for a company and how to make full use of its possibilities. According to scientific research, the average company uses less than 10% of the collected data. When we add external data (competition, macroeconomic indicators, etc.), we see that the situation is far from ideal. The amount of data we produce is growing exponentially. The fact is that today we are "suffocating" in the data, and we demand more and more knowledge. Obviously, there is a great need in the business world to analyze this data. Methods for analyzing this data exist, and some of them will be described in this paper. There are a number of so-called main and generally accepted methods, but there are also a number of methods from other areas that cannot be categorized. Some methods are constructed with the help of elements of linear algebra, information theory, mathematics and other

fields. This paper will describe the methods that are expected to contribute to the goals of research work, and these are also the most important representatives from the family of a certain group of methods, such as neural networks and grouping methods. In economic research, we first prepare the data by classifying them into groups and then analyze them using one of the methods listed in the paper.

**GROUPING METHODS**

Grouping can be defined as finding similar entities (with common features) within data. Groups are formed by the process of sharing a set of data, where group affiliation is defined on the basis of similar characteristics (for example, gender, age, district). The grouping algorithm aims to find similarities within the given data set, using the selected attribute set. Depending on the specific method, groups can be defined in the following ways:

- exclusive: each element belongs exclusively to one of the groups;
- overlapping: an element can belong to several groups at the same time;

- probabilistic: the element belongs to each of the groups with a certain probability;
- hierarchically structured: with a rough division of elements at the highest level, which can then be more finely structured at lower levels.

The aim of this analysis is to create a procedure for grouping elements into groups (clusters), so that each group is, as much as possible, homogeneous with respect to the grouping variables. The first step in grouping is to choose a measure of similarity, followed by deciding on the type of grouping technique we will use (hierarchical or non-hierarchical). The third step is to select the type of grouping method for the selected technique (e.g., the centroid method in a hierarchical grouping technique). In the fourth step, we make a decision based on the number of groups. Finally, an interpretation of the results follows. Hierarchical methods do not require a priori knowledge of the number of groups. Grouping can be performed using multiple methods: centroid method, single bond method, full connectivity meth-

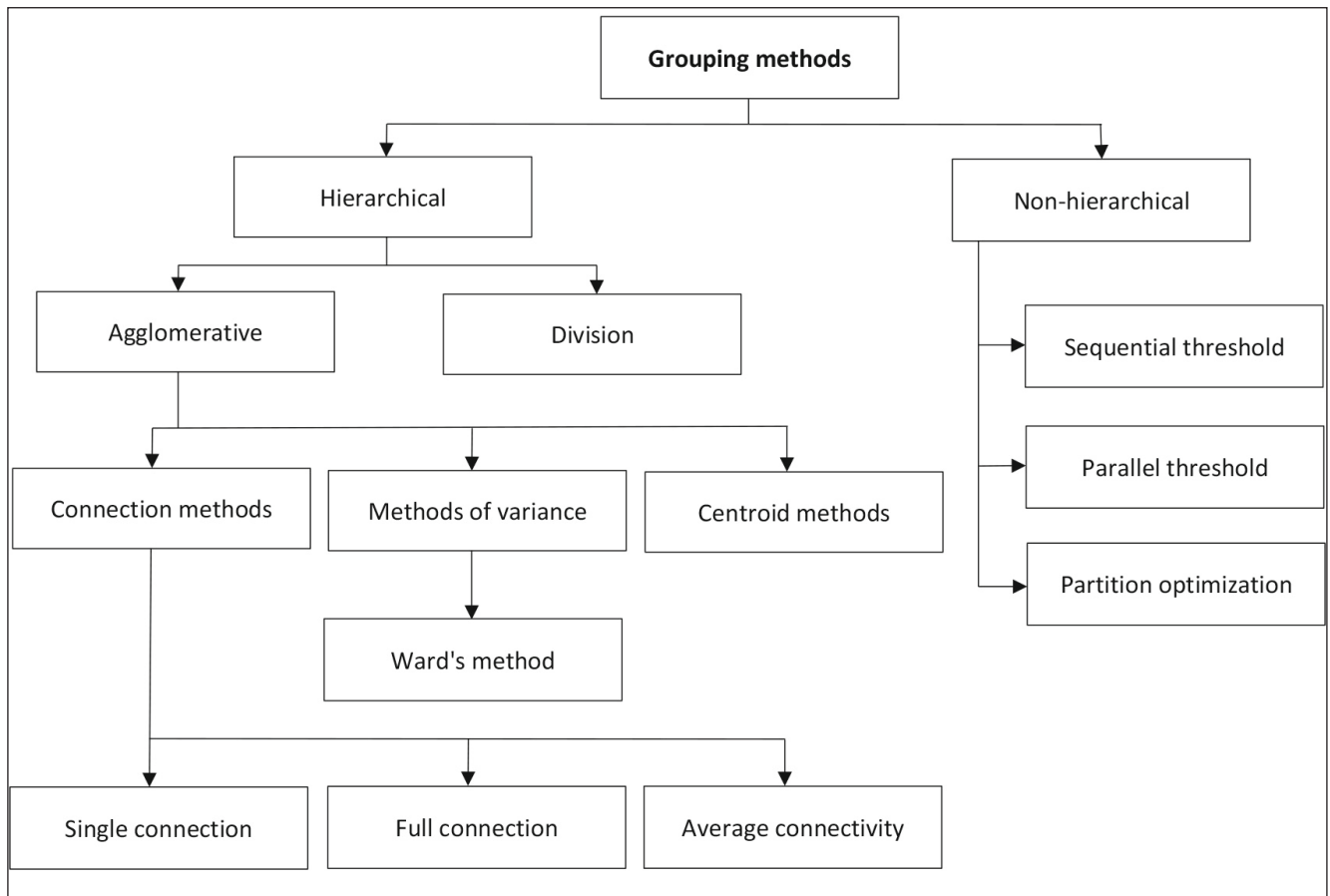


Figure 1: Grouping method types

od, average connectivity method, Ward method. The disadvantage of hierarchical methods is that we cannot redistribute an assigned element to another group. Therefore, the hierarchical method is used for the purpose of detecting groups, and the resulting solution is further refined by non-hierarchical methods.

**K-mean algorithm**

There are a number of grouping algorithms, but the most well-known grouping algorithm is the k-mean algorithm, which, using distance estimation functions and centroids, creates groups in an iterative procedure.

The main characteristic of this method is the division of the basic population into “k” groups, where each of the groups contains “n” similar elements. The similarity of the elements is estimated by the algorithm based on the distance function. Initially, the number of desired groups is set and centroids are defined for each group. In the iterative procedure, each group is joined, using the distance function, by the most similar elements from the population (the calculation is done based on the calculation of the distance of each element of the population from the central values (“centroids”). After each cycle (iterations), the new mean values of each group (centroids) are recalculated, and a new iterative cycle is entered, until the centroid values become stable. This process is illustrated by the following scheme:

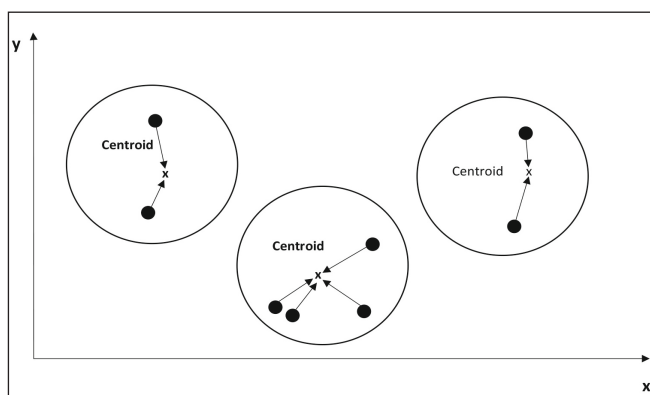


Figure 2: Simplified scheme of the k-means algorithm [8]

The following characteristics need to be considered when preprocessing grouping data:

1. perform standardization on the series of attribute values that participate in the analysis process (thus neutralizing the influence of variables with the highest range of values on the analysis results); for example, we perform grouping using the k-means algorithm values where the analysis process processes two variables: the customer’s age, can range from 12-100, and the amount of purchase for six months in a retail facility, can range from 0-4000; in case the variables are not standardized, the variable purchase amount would have a significant impact on the analysis due to the large interval (range) of values in relation to the customer’s age;
2. transform the values of non-numerical variables into numerical ones (it is necessary to design a numerical system that will best interpret descriptive values taking into account the meaning of grouping algorithms); this means that, for example, when numbering municipalities (cities), their territorial distance will be taken into account - for example, Prijedor will be assigned a numerical value that is closer to Banja Luka than is the case with, for example, Trebinje: in this way the algorithm will recognize the similarity at the territorial level between the districts.

The main disadvantage of the grouping method stems from the fact that the decision maker determines the number of groups before conducting the analysis, while in practice it is necessary to conduct several iterative grouping processes to form the optimal number of groups.

This method is rarely used as a target method, but rather as a method for “field testing” and introducing analysts to the data (for example, initial market segmentation). Due to the impossibility of interpreting the results of the analysis on the formed groups (for example, a group of buyers of healthy food, a group of buyers of luxury products), other methods of data analysis (most often, neural networks) are applied to them.

**NEURAL NETWORKS**

The main idea of neural networks comes from neuropsychology. The knowledge about the behavior



of the nerve cells of the human brain, which function on the principle of activation, i.e. increasing the potential at the synapses, is used. The functioning of the human brain is not fully known, but according to existing knowledge, the following is considered valid [7]:

1. information processing in the human brain is realized through a network of millions of simple process units, which are called neurons (the human brain contains about  $10^{11}$  neurons);
2. each neuron is a simple processor: it receives signals from a large number of other neurons, combines them and sends signals to other neurons;
3. knowledge is distributed in the human brain through a large number of connections between neurons.

Existing biological neural networks are incomparably more complex than the mathematical model used in practice. In the mathematical model of the neural network, the basic unit is designed on the model of a biological neuron. Units combine inputs into a single result (usually a summation function), which is then redirected to a transformation function that calculates the output value and usually takes the values 0 and 1. The combined and transfer function form the activation function of neurons. Figure 1 shows the mentioned relations.

Neural networks differ from each other in terms of the learning approach they use. Learning approaches can be divided into:

1. supervised learning: the neural network is given the right answers together with the input quantities, i.e. real output quantities, where the system itself determines the weighting coefficients (for example, when a student learns a new lesson with the help of a teacher [7]);
2. supervised learning: the system receives only input values, without knowing the output values, and is expected to detect or recognize some patterns of behavior in the data itself (for example, a child's learning that is exposed to repeated situations; a typical example is the Kohonen neural network (self-organizing maps) [7]).

Although there are hundreds of neural network architectures, here we will only talk about the most popular architecture: multilayer perceptron or Back-propagation neural network (BNP network). The BNP network is organized into three or more layers of neurons (input, hidden, and output), where data travels in one direction. Each neuron is actually an independent logical unit that receives information in the form of stimuli at its receptors that have different levels of significance (depending on the weighting factor), and accordingly the stimuli

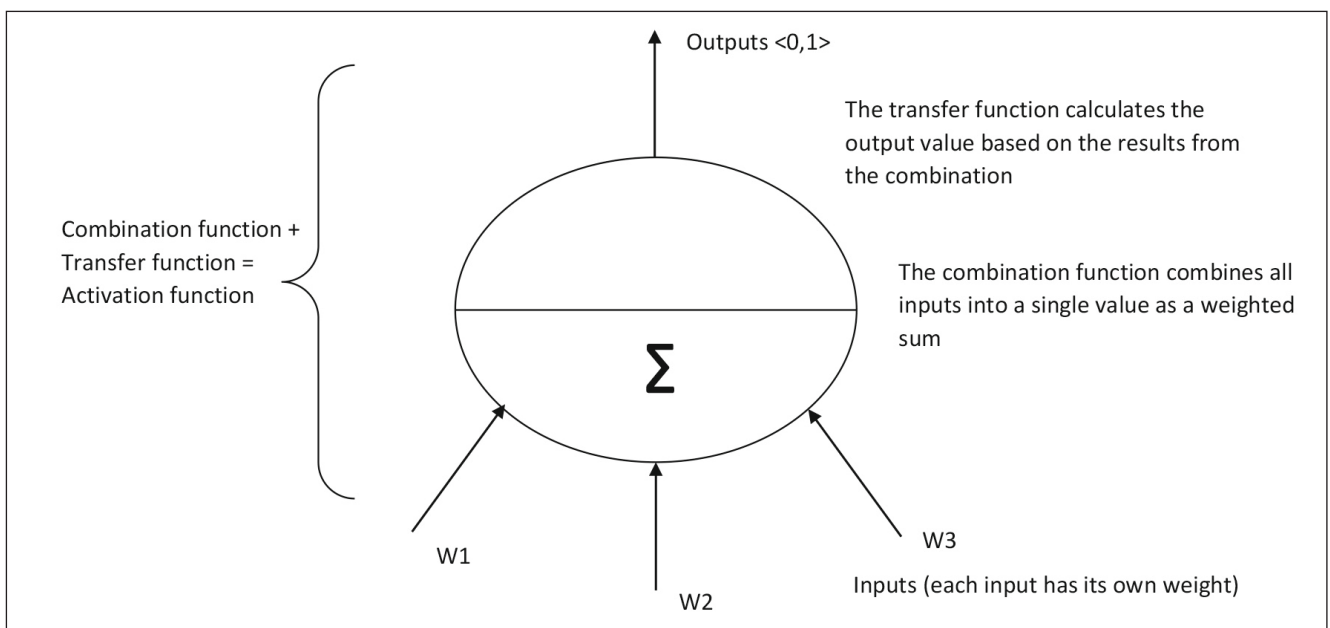


Figure 3: Mathematical model of neurons [6]

become stronger or weaker. If the sum of all stimuli is greater than the sensitivity threshold of the neuron, then the neuron sends (transmits) a pulse at the output that serves as an input pulse to the neurons in the next layer. It is important to note that there is no single neural network model that would apply to all types of problems. The characteristic of each (so far) developed model is that it has certain advantages when applied in a specific area. The advantage of neural networks is that they can be easily applied and implemented in a large number of parallel processors, with each processor simultaneously performing its own calculation.

The application of neural networks, ie nonlinear prediction models, enables modeling of large and complex problems. Neural networks are a powerful tool, especially for forecasting trends and predicting based on historical data. They serve to answer questions such as, for example: If the price of product X decreases by a certain percentage, by how much will the demand for that product increase? The problem with neural network-based models is the determination of appropriate values for weighting coefficients and sensitivity thresholds. Existing algorithms solve this problem by looking for a local minimum in nonlinear space. Another problem with neural networks is that the knowledge in them is not descriptive, that is, it cannot be translated into a human-readable form, so they should be viewed as black boxes. This is also the reason why they are not acceptable in cases where the description of the acquired knowledge is of great importance, and when analysts actually want to get an answer to the question of how the network came to the results.

## CONCLUSION

In their work, modern companies are increasingly oriented towards the integration of their business activities, and in general a more comprehensive and extensive view of their business processes. However,

without the support of modern software applications, as well as information and communication technology, such an approach is not possible.

Special attention should be paid to the construction of the model and the choice of the appropriate technique. In the business field, it is important that the obtained models are understandable to those who use the results of the analysis to make business decisions. The importance of interactive and visualization techniques, which have the possibility of visualization, is especially emphasized here, as very often a picture speaks more than words. The use of complex, highly parameterized models may not always be the best solution. The use of analysis techniques that can have their own visual presentation shortens the total time of the analysis, as well as undertaking activities based on the results obtained in the analysis.

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# ASSESSMENT OF INTELLIGENT SOLUTIONS FOR IMPROVING ELEVATORS' PERFORMANCES

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**Abstract:** In the process of introduction of information as well as data capabilities the first approach is adding technology that can be used in many spheres for buildings and upgrading apparatus and utensils. However the focus of this study is on the deficiency of current elevators associated with efficiency and debugging of the errors or security systems where we concentrate on the introduction of new trends which advise that elevators should be implemented with intelligent devices. Smart elevators easily provide means to predict and prevent errors and bring the chances of an error to a minimum. Needless to say is that a range of negative effects are unavoidable when it comes to the introduction of new technology. This paper will illustrate both the advantages and the disadvantages of using intelligent devices in elevators and through an analysis of the various options using Multi- Criteria Analysis method perform ranking of the presented solutions.

**Keywords:** elevator, intelligent technology, The Multi-Criteria Decision-Making (MCDM).

## INTRODUCTION

Nowadays, the design of buildings calls for architectural, civil and mechanical skills, resulting with no universally accepted definition of 'smartness' or 'intelligence' in this domain [7, 12]. However in our everyday performance a key essential element is the utilization of smart devices due to the fast path of technological expansion. Consequently the world of technology changes into advancement and improvement while peoples' needs become more complex. Meanwhile the needs become somewhat a paradox to itself while the necessity of better quality, higher speed or even effectiveness features require meeting the criteria of eco-solution at the lowest cost [2].

The paper will focus on smart ready technologies which are connected with the elevator operation as well as automatic rescue devices for elevator [4, 7]. The smart technologies referenced in this study improve the operation of the elevators in the following areas [13, 14]:

1. increase energy efficiency and comfort,
2. facilitate the management and maintenance and
3. increase the security.

Related to the idea of using elevators in some buildings and making a building economical and efficient, the main goal of this paper is to give a direction to choose the right elevator smart technology for a given building, through an analysis of the various options using Multi-Criteria Analysis method (MCA) to provide the best solution [9, 10].

## AN OVERVIEW OF SMART TECHNOLOGIES

### A PLC control table

A control system of an elevator has a key purpose to administer movements of an elevator in response to the user's requests. The electric driving system includes the following: elevator car, the traction motor, door motor, brake mechanism, relevant switch circuits. Throughout developing a new system,

programmable logic controllers (PLC) are used to change the numerous relays [5].

Nowadays, control signals of the elevators are mainly realized by PLC. The PLC collects data from the sensors or the input devices, processes them, and after that generates outputs which are based on pre-programmed parameters while being compliant just about any application.

The foundation of PLC control table structure is explained in the next section with an example to simplify and demonstrate the key idea. The logic function of the way an elevator operates consists of the following steps:

1. When a person enters, light/ fan switch ON automatically;
2. The door is closed, motor is switched ON and brakes are free;
3. When the floor is reached the limit switch of the particular floor gets activated and switches OFF the motor;
4. When none of the floor call switches are pressed up to 40 seconds time duration, then elevator's cabin fan and light will automatically be switched OFF which will save electricity;
5. When a STOP button is pressed the cabin fan will still function and the lights will be ON as well;
6. What permits the elevator to function as well as before an error occurred in case of power crash is that the PLC remembers the progression of the last status.

**Rescue Device for Elevator**

Among other things, one of the main goals of elevators is to guarantee security even during failure of main power supply. Every time there is a power defect in the elevators where there is a supply of power shortage or damage there is a device for rescue in the system especially designed for this kind of emergencies. Consequently, this device is designed for the case having people in the elevator, having their safety a priority. In the system presented in [10], about 12 batteries of 12V each in series-parallel relation are used as a source for the Uninterruptible Power Supply (UPS) system. In the next section we have depicted through a diagram how this system is functioning (Figure 1, Figure 2). Overall, there are seven stages in the process, beginning with "I"

and the "P" signals (the "I" stands for an electrical current signal and the "P" stands for a pneumatic or pressure signal). Moreover, in order to start "I"/"P" needs a signal that is required to be distributed. After the signal is distributed it is utilized in splitting the procedure of opening and closing the door. A sensor assists in this process. During normal running through the main power supply the aim is to turn the motor in mode of OFF. Opposite, failure of main power supply should switch off other sensors and active ground floor sensor.

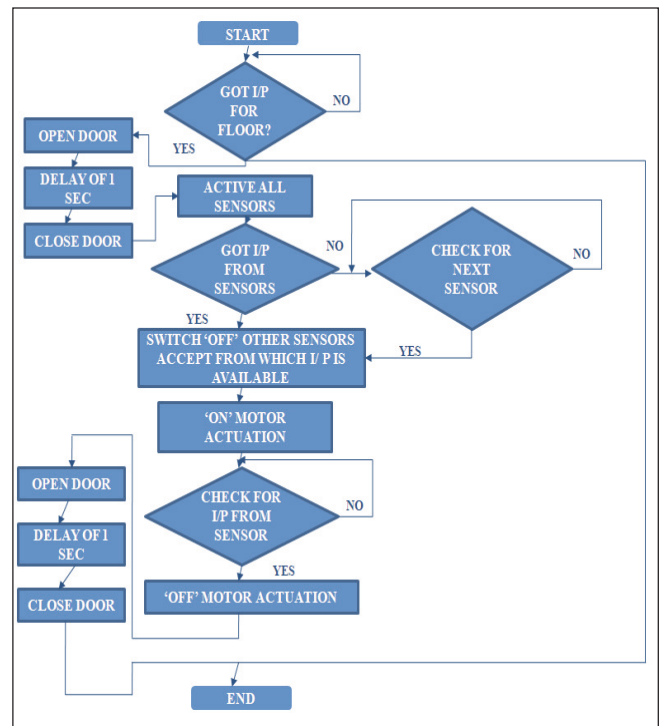


Figure 1. Flow chart of elevator during normal running through main power supply

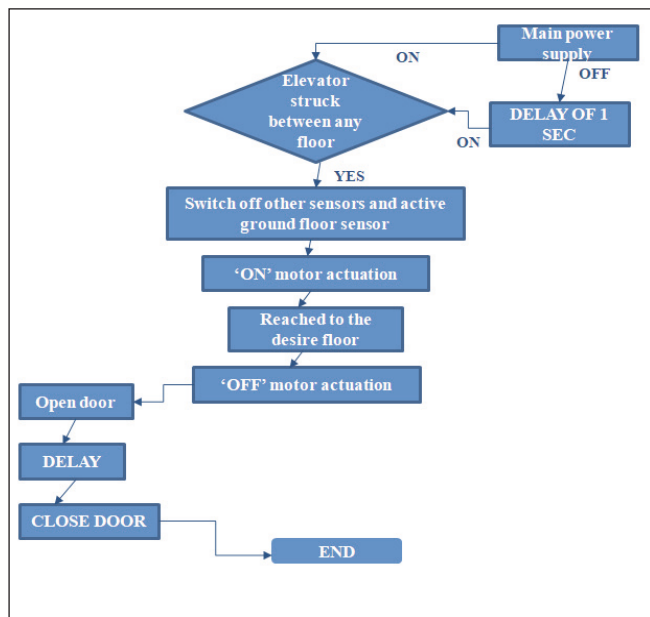


Figure 2. Flow chart of elevator during failure of main power supply

Some of the disadvantages of using battery as a source in this device are listed in [10]:

1. To avoid reducing the life of a battery, to use fully charged provision has to be made after the battery has fully charged and at the same time it is necessary to take in consideration that after the battery is completely full it still needs to be held in charging mode. If the battery takes longer time to be charged means that the system cannot function till the battery is fully charged;
2. The investment is expensive.

Accordingly, electrolytic capacitors have been taken as an example in this paper that can be applied as a foundation in case where there is battery replacement needed in various systems where a restricted period power supply is needed.

The advantages of electrolytic capacitors opposed to the battery are:

1. Electrolytic capacitors don't need any supply after they are fully charged because they stop current when they are charged;
2. A lesser amount of time versus the actual time for charging the battery;
3. Investment of electrolytic capacitors is much less than the cost of battery for the same ratings. However the repair cost of the capacitors

is not as high as the costs for repair of the battery.

### Research on the elevator door control system based on the image processing technology

As passengers, we tend to ignore the role of security until something goes wrong, but we tend to notice the elevator's speed and the driving time. For instance, most passengers are frustrated by spending up most of the time waiting for the elevator. So, in a case where the elevator has to come down from floor A to another floor and if the average weight of the persons waiting for the elevator in the another floor be more than the relation B-w, then there is no point to put down the elevator to that floor because the elevator will give an overload notice at the time the person that is down on the floor enters the elevator (Figure 3). The problem is that not everyone will be serviced and a few people will not be able to enter the elevator while waiting for another one to arrive and pick them up.

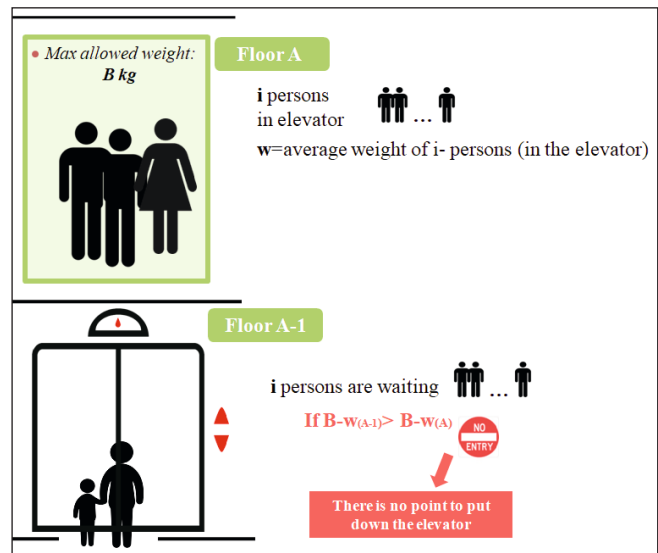


Figure 3. Elevator control system based on the maximum allowed weight

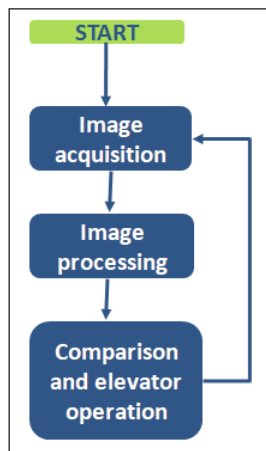


Figure 4. Flowchart of the flow of operation in the proposed technique

On Figure 4 a technique is shown that is proposing a stream of different operations while each part is explained in details in [9].

1. Call button: The call button follows a First In First Out (FIFO) queue, meaning the person who pressed the call button first will be served first. However there are cases where elevators cannot be used, like for example earthquakes; fires etc, but there may be a few instances of high priority calls. In these cases a separate emergency high priority button can be used to select floors. These high priority elevators can be managed by the same hardware but a separate row can be used that is marked with the highest priority [14].
2. Image Acquisition: A video camera feed continuously notes the activities that occur in the elevator hallway. It is positioned in a way where it observes the call button as well as a part of the elevator hallway. Consequently, the positioning of the camera is determined due to the need to monitor the area where people are expected to stand and wait for the elevator. Snapshots can be taken in the moment when a call button is pressed.
3. Image Processing: There will be a video camera running covering the hallway of the elevator. When the call button is pushed the camera will capture an image of the corridor as well as the people waiting for the elevator. In order to keep track of the number of people in front of the elevator it is necessary to use edge detection method while image is processing.

4. Comparison: The final output archived from the image processing module is a value that concurs with the number of white pixels that are given in the image [13].

### Ranking the smart implementation using MCDM methods

The Multi-Criteria Decision-Making (MCDM) methods are a significant prospective instrument in order to analyze difficult situations since their innate nature to review different choices like for example scenarios, strategies or policies, while utilizing a range of criteria in order to select the best-suitable alternative or alternatives [1]. Consequently in order to get to the final performance we need to further more analyze these alternatives. In this research paper, the method Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used. The fundamental conception of TOPSIS method is that the selected alternative should have the shortest geometric distance from the ideal solution and the farthest geometric distance from the negative-ideal solution. In this paper we will apply TOPSIS to find the best alternative for smart investment in elevators by using an example.

### The TOPSIS method

The TOPSIS method procedure consists of series of steps [11]. Table 1 contains the performance of the evaluated alternatives, which is the starting information for the TOPSIS calculation.

Table 1. TOPSIS information

Alternatives	Criteria			
	C <sub>1</sub>	C <sub>2</sub>	...	C <sub>j</sub>
A <sub>1</sub>	X <sub>11</sub>	X <sub>12</sub>	...	X <sub>1j</sub>
A <sub>2</sub>	X <sub>21</sub>	X <sub>22</sub>	...	X <sub>2j</sub>
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
A <sub>i</sub>	X <sub>i1</sub>	X <sub>i2</sub>	...	X <sub>ij</sub>
W	W <sub>1</sub>	W <sub>2</sub>	...	w <sub>j</sub>

Where [1]:

A1, A2, ... , Aj represent possible alternatives among which a decision maker has to choose,

C1, C2, ... , Cj are criteria with which alternative performance are measured,

xij is rating of alternative Ai with respect to the criteria Cj,

wj is the weight of the criteria Cj,

i=1, ... , m is the number of alternatives,

j=1, ... , n is the number of criteria.

When some of the criteria are shown as the qualitative values, they need to be changed into quantitative values. We conducted a survey among maintained service companies. Interviewed people gave the score for three alternatives: Elevator door control system based on the image processing, PLC control table and Rescue Device for Elevator in comparison with four evaluation criteria (C1 C2, C3, C4), using the numerical scale by (Table 2) [8]. The results of the survey are converted into qualitative values shown in (Table 3).

**Table 2.** Transformation of linguistic scales into quantitative values

Linguistic scale	Quantitative value	
	Benefit- max	Cost- min
Very high	9	1
High	7	3
Average	5	5
Low	3	7

**Table 3.** Raw data

Alternatives	Security	Costs investment	Maintenance cost	Easy to deploy
	max	min	min	max
A1: Elevator door control system based on the image processing	5	1	1	3
A2: PLC control table	9	5	5	5
A3: Rescue Device for Elevator	7	5	3	9
<b>weightage</b>	<b>0.25</b>	<b>0.35</b>	<b>0.25</b>	<b>0.15</b>

Next, normalized decision matrix (step 1), is obtained by applying formula (1).

$$\bar{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^n X_{ij}^2}} \tag{1}$$

In step two, calculation of weighted normalized matrix vij of each criterion is made using the following formula (2):

$$v_{ij} = \bar{X}_{ij} \times W_j \tag{2}$$

Step three performs calculation of the ideal best (3) and ideal worst (4) value [12]:

$$V^+ = (v_1^+, v_2^+, \dots, v_n^+) = [(i, \max v_{ij} | j \in I), (i, \min v_{ij} | j \in J)] \tag{3}$$

$$V^- = (v_1^-, v_2^-, \dots, v_n^-) = [(i, \min v_{ij} | j \in I), (i, \max v_{ij} | j \in J)] \tag{4}$$

I- associated with benefit criteria;

J- associated with the cost criteria,

i=1, ... , m;

j= 1, ... , n

In step four, the Euclidean distance from the ideal best (Si+), formula (5), and ideal worst (Si-), formula (6), values are calculated.

$$S_i^+ = [\sum_{j=1}^m (v_{ij} - v_j^+)^2]^{0.5} \tag{5}$$

$$S_i^- = [\sum_{j=1}^m (v_{ij} - v_j^-)^2]^{0.5} \tag{6}$$

The last step in the implementation of the TOPSIS method is the calculation of Performance Score, Formula (7).

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{7}$$

In the end we perform ranking of the Pi values.

### Performing TOPSIS calculation in R

For the purpose of performing TOPSIS calculations, we have used R, which is a state of the art tool widely used for statistical computing and data analysis by a large community [6]. A set of statistical



```

#values of rating matrix Xij
dataTable<- matrix(c(5,1,1,3,9,5,5,5,7,5,3,9),
nrow=3,
ncol=4,
byrow=TRUE)

row.names(dataTable) <- c("System based on image processing", "PLC control
table", "Rescue device for elevator")

colnames(dataTable) <- c("Security", "Costs Investment",
                        "Maintenance cost", "Easy to deploy")

#weight for criteria Cj
weights<- c(0.25,0.35,0.25,0.15)

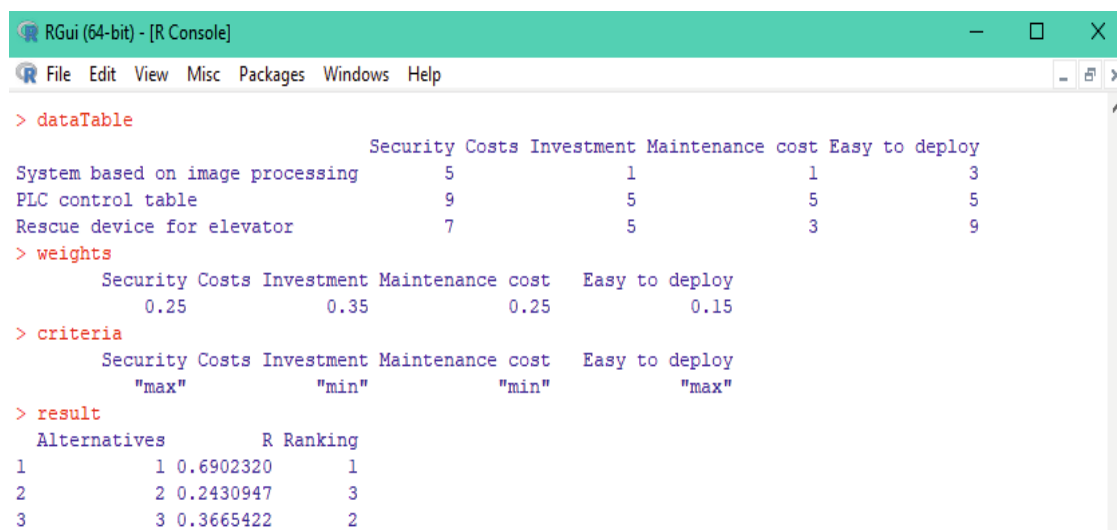
#criteria min/max for criteria Cj
criteria<- c("max", "min", "min", "max")

names(weights) <- colnames(dataTable)
names(criteria) <- colnames(dataTable)

#calculate Pi ranking
result<- TOPSISVector(dataTable, weights, criteria)

```

**Figure 5.** R script for Pi values calculation



```

> dataTable
                Security Costs Investment Maintenance cost Easy to deploy
System based on image processing      5          1          1          3
PLC control table                    9          5          5          5
Rescue device for elevator            7          5          3          9

> weights
                Security Costs Investment Maintenance cost Easy to deploy
                0.25          0.35          0.25          0.15

> criteria
                Security Costs Investment Maintenance cost Easy to deploy
                "max"          "min"          "min"          "max"

> result
  Alternatives      R Ranking
1             1 0.6902320     1
2             2 0.2430947     3
3             3 0.3665422     2

```

**Figure 6.** Executing R script in R console

techniques are implemented in the base R environment, but a much larger collection of functions are available through packages accessible through the Comprehensive R Archive Network (CRAN) sites.

The above described calculation of performance score is done via a function from the MCDM package for R. The R script presented in Figure 5 is used to obtain the results:

The script is then executed in the R Console. Figure 6 shows the values of dataTable, weights, and criteria, which contain the values for xij, wj and cj respectively, along with the score table for the three alternatives.

**Table 4.** Rank of the Pi value

Pi	Rank
0.6902320	1
0.2430947	3
0.3665422	2

From Table 4, we can conclude that the ideal option, in this general example, is alternative no.1.

This example illustrates the way to make a decision based on MCDM on what is the best option for an investment in the case of the analysis performed in this paper. The process can be further refined and augmented by using more criteria, in order improve the selection of the best option.

### CONCLUSION

The development of the proposed systems: elevator control system and security devices can easily reduce shortcoming of today’s systems. However we have to take in consideration the opportunity for development in the engineering field.

An overview of all ideas and solutions above ensures high reliability which is one of the most important goals. After applying TOPSIS calculation, we can conclude that the best option is to use elevator door control system based on the image processing. In order to show the exact percentage of the effectiveness of the proposed method, quantitative values that are obtained from the conducted survey are not enough. We need more structured tests for executing the model. Needless to say the needs of the client are above all importance.

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# PERSONALIZATION OF TEACHING IN E-LEARNING SYSTEMS

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**Critical Review**

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UDC: 37.018.43:004.738.5

**Abstract:** Personalized teaching offers students the opportunity to study independently, with a focus towards fostering and developing their research traits, to intensively develop students' abilities and competencies. Traditional teaching is a common mode of education through which tutors use the same teaching method, regardless of the differences and complex personalities of students in a single class or group. Such an approach to teaching has the effect of slowing down the progression of talented students on one hand while making it harder for less successful students to follow classes on the other. The consequences of this approach to teaching are a rapid loss of learning motivation and perception of classes and learning as unpleasant obligations.

Contemporary e-learning systems offer personalized learning, by tailoring it to the needs and unique traits of each student. Usage of neural networks in data processing for personalized learning will ensure the formation of adequate classes, full understanding, and adoption of the material prescribed by the curriculum, compliance with the general curriculum, and constant insight into the students' progress.

**Keywords:** personalized learning, e-learning, neural network.

## INTRODUCTION

Different types of intelligence described by the Theory of Multiple Intelligences are the basic factors to be considered in correlation with the personalization and individualization of teaching methods in general [3, 4, 6, 7].

Each person is an individual, characterized by specific traits and abilities that are different by their nature. Students differ in their ability to perceive, organize, conceptualize, recollect memories, and use information (holistic/analytical type, dependent/independent type, socially sensitive/insensitive type, etc.). Also, personality factors influence the development of the traits of an individual (extrovert/introvert type, social skills, inhibitions, and more) [8].

Numerous studies have been devoted to teaching/learning styles such as visual, auditory, kinesthetic, as well as the strategies of teaching/learning such as cognitive, meta-cognitive, or social-affective [2].

In their research, Felder and Henriques concluded that students can learn in many different

ways, by looking and listening, thinking, and acting, through logical reasoning or intuitively, memorizing, or visualizing. The teaching methods can also differ. Some tutors teach orally, others demonstrate or discuss. Some formally focus on rules, others on examples, some emphasize memorization, and so on. How much an individual student will learn in class depends in part on their innate ability and preparedness, but also on the compatibility of his or her approach to learning, and the tutor's approach to teaching [9].

The goal of personalizing teaching is to help students become aware of their learning strategies, analyze them, and identify which ones benefit them the most in different situations, as well as to develop new or to refine existing strategies. Developing awareness of such strategies would help students in becoming more effective learners and learn continually through their lives [13].

Usage of neural networks in data processing for personalized learning will provide the conditions for the adequate formation of classes, by respecting all the diversity of students, full understanding

and adoption of the material prescribed by the curriculum, consistency with the general curriculum and the constant insight into the progress of student achievement. This paper will use artificial neural networks as a method of processing and displaying data.

**METHOD**

Predicting student success is important for defining one’s career, counseling, and guidance towards major choices. The development of predictive models is needed to become more aware of factors that could negatively affect student success (for instance, poor previous school experience, poor grades in an individual subject, etc.). Artificial neural networks that were previously researched to manage academic data, which was used to predict students’ success. Emphasizing students’ basic characteristics is one of the most important items in predictive modeling, as well as analyzing the studies addressing different classification methods.

Artificial neural networks are systems of interconnected neurons, which relay messages between themselves. The connections between these neurons have numerical weights that may be subject to change depending on experience, which makes the neural networks adaptive and capable of learning [15].

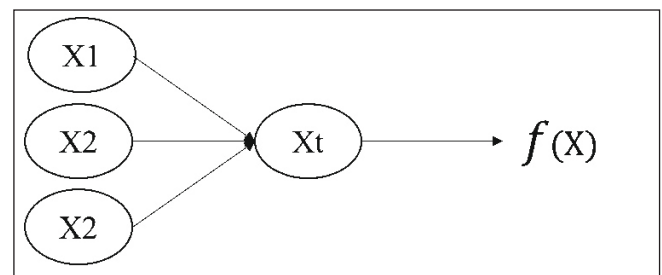
The structure of artificial neural networks consists of an input layer, output layer, and at least one hidden layer [17]. The data that is presented to the output layer are the desired values of the output variables. Before learning itself, it is necessary to define the model (input and output variables) and collect data from the school/student service and e-learning system on which the network will be applied.

Data should be divided into three samples: for training, cross-validation, and testing. There are no rules for the creation of this division, but it is recommended that most of the data points should be used for training of the network, while a smaller segment of data should be aimed at the testing and validation process.

A classification of data is defined to enhance the student’s success. Such classification is determined by the minimum and maximum values related to student achievement during schooling. Its accuracy

is increased during teaching by introducing variables such as records on student status, the average grade of students by current and past school years, number of subjects, the average grade of students by subjects.

In the network of artificial neurons that we are presenting, a simple model of what a neuron does is used. The neuron is modeled as a logical unit [10].  $X_t$  (Figure 1) symbolizes the body of the neuron, while the input branches represent dendrites. Also, there is one output branch that represents the axon. In professional literature, such a unit is called a “perceptron”.



*Figure 1: Model of a neuron*

A neural network with forwarding propagation was used in this paper. In such a network, information flows one way; from the input units, data passes through hidden units, all the way to the output units. There are no cycles in the network, in contrast with recurrent neural networks [5].

The activation function used in the neural network is a sigmoid function:

$$h_{\theta} = \frac{1}{1+e^{-\theta^T x}} \tag{1}$$

where “x” represents the input, “ $\theta$ ” weighting factors, and “T” a transposition function. The activation function is also referred to in the literature as a hypothesis or a model, which is a generic term referring to a solution to a problem of a certain data exploration algorithm. The general form of a sigmoid function is:

$$g_z = \frac{1}{1+e^{-z}} \tag{2}$$

and its graph is shown in Figure 2. In addition to the sigmoid function, the unit step function, part by part linear, Gaussian function ie. normal distribution, as well as many others [1, 12, 16, 18].

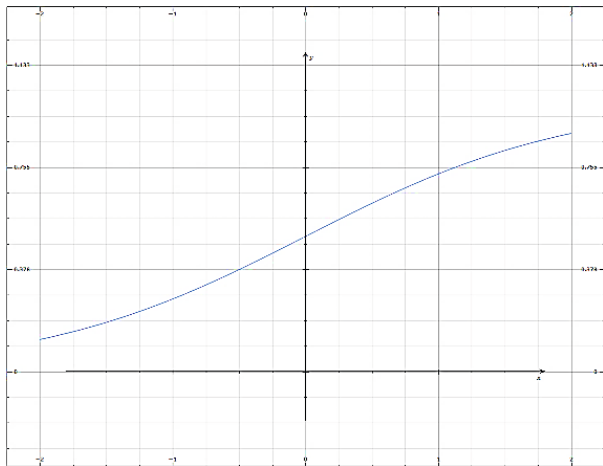


Figure 2: Graph of a sigmoid function

To develop the neural network model, a database with variables was created containing: records of student status, the average grade of students during current and past school years, number of subjects, the average grade of students per academic subjects.

The database with said variables includes processed results for 101 students of elementary school “Vojvoda Radomir Putnik”, Dedinje, Belgrade, Republic of Serbia.

Input attributes were:

1. student status records
2. grading,
3. tests,
4. average grade of students per current year,
5. success in past school years and
6. mathematics assignments.

The output or target variable was:

7. result - the level of achievement - satisfactory

After arranging the data and transcribing it into CSV (comma-separated values) format, the data was compiled with the Neuro designer software application. Figure 3 shows the input variables and the output or target variable.

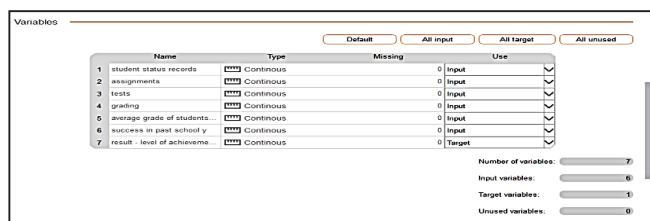


Figure 3: Input variables and output or target variables

Furthermore, the data for training and testing were determined in such a way that 60.8% of the total data points were determined for training and 19.6% of the data points were determined for testing. Figure 4 shows the historical error data for the applied Quasi-Newton optimization method by epochs.

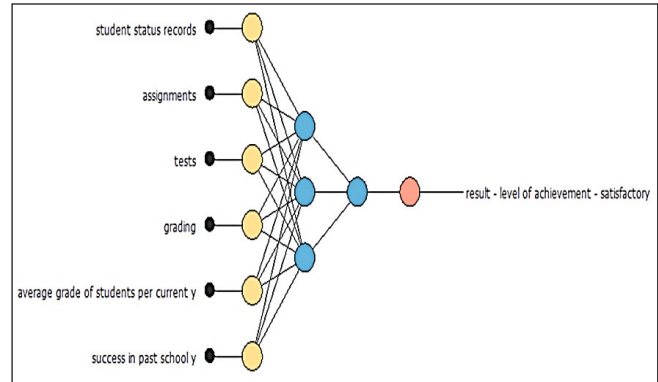


Figure 4: Graphical representation of the Quasi-Newton optimization method

The artificial neural network formed in this way has an input layer, three hidden layers, and an output layer as shown in Figure 5.

The value of the target variable “result - level of achievement - satisfactory” is determined by the values (0 and 1). The value of the target variable “0” is a value that indicates that in dealing with students it is necessary to take corrective measures, related to the individual characteristics and needs of the students. The corrective measures that need to be applied relate primarily to the revision of teaching methods, ie. the adaptation of activities to the needs of the individual student, reflected in other learning styles.

Numerous studies are devoted to learning styles such as: visual, auditory, kinesthetic (abbreviation: VAK), and learning strategies such as: cognitive, meta-cognitive, or social-affective. VAK concepts were originally developed by psychologists and teachers such as Fernald, Keller, Orton, Gillingham, Stillman, and Montessori, beginning in the 1920s. The VAK principles and theories today extend to all types of learning and developmental methods, well beyond its original fields of application. The VAK model provides a different perspective for understanding and the explanation of the preferred or dominant way of thinking and learning [14, 19].

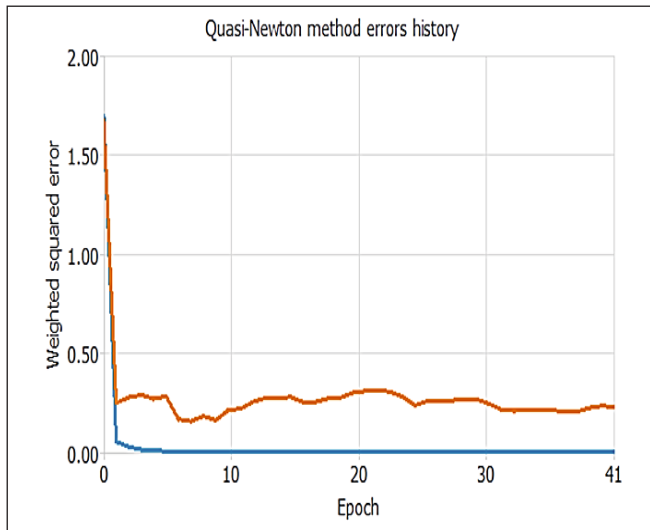


Figure 5: View of the neural network

To model an e-learning system that focuses on personalized learning, we have used the results obtained using artificial neural networks.

**RESULTS**

The results of the classification accuracy of artificial neural network models represent the rate of correct classification on the training and testing samples [11]. The classification rate by output category applies to each grade separately. The average classification rate, in this case, is the rate of correctly classified students relative to the test sample. The average classification rate is 69.3%. As a model, we have used a multilevel perceptron with a forward propagation algorithm, containing three hidden layers, four neurons in hidden layers, a sigmoid activation function, and a forward propagation algorithm.

The obtained results show that in the test sample 69.3% of cases were correctly classified, while 30.7% of cases were wrongly classified. This network represents the classification rate for the output variable - "student mathematical achievements".

Based on the research, we have learned that students will be 85% more likely to receive a grade of three or more in the subject of mathematics, depending on the number of access to the eLearning system, and with the active guidance of teachers, which primarily refers to the proper identification of an adequate learning style.

To determine the results related to the value of the output variable "result - level of achievement - satisfactory" in the "NeuroDesigner" software ap-

plication, testing was conducted to find the extreme values for the obtained grades, in case no corrective measures related to learning styles were applied. Figure 6 shows the values of grades at the lowest level of achievement which is "1", while the cumulative value is expressed in percentages indicating the probability that a student will meet a satisfactory level of achievement, and is 0.008%.

	Value
student status records	1
assignments	1
tests	1
grading	1
average grade of students per current y	1
success in past school y	1
result - level of achievement - satisfactory	0.00829400187

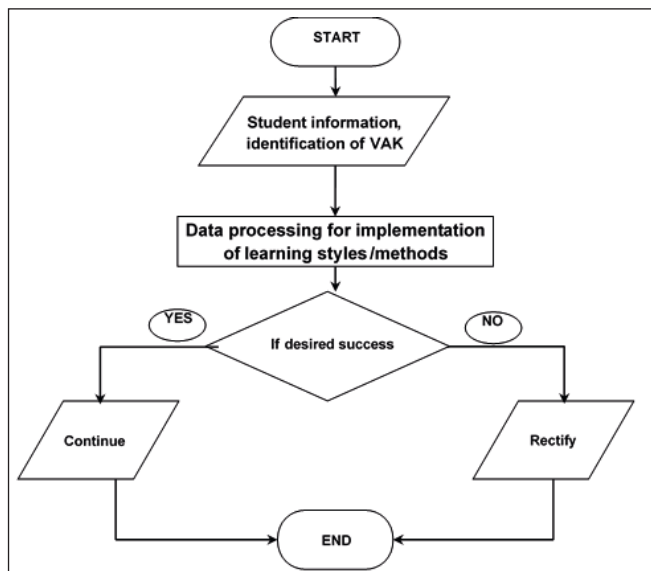
Figure 6: Value of grades at the lowest achievement level

Contrary to the case above, when corrective measures are applied to learning styles and when the grades are in the highest achievement level of "5", the cumulative value is expressed as a percentage indicating that the student is likely to meet a satisfactory level of achievement is at 0.987%. Figure 7 shows the values of the grades at the highest level of achievement which is "5".

	Value
student status records	5
assignments	5
tests	5
grading	5
average grade of students per current y	5
success in past school y	5
result - level of achievement - satisfactory	0.98732141

Figure 7: Values of grades at the highest level of achievement

The research presented in this paper indicates that the implementation of the proposed neural network model in the system of integrated e-learning platform can improve the rate of students' academic success and properly orient them towards the implementation of corrective measures, related to the identification and the utilization of adequate learning methods.



**Figure 8:** Shows the functionality algorithm for applying artificial neural network results in the personalization of learning through e-learning systems.

**DISCUSSION**

The basic contribution of this paper is reflected in several aspects. Firstly, the developed models of artificial neural networks can indicate to the teaching staff the success rate of the students.

Models for predicting student achievements can indicate to students which classroom activities they need to improve. This primarily refers to certain activities in an adequate e-learning system, such as homework, tests, quizzes, etc., where the algorithms developed specifically for this task may indicate certain activities that need to be stepped up to increase the academic achievements among students. Secondly, models can also be used by students themselves, to assess their future development during schooling, based on existing learning and grading habits or patterns, assessing the time needed to organize themselves, or the amount of additional effort needed for achieving their desired success.

**CONCLUSION**

In terms of the achieved scientific goal of our paper, we can conclude that a good basis has been created for the improvement of the teaching/learning process, in accordance with the student traits obtained, by developing and analyzing models based on artificial intelligence and neural networks.

The recommendation is based on the results of models that achieve predictive validity greater than

70% for average grades, grades for individual school subjects, as well as the identified factors and variables that are of great importance for the success of the learning process. The paper concludes that neural network models provide the highest accuracy in predicting student success.

The research findings presented in this paper will help identify the requirements that prospective students are facing, as well as the ways they can achieve the best possible outcomes during school years. The results of this research may be used by other educational institutions.

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